UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

RJ MACHINE COMPANY, INC.
Petitioner,

v.

ARMATURENFABRIK FRANZ SCHNEIDER GMBH + CO. KG,
Patent Owner

Inter Partes Review IPR2024-00851

Declaration of
Dr. John P. Rodgers in Support of the

Petition for *Inter Partes* Review of:

U.S. Patent No. 9,851,030

EXHIBITS CONSIDERED

Exhibit No.	Description
1001	U.S. Patent No. 9,851,030
1002	Reserved
1003	Prosecution File History, U.S. Patent No. 9,852,030
1004	Original Complaint served on September 20, 2023
1005	U.S. Published Application No. 2013/0187075 to Craig (“Craig”)
1006	AS Schneider Catalog: “Instrument Valves and Manifolds - Hook-Ups” (“2008 Hook-Ups Catalog”)
1007	Webpage Wayback Machine ® showing Hook-Ups Catalog dated 2008
1008	AS Schneider Catalog: Instrumentation Products – Pressure Instrument Accessories (“2012 Accessories Catalog”)
1009	Webpage Wayback Machine® showing Accessories Catalog dated 2012
1010	Parker Direct-Mount Duo I.O.M. Manual (“Parker-1”)
1011	Parker Direct-Mount® Duo™ I.O.M. Manual (“Parker-2”)
1012	Webpage Wayback Machine® Parker Catalog dated March 2014
1013	RJ Machine Waiver of Service of Summons dated October 2, 2023

APPENDICES CONSIDERED

Appendix No.	Description
A	C.V of Dr. John P. Rodgers
B	Reserved
C	Southwest Research Institute publication entitled "Orifice Flow Meter Calibration" ("SWRI")
D	Parker Instrumentation – Instrument Tube Fitting Installation Manual ("Parker-3")
E	Yokogawa Electric Corporation; DPharp User's Manual – "Differential Pressure Transmitters" (Yokogawa")
F	The American Society of Mechanical Engineers (ASME) B16.39-2009 standard
G	Wilwood publication – "Flaring Hard Brake Lines Made Easy" ("Wilwood")
H	Endress & Hauser publication – "Flow Measurement with Primary Devices" (Endress & Hauser")
I	McCrometer Installation Operation & Maintenance Manual – "Advanced Differential Pressure Flowmeter Technology" (McCrometer")
J	Krohne OPTIBAR DP 7060 C Handbook – "Differential pressure transmitter for measuring flow, level, differential pressure, density and interface" ("Krohne")
K	World Wide Fittings Catalog – 5000 Series; web archive from The Wayback Machine® ("World Wide Fittings")

DECLARATION OF DR. JOHN P. RODGERS

I, Dr. John P. Rodgers, declare as follows:

[1]. I am over the age of 18 years and am fully competent to make this Declaration. I make the following statements based on personal knowledge and, if called to testify to them, could and would do so.

I. INTRODUCTION

[2]. I have been retained on behalf of RJ Machine Company, Inc. ("Petitioner").

[3]. I have been asked to study and provide my opinions concerning U.S. Patent No. 9,851,030 (the "'030 patent" or the "Challenged Patent"), and the patentability of claims 1-7 (the "Challenged Claims"). The opinions I offer here are made in view of certain prior-art references, the state of the art at the time of the claimed inventions, and the knowledge that a person of ordinary skill in the art would have had at the time of the claimed invention.

[4]. My opinions and views set forth in this Declaration are based on my education, training, and experience in the field of mechanical engineering, sensors, and related technical areas, as well as Petitioner's Exhibits 1001 and 1003-1013, and other materials that are cited and discussed herein.

II. BACKGROUND & QUALIFICATIONS

[5]. My curriculum vitae ("vitae") which includes a summary of my

background, experience, publications, and expert-witness experience is included as Appendix A.

[6]. I am the President and Founder of Starboard Innovations, LLC an engineering consulting firm specializing in concept development, new technology research, design, analysis, prototyping and testing in the areas of fluid mechanics, mechanical testing, mechanical analysis, finite element analysis (FEA), mechanical engineering, downhole tools and failure analysis. I have been consulting on a wide range of oilfield projects over the past 20 years involving the equipment and operations related to oil well completions, both downhole and at the surface, and including failure investigations and new technology development. Much of this work has involved instrumentation and sensing used in the field, on test wells, or in test labs. My work includes working with high-pressure tubing and piping, pressure vessels, an array of different varieties of pressure measuring devices, and data recording equipment. I have often specified the instrumentation, particularly pressure transducers, used in both downhole tool designs and in test equipment. I have frequently worked directly with pipe fitters and other mechanical and electrical technicians in the installation of piping and tubing, including pressure transducers, for use in test wells and test facilities, particularly at Halliburton Energy Services at locations in Texas and Oklahoma. The test facilities include test wells, surface flow loops,

and pressure vessels that simulate downhole operating temperatures and pressures. The pipe and tubing connections are utilized to connect pumps, valves, instrumentation, accumulators, manifolds, and other equipment to the test well, flow loop, or pressure vessel.

[7]. Prior to founding Starboard Innovations LLC, I was a senior engineer for Mide Technology Corporation where I was active in technology, product and business development. As part of my work I served as the principal investigator for an Air Force-funded research program to develop advance rotor concepts and served as team lead for the Bell Helicopter Dynamically-Tailored Airframe Structures program.

[8]. Prior to my work at Mide Technology Corporation, I worked as a research assistant at the MIT Active Materials and Structures Laboratory, the MIT Space Engineering Research Center and the Duke University Department of Mechanical Engineering.

[9]. I have a Ph. D. in Aeronautics and Astronautics in the field of structural dynamics which I earned in 1999. I also hold a B.S.E. degree in Mechanical Engineering and Materials Science which I earned in 1992.

[10]. I am a Licensed Professional Engineer (PE) in mechanical engineering in Texas, North Dakota, and Connecticut. I am also a Professional Engineer License review instructor for the American Society of Mechanical

Engineers. I am also a member of the Society for Petroleum Engineers.

[11]. I have served as a guest lecturer at Texas Christian University and the University of North Texas.

[12]. I have authored and published numerous publications in my field as detailed in my curriculum vitae attached as Appendix A.

[13]. I am a named inventor on 37 U.S. Patents.

[14]. I am an engineer by training and profession. The opinions I express in this Declaration involve the application of my engineering knowledge, expertise, and experience to the evaluation of the Challenged Claims in this matter.

[15]. I have previously testified as an expert witness. A list of those matters is attached to this Declaration as part of Appendix B.

[16]. I am being compensated for services provided in this matter at a rate of $400 per hour. I am also being reimbursed for any reasonable expenses, such as travel expenses. My compensation is not contingent on my opinions, on the outcome of any aspects of this matter, or on any of the technical positions that I explain in this Declaration.

[17]. I have no financial interest in Petitioner, the Patent Owner (whom I understand to be Armaturenfabrik Franz Scheider GMBH + CO. KG), or the ’030 Patent.

III. BASES FOR OPINIONS EXPRESSED

[18]. The opinions set forth in this Declaration are my own. My opinions are based on my review of materials provided in this matter itemized in "Exhibits Considered" preceding this Declaration, the Appendices, in addition to those cited throughout this Declaration; my educational background as a mechanical engineer; my experience working in the oilfield with pressure testing and measurement; and my experience as a technical consultant in other litigation involving related technology.

[19]. My analysis of the materials relating to this matter is ongoing, and I will continue to review any new material that is provided to me. This Declaration represents certain opinions that I have formed to date and the bases for those opinions. I reserve the right to revise, supplement, and/or amend my opinions based on new information presented to me and on my continuing analysis of the materials cited throughout this Declaration and those identified in the "Exhibits Considered" list.

IV. UNDERSTANDING OF LEGAL STANDARDS

[20]. I am not an attorney or a legal expert and offer no opinion on the law. For the purpose of preparing this Declaration, I have been informed about certain aspects of the law that are relevant to my analysis and opinions, as set forth below.

A. PATENTABILITY

[21]. I understand that for an invention claimed in a patent to be valid and patentable, it must be, among other things, new and not obvious in light of what was known and came before it. That which was known or came before the claimed invention is generally referred to as "prior art."

[22]. I understand that there are two ways in which prior art may render a patent claim unpatentable. First, the prior art can be shown to "anticipate" the claim. Second, the prior art can show that the claim would have been "obvious" to a person of ordinary skill in the field of the invention at the time the invention was made.

1. *Anticipation*

[23]. It is my understanding that anticipation is a question of fact that is determined from the perspective of a person of ordinary skill in the art (a "POSITA") at the time of the claimed invention. I also understand that the standard for anticipation in an *inter partes* review proceeding is "by a preponderance of the evidence." My understanding of this burden of proof is that it requires that there be a greater than 50% chance that something is true. It is my further understanding that a claim is anticipated only if each and every element in the claim is found, expressly or inherently, in a single prior-art reference.

[24]. I understand that if a prior-art reference does not expressly set forth

a particular claim element, the prior art may still anticipate a claim if that element is "inherent" in its disclosure. My understanding of the inherency standard is the evidence must make it clear that the missing descriptive matter is necessarily present in the thing described in the reference. It is my further understanding that inherency may not be established by probabilities or possibilities. In other words, the mere fact that a certain thing may result from a given set of circumstances is not sufficient to establish inherency.

[25]. I understand that if a claim recites alternatives, for example in the format "selected from the group consisting of A, B, and C," or "at least one of", then anticipation of the entire claim limitation can be achieved through prior art that discloses just one alternative, for example, a prior art reference that simply discloses B.

[26]. I also have been advised that if a prior-art reference discloses one feature of a challenged claim, the reference can anticipate a claimed invention if the feature is described in another document that has been incorporated by reference into the patent of the challenged claim.

2. *Obviousness*

[27]. It is my understanding that obviousness is a question of law with underlying factual inquiries that are determined from the perspective of a POSITA at the time of the claimed invention. I also understand that the

standard for obviousness in an *inter partes* review proceeding is again "by a preponderance of the evidence".

[28]. It is my further understanding that a claimed invention is obvious if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious to a POSITA prior to the effective filing date of the claimed invention to which the claimed invention pertains. I understand that a POSITA is presumed to have knowledge of all relevant prior art.

[29]. It is my understanding that obviousness requires consideration of the following underlying factual inquiries:

- determining the scope and content of the prior art;
- ascertaining the differences between the claimed invention and the prior art;
- resolving the level of ordinary skill in the art; and
- evaluating any "objective evidence" or "secondary considerations" of non-obviousness, such as commercial success, long-felt but unresolved needs, failure of others, industry praise, and unexpected results.

[30]. I understand, however, that for such "objective evidence" or "secondary considerations" to be relevant to the obviousness of a claim, there

must be a causal relationship (called a “nexus”) between the claim and the evidence. I also understand that this nexus must be based on a novel element of the claim rather than on something in the prior art. I further understand that there are instances in which secondary considerations are unable to overcome primary evidence of obviousness (e.g., motivation to combine with predictable results) that is sufficiently strong.

[31]. It is my understanding that a reference must be analogous art to the claimed invention in order to be properly considered for use in an obviousness inquiry. It is my understanding that a reference is analogous art to the claimed invention if:

- the reference is from the same field of endeavor as the claimed invention (even if it addresses a different problem); or
- the reference is reasonably pertinent to the problem faced by the inventor (even if it is not in the same field of endeavor as the claimed invention).

[32]. It also is my understanding that a patent claim is not obvious merely by demonstrating that each of its elements was independently known in the prior art. An obviousness determination requires finding both that a skilled artisan would have been motivated to combine the teachings of the prior art references to achieve the claimed invention, and that the skilled artisan would have had a

reasonable expectation of success in doing so. It is my further understanding that it is important to be careful not to allow hindsight reconstruction of references to produce the claimed invention without any explanation as to how or why the references would have been combined by a person of ordinary skill in the art to produce the claimed invention.

[33]. It is my understanding that the following are exemplary rationales for combining references that may support a conclusion of obviousness:

a) Combining prior-art elements according to known methods to yield predictable results;

b) Simple substitution of one known element for another to obtain predictable results;

c) Use of a known technique to improve a similar method or product in the same way;

d) Applying a known technique to a known method or product ready for improvement to yield predictable results;

e) "Obvious to try", i.e., choosing from a finite number of identified, predictable solutions with a reasonable expectation of success;

f) Known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design

incentives or other market forces if the variations would have been predictable to one of ordinary skill in the art; and

g) Some teaching, suggestion, or motivation in the prior art or in the POSITA's knowledge that would have led one of ordinary skill to modify the prior-art reference or to combine prior-art reference teachings to arrive at the claimed invention.

[34]. In addition to the above, it is my further understanding that a POSITA could have resorted to logic, judgment and common sense available to him or her at the time of the invention to find a claimed feature obvious, even if the prior art relied on did not explicitly state or teach that feature. It is also my understanding that when common sense is relied on to find a feature obvious, the reasoning for that conclusion must be articulated with sufficient clarity.

[35]. It is my understanding that an element or term recited in a dependent claim must have a proper antecedent basis. In other words, the term must be defined in such a way that a person of ordinary skill in the art would have understood what that term is referencing.

B. PRIOR ART

[36]. I understand that for the purposes of this proceeding, prior art includes patents and printed publications appearing in or outside the United States before the effective filing date of the claimed invention. I also understand

that prior art includes U.S. patents, published U.S. patent applications, and published international applications (pursuant to the Patent Cooperation Treaty) that themselves have an effective filing date before the effective filing date of the claimed invention, as long as they name another inventor.

[37]. I have been instructed to assume in my analysis, that, for the purpose of determining what qualifies as "prior art", the effective filing date for each of the Challenged Claims ("Effective Filing Date") is April 23, 2014. In other words, I may consider as "prior art" any patents or publications that were publicly available prior to the Effective Filing Date, as well as any patent application filed in the United States before the invention. I further understand that for purposes of this proceeding before the United States Patent Trial and Appeal Board, only patents and other documents that have the legal status of a "printed publication" may be relied upon as prior art.

C. PERSON OF ORDINARY SKILL IN THE ART

[38]. I understand that a POSITA is not an actual, specific individual; rather, a POSITA is a hypothetical person who is presumed to have knowledge of all prior art in the relevant art at the time of the invention. The POSITA would have had the skills needed to take from each reference the information needed to understand and teach to an ordinary person the relevant subject matter.

[39]. I also understand that the factors considered in determining the level of skill of a POSITA include: (*i*) the levels of education and experience of persons working in the field; (*ii*) the types of problems encountered in the field; (*iii*) prior art solutions to those problems; and (*iv*) the sophistication of the relevant technology.

[40]. I also understand that a POSITA would have been a person of ordinary creativity, not an automaton. Therefore, it is assumed that a POSITA would have applied common sense or have been able to modify or combine prior-art references together, and could also have found a teaching, suggestion, or motivation (whether to modify or combine) either in the references themselves, whether explicitly or implicitly, or in the POSITA's knowledge.

[41]. I understand that sometimes it will be necessary to look to interrelated teachings of multiple patents and publications; the effects of demands known to the relevant field or present in the marketplace; and the background knowledge possessed by a person having ordinary skill in the art. I understand that all of these issues may be considered to determine whether there was an apparent reason to combine the known elements in the fashion claimed by the patent at issue.

[42]. I understand that a POSITA may collaborate with one or more other persons of ordinary skill in the art for one or more aspects with which

the other person may have superior expertise, experience, and/or knowledge. In other words, a POSITA may work as part of a multi-disciplinary team and not only draw upon his or her own skill, but also take advantage of certain specialized skills of others in the team to solve a given problem.

D. CLAIM CONSTRUCTION

[43]. It is my understanding that claim construction, or the interpretation of the claims in the patent, is ultimately a question of law. It is my understanding that, in an *inter partes* review, the claim term is given its ordinary and customary meaning as would have been understood by a POSITA at the time of the claimed invention, in light of the specification and the prosecution history, as well as pertinent extrinsic evidence.

[44]. It is my understanding that the claims, the specification, and the prosecution history are referred to as "intrinsic evidence" and are to be read as a POSITA would have done at the time of the alleged invention.

[45]. In addition to the intrinsic evidence, it is my understanding that the court or tribunal may also consider other relevant evidence, called "extrinsic evidence," concerning relevant scientific principles, the meaning of technical terms, and the state of the art. Such evidence includes the testimony of expert witnesses. Although extrinsic evidence may be used to resolve ambiguities that may exist after reviewing the intrinsic evidence, I understand that extrinsic

evidence cannot be used to contradict a claim construction that is clear from the intrinsic evidence.

[46]. It is also my understanding that the ordinary and customary meaning of a term may be evidenced by a variety of sources, including the words of the claims themselves, the specification, the prosecution history, plus any extrinsic evidence that provides relevant scientific principles, the meaning of technical terms, and the state of the art.

[47]. I also understand that some claims are independent and are thus complete by themselves. Other claims that refer to such independent claims are deemed "dependent" on those independent claims. A dependent claim includes all of the limitations of the independent claims on which it depends.

V. TECHNICAL DISCUSSION OF THE FIELD AND LEVEL OF ORDINARY SKILL IN THE ART

A. FIELD OF THE CHALLENGED PATENTS

[48]. The specification of the Challenged Patent describes its field as a connecting apparatus for creating a sealing connection between a measuring instrument or a valve block/valve with a measuring instrument and a metering orifice device installed in a pipeline. *See* Ex. 1001, col. 1, lines 12-24. I believe that the field of endeavor as would have been understood by a POSITA would be the field of pipe fitting, which would include connecting devices for

sealably connecting piping components of a measuring instrument, valve block, or gas pipeline.

B. LEVEL OF ORDINARY SKILL IN THE ART

[49]. Based on my extensive experience and activities in the field summarized above, I have an understanding of the capabilities of a person of ordinary skill in the relevant field. At the time of filing of the ‘030 patent, I possessed at least the same level of skill as a POSITA.

[50]. I have been asked to provide my opinions regarding the knowledge and understanding that a POSITA would have had as of the Effective Filing Date of the Challenged Patents (i.e., April 23, 2014). Accordingly, the analysis set forth herein is based on the timeframe of the alleged invention as of April 23, 2014.

[51]. It is my opinion, based on reviewing the ’030 patent, that as of the Effective Filing Date, a POSITA would have had at least a trade school certificate in pipe fitting or equivalent training and experience, or a certificate in plumbing. Alternatively, a POSITA could have a mechanical or petroleum engineering degree.

[52]. I note that as of the Effective Filing Date, I qualified for or exceeded the level of ordinary skill required by the above definition. I am thus in

a position to opine on the understanding that a person of ordinary skill in the art would have had as of the Effective Filing Date. My qualification to do so is based, at least in part, on my education and experience working in oilfield pipeline pressure testing and instrumentation, including connections for sealably connecting piping components of the associated measuring instruments, valve block, or pipeline on my studying of engineering as a graduate student at the Massachusetts Institute of Technology (MIT) for six years, and my studies as an undergraduate at Duke University for over three years. When I address the understanding of a POSITA, I am referring to the understanding that such a person would have had as of the Effective Filing Date, whether or not it specifically stated.

VI. THE CHALLENGED PATENT - U.S. PATENT NO. 9,851,030

[53]. The technology of the Challenged Patent relates to a connecting apparatus adapted to connect a pipeline or fluid line, such as a natural gas pipeline, with a pressure measuring instrument and/or with a valve associated with the measuring instrument, such as a 3-way or 5-way valve block, to measure the flow rate through the pipeline. *See* Ex. 1001 at col. 1, lines 12-38. The connecting apparatus employs a connecting unit that is a nut for interconnecting the components of the connecting apparatus in a sealing manner, by rotation of the nut without rotating the components. *Id*. at col. 2, lines 59-67.

A. EFFECTIVE FILING DATE OF THE CHALLENGED PATENT IS NO EARLIER THAN APRIL 23, 2014

[54]. The Challenged Patent was filed as application no. 14/694,205 on April 23, 2015 and granted on December 26, 2017. *See* Ex. 1001 at (21), (22), and (54). The ‘030 patent claims priority to a German application no. DE 10 2014 005 783, which was filed on April 23, 2014. *Id.* at (30).

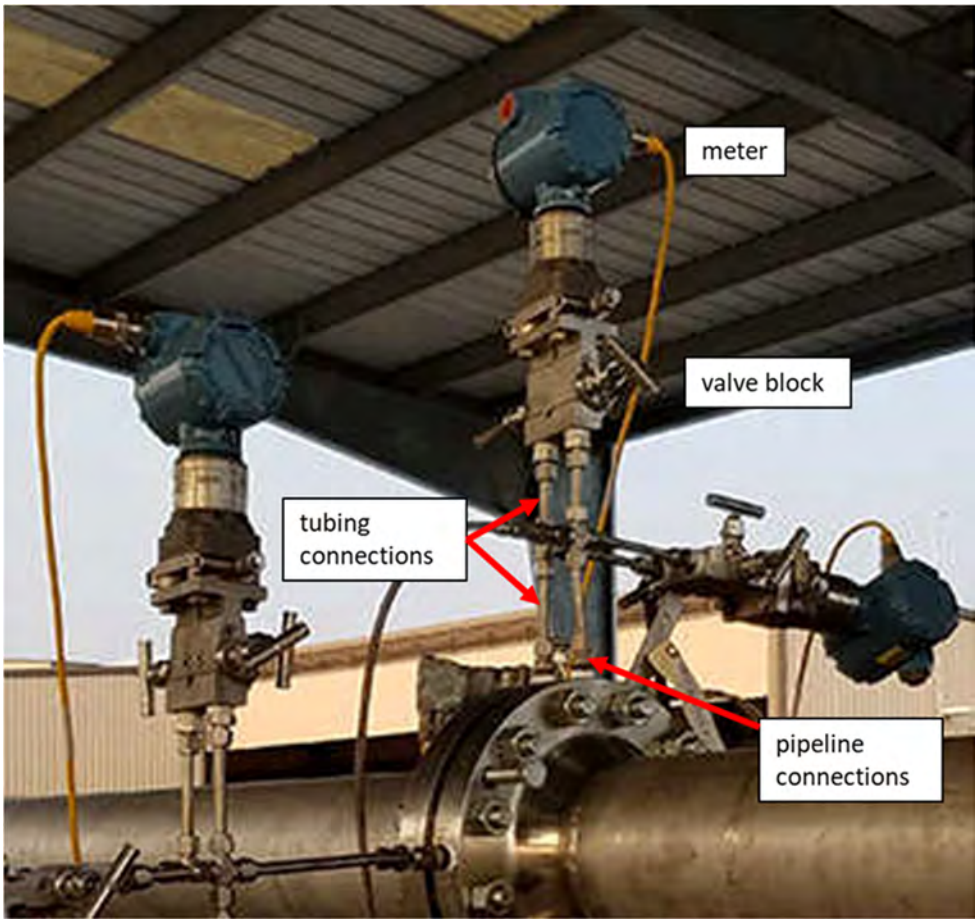
[55]. For purposes of this Declaration, I thus assume that April 23, 2014 is the earliest priority date of the ’030 Patent. However, I offer no opinion as to whether the Challenged Claims are actually entitled to that priority date or are enabled by the ’290 Application.

B. TECHNOLOGY BACKGROUND

[56]. Gas pipelines were and are widely used to transport natural gas and other gas products. Such pipelines are used to move gas from the source well where it is produced to processing facilities and then on to consumers. It is necessary to monitor the flow rate of the gas within the pipeline to know the amount of gas passing through it. One common technique for determining the gas flow rate is based on taking and comparing two pressure measurements, one upstream and one downstream of a restriction placed in the pipeline. The two pressures are compared to calculate a differential pressure, and that pressure is calibrated to provide an indication of the flow rate. An orifice plate is commonly

used to provide a specific flow restriction that can be installed in a flanged connection made within a straight section of the pipeline. A pressure tap on either side of the plate provides the access points for the differential pressure measurement. The two pressure taps must be connected to a measuring device in order to determine the differential pressure and flow rate. The connections are made using either pipe or tubing between the taps on the pipeline and the measuring device.

[57]. The annotated photo below of the SWRI system provides an example of such a pipeline monitoring system. *See* Appendix C at pg. 1. Two pressure taps, one located on each side of a bolted flange connection in the pipeline, are connected to a valve block and differential pressure flow meter via tubing.



Annotated Figure of SWRI (Appendix C)

[58]. It is also desirable to provide one or more valves in between the pipeline and the meter, within the process connections, as in the example above. One type of valve is a shutoff valve that is installed as a singular component in each process line that can be opened or closed to either allow communication or to close and seal off the pipeline. Another type of valve is a valve block which integrates multiple valves into one component. The valve blocks serve multiple functions including shutoff of each process line, opening cross-communication

between the process line, and bleeding or relieving pressure from each line.

[59]. Traditionally, the process connections between the pipeline and the meter have been made up with hard pipe and pipe fittings. The responsibility for installation of the plumbing connections associated with the flowmeter is typically that of a pipe fitter. A pipe fitter is a technician having training and experience with pipe and pipe fittings, tubing and tubing fittings, and flange connections. It would be typical for such an individual to carry an array of standard components commonly used in flowmeter installations to use on site. The pipe fitter follows the manufacturer's installation instructions in configuring the system. A pipe fitter would be familiar with union fittings used with pipe and union nuts used on the ends of tubing connections.

[60]. Most flowmeter manufacturers provide instructions that include configuration guides for pipeline installation. The configurations typically include various options for use in different circumstances including use with gases, steam, or liquids. In addition, pipe fitting and tubing fitting manufacturers and suppliers often provide installation guidelines. These are directed toward how to best utilize the parts in their catalogs including parts selection and proper assembly techniques.

[61]. Tubing and tubing fittings are commonly used for the connections (see previous example from SWRI above). Tubing offers a number of

advantages over the older-style pipe and pipe fittings and these are discussed in Parker-3 (Appendix D at pgs. 4-5). One particular advantage is that tubing connections have a built-in union nut on each end enabling a non-rotating connection to mating components of the system. This is illustrated in the example below of the Yokogawa system (Appendix E at pg. 27). A section of the tubing, used to connect the transmitter to the valve block, is broken out on the right side of the figure and includes a union nut on each end (labeled as a ball head lock nut in this catalog).

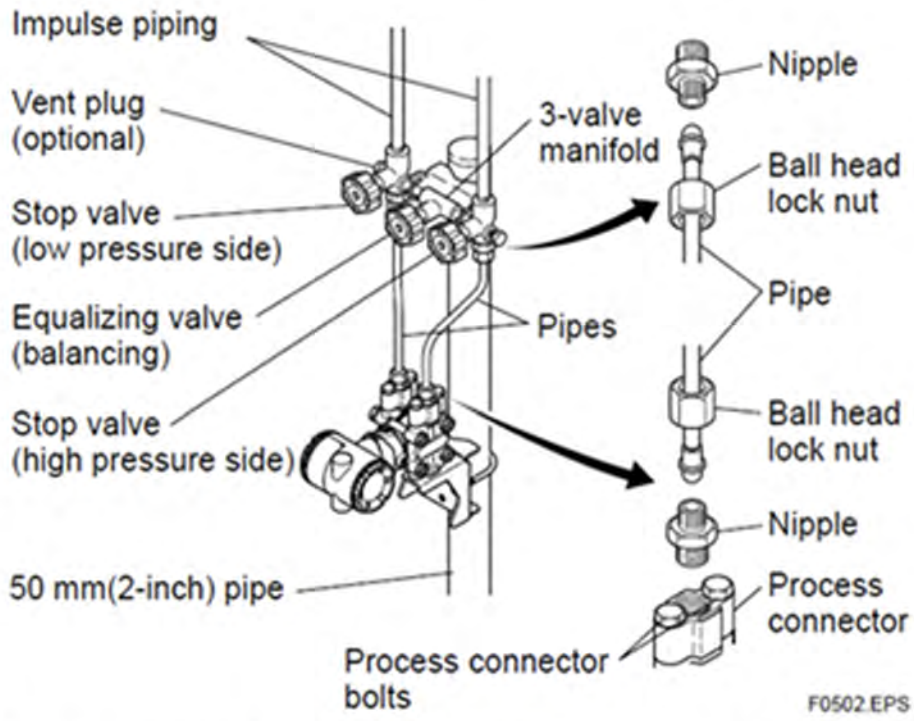


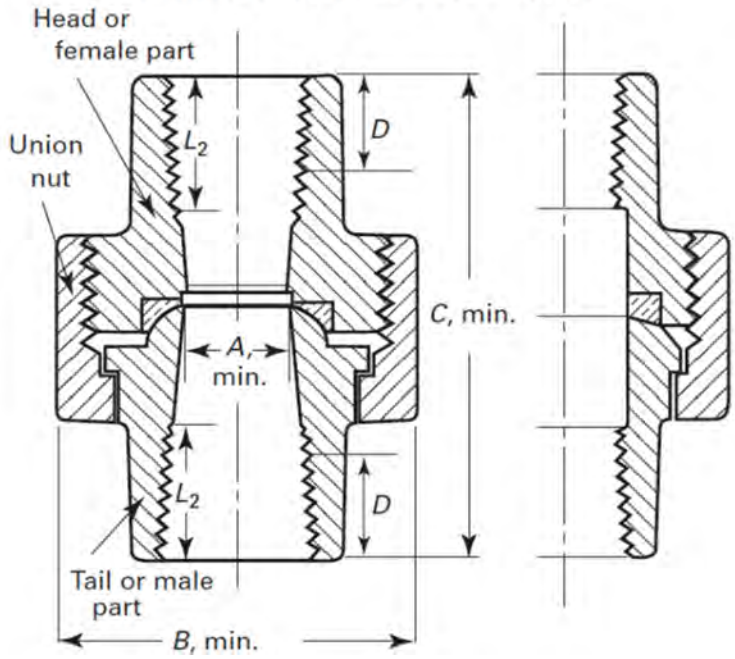
Figure 5.1.1b 3-Valve Manifold (Pipe-Mounting Type)

Figure from Yokogawa (Appendix E)

[62]. As of the Effective Filing Date, there were two primary types of

non-rotating pipe connections used across all industrial pipe applications: unions and flanges. One commonly used type of pipe fitting is a pipe union which provides a non-rotating means of connecting the ends of two pipes. Tightening the nut engages a flange on one side of the part and pulls the two halves of the assembly together causing the mating ends to seal together. This common pipe fitting has been utilized in industry for over a century and the design of unions is covered by the ASME B16.39 (2009) standard (Appendix F). It is commonly used where rotating one side of the threaded connection between two pipes is not possible. An example of a typical union is shown below. *See* Appendix F at pg. 10.

Table 3 SI Dimensions of Class 150 Malleable Iron Threaded Unions



ASME (Appendix F)

[63]. A swivel is a type of union connection also commonly used in general industry as of the Effective Filing Date. While the standard union has a female threaded connection on both ends for connecting to the threaded ends of pipe, the swivel connection has a male threaded connection on one end and a female connection on the other end. The nut engages the flange on the lower half and pulls the two sides together in a non-rotating connection until the two mating faces make a seal. It is common to use a sealing element in between such mating seal faces. An example of a swivel is shown below from the AS Schneider Catalog: Instrumentation Products – Pressure Instrument Accessories ("the Schneider Adaptor"). *See* Ex. 1008 at pg. 111.

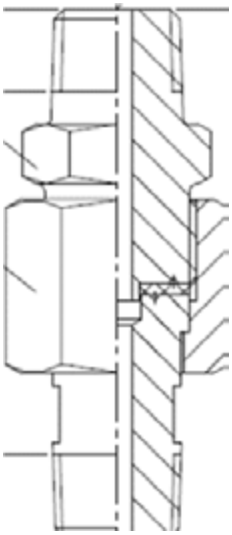


Figure of the Schneider Adaptor

Petitioner's Exhibit 1002
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[64]. Union connections can also utilize a nut with male thread instead of the female threads illustrated in the examples above. The male threaded nut is most commonly found in automotive hydraulic brake lines illustrated below of the Wilwood system (Appendix G at pg. 2). The union functions in the same manner as the more typical female-threaded nut.

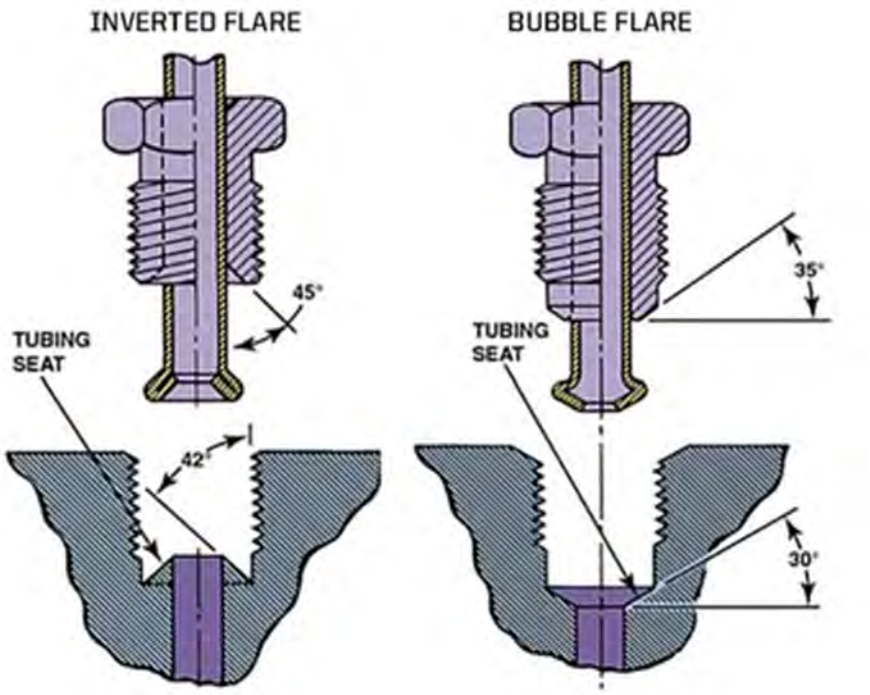


Figure from Wilwood (Appendix G).

[65]. Flange connections were another non-rotating pipe connection commonly utilized on larger diameter pipes, such as on pipelines. Union connections are commonly found on smaller diameter pipes and tubing. Union

connections are generally found to be more forgiving for the relative alignment and positioning of the mating pipes as compared with flange connections. In the example below (from the AS Schneider Catalog: Instrumentation Products – Pressure Instrument Accessories), the mating halves of the flanges are pulled together using a pair of bolts (not shown below but visible in the pipeline flange connection above). *See* Ex. 1008 at pg. 76. This particular style of flange is commonly used to interface with the pressure transmitters used with pipeline monitoring.



Figures from AS Schneider Instrumentation Products Catalog

[66]. Prior to the Effective Filing Date, the pipeline flow monitoring industry had a wide range of products and installation configurations all of which included a pair of plumbing connections between a pipeline and a measuring device/meter/transmitter, which also included one or more valves in between, and a non-rotating connection that utilizes a union nut. Indeed, a wide

variety of pipe or tubing connections for differential pressure flow meters utilizing a union nut were available in the years prior to the filing of the Effective Filing Date.

System Installation Examples

[67]. The Endress & Hauser differential pressure measurement configuration shown below from 2001 (Appendix H at pg. 20) includes tubing connections with union nuts on both sides of the shutoff valves (item 2) in the process lines.

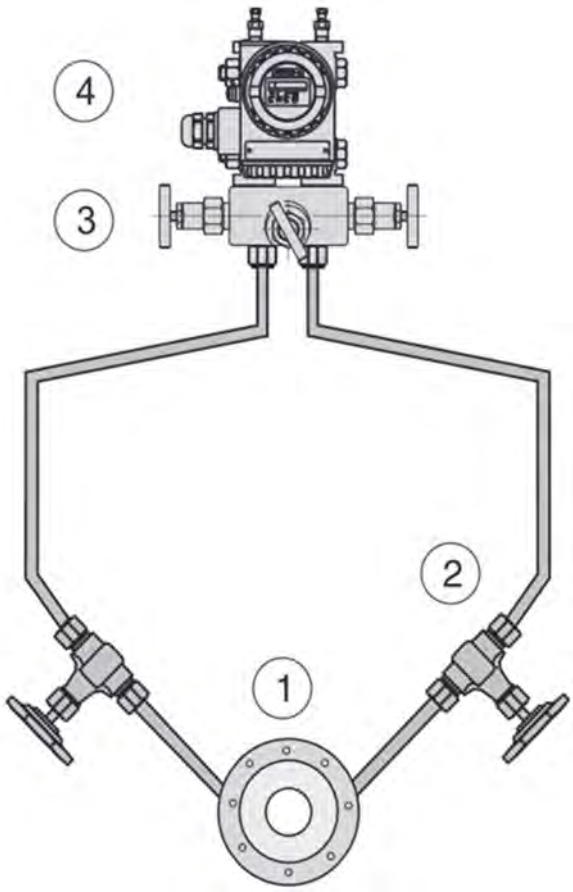


Figure from Endress Hauser(Appendix H)

[68]. The example below McCrometer differential pressure flowmeter installation (Appendix I at pg. 1) utilizes a v-cone as an alternative to an orifice plate. The connection between the pressure taps and the valve block is made with tubing and incorporates union nuts on both interfaces.

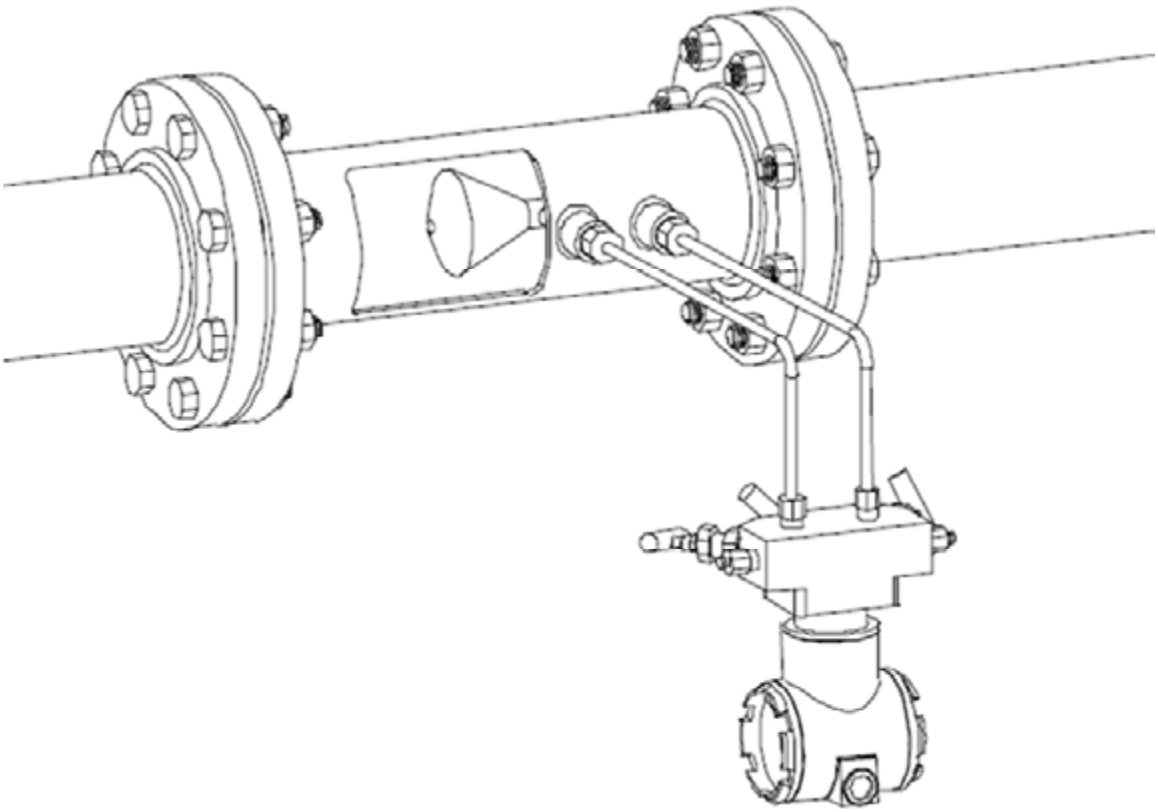


Figure from McCrometer (Appendix I)

[69]. Yokogawa's system configuration also illustrates the use of tubing connections with union nuts. The right side of the figure below of the Yokogawa

system (Appendix E at pg. 27), highlights the union nuts and flange on the ends of the tubing.

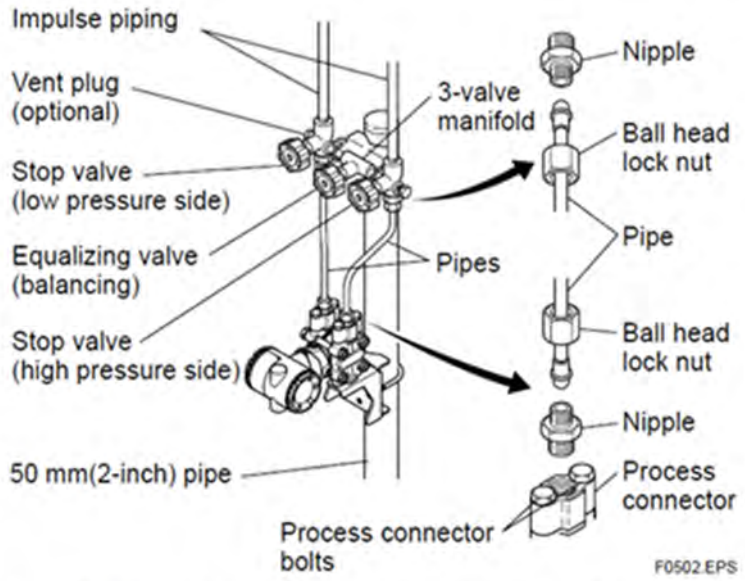


Figure 5.1.1b 3-Valve Manifold (Pipe-Mounting Type)

Figure from Yokogawa (Appendix E)

[70]. Krohne (Appendix J) provides a couple of installation examples for its different pressure flowmeter product that utilize pipe connections that incorporate a union. In the first example (Appendix J at pg. 24), the union connects the process lines to the valve block. In the second example (Appendix J at 25), the union nut connects the process lines to shutoff valves.

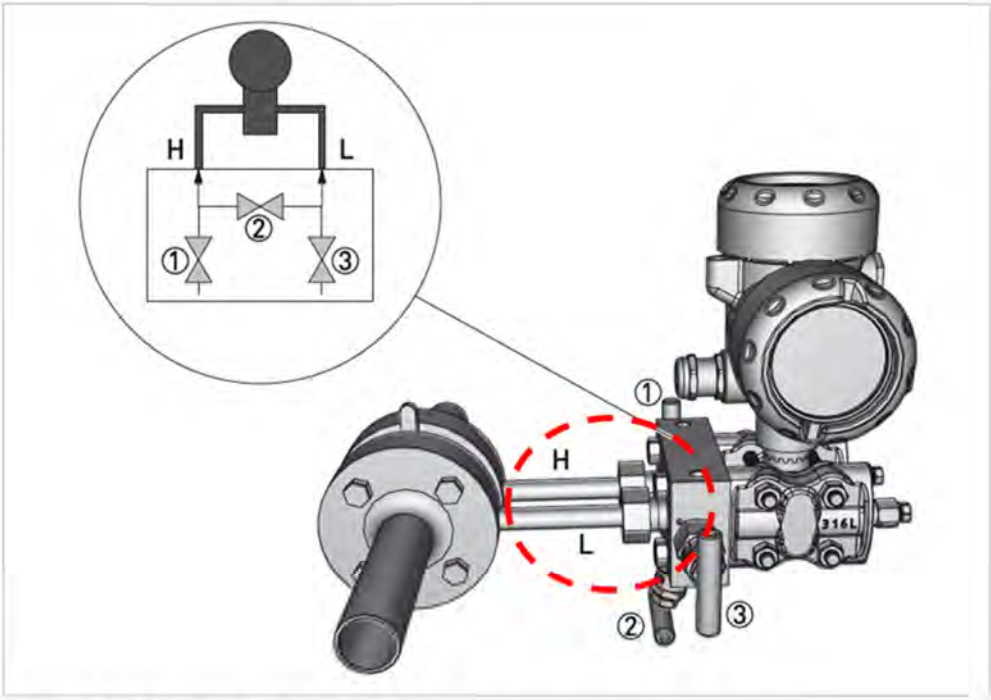


Figure 3-6: Application example

① Shut-off valve
② Equalizing valve
③ Shut-off valve

Figure from Krohne (Appendix J)

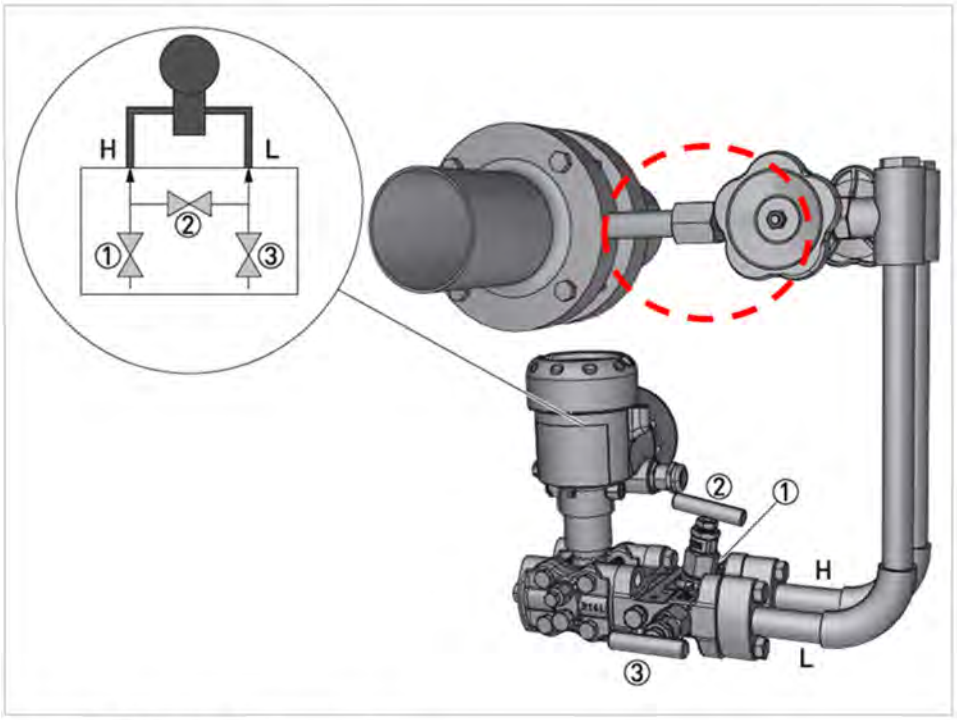
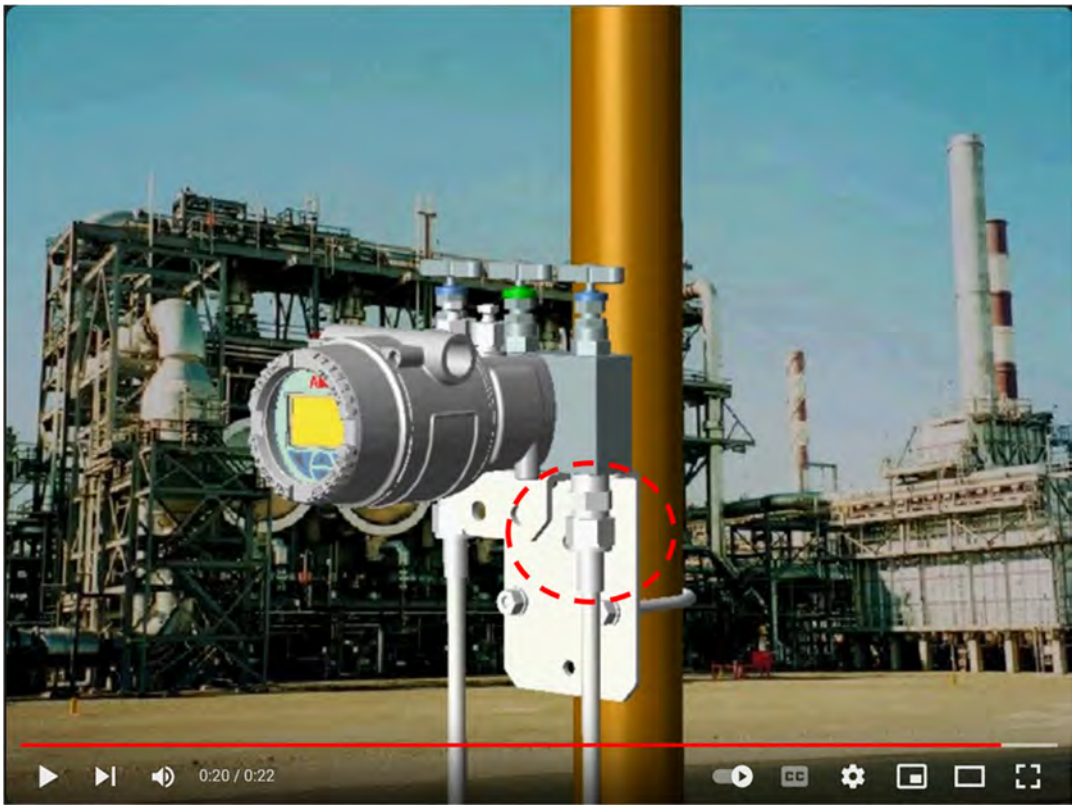


Figure 3-7: Application example

① Shut-off valve
② Equalizing valve
③ Shut-off valve

Figure from Krohne (Appendix J)

[71]. ABB also demonstrated installation of a differential pressure flowmeter system on Youtube illustrating how to tighten the two union nuts to make up the connections from the process lines (tubing) to the bottom of the valve block.

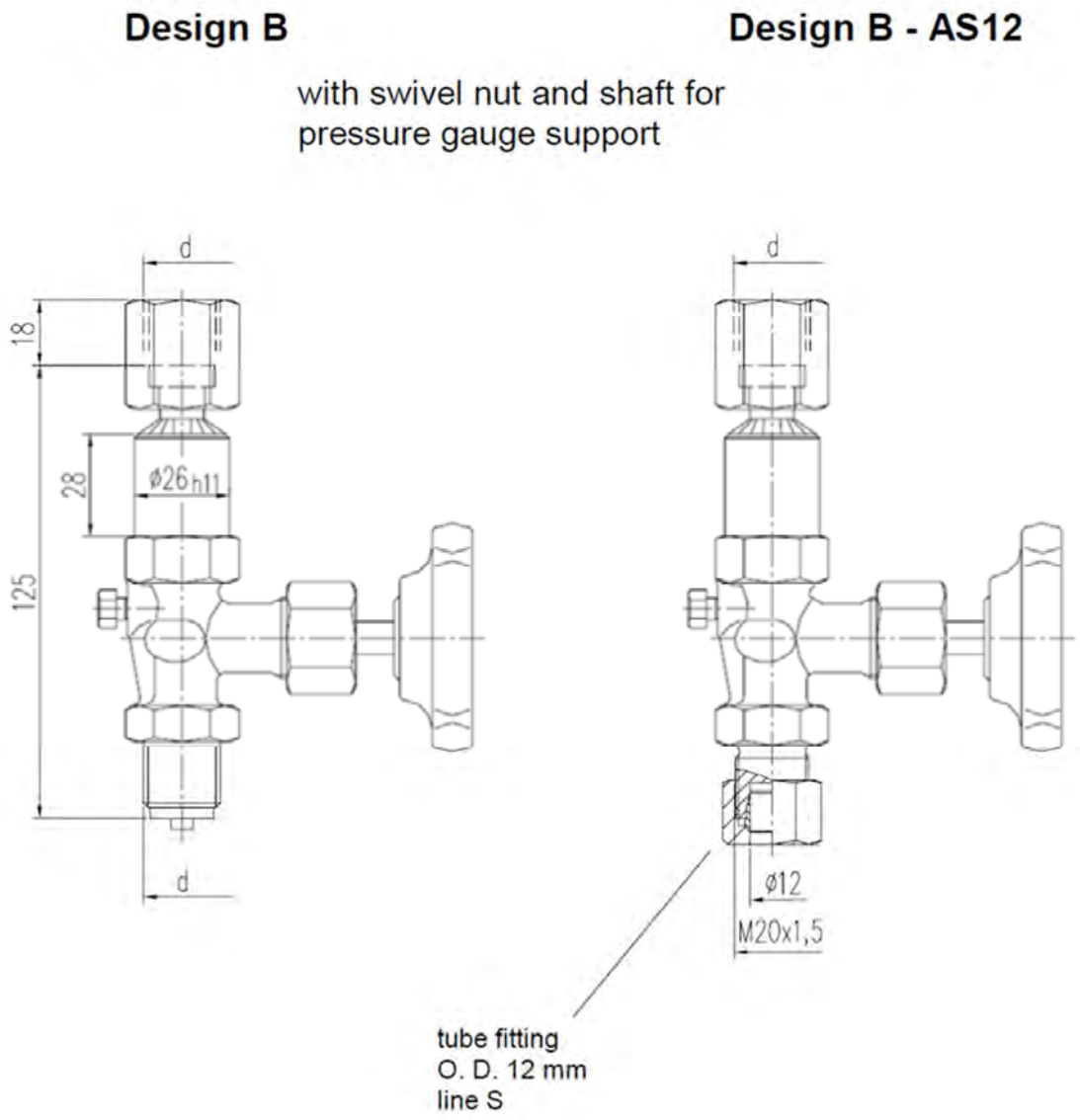


https://www.youtube.com/watch?v=6xaNxMyopSs (Dec 1, 2011). (annotated)

Valve Examples

[72]. Valves are available in a range of forms and with variety of options for the pipe or tubing connections on each side. The following shutoff valve example (Design B – AS12) from the from the AS Schneider Catalog: Instrumentation Products – Pressure Instrument Accessories (*see* Ex. 1008 at pg. 82) includes a swivel connection on the outlet (upper) side and a tubing connection on the inlet (lower) side. Only the union nut of the outlet connection is shown in this figure. The union nut of the tubing connection is shown on the

inlet side.

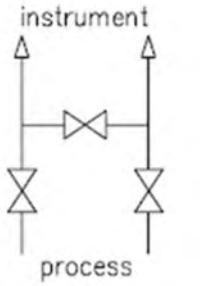


Figures from Schneider Instrumentation Products catalog (Ex. 1008)

[73]. Valve blocks are available with a variety of forms and plumbing connections including flange mounts or other tubing or piping interfaces. Valve blocks are commonly found in 3-way and 5-way configurations such as in the two examples below. *See* Ex. 1008 at pgs. 14, 16, 26, and 28. The left- and

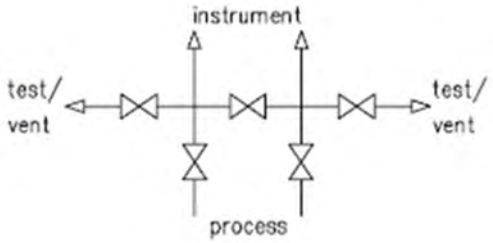
right-side handles are a shutoff valve for each of the inputs, typically the process lines. The third handle in the middle connects the left and right inputs when opened and functions to equalize the pressure between the two inputs. This valve would typically be in the closed position during differential pressure measurements. A 5-way valve adds two additional valves and handles, one for the left input and one for the right. The valves open communication with the ambient air and act as a bleed valve to relieve pressure.





Schneider *Instrumentation Products catalog (Ex. 1008)*at pgs. 14, 16.





Schneider *Instrumentation Products catalog (Ex. 1008)* at pgs. 26, 28.

Tubing Examples

[74]. Tubing connections are available in a variety of forms from different manufacturers. Parker-3 is one of the largest tubing firring suppliers and an example connection is shown below (Appendix D at pg. 15).

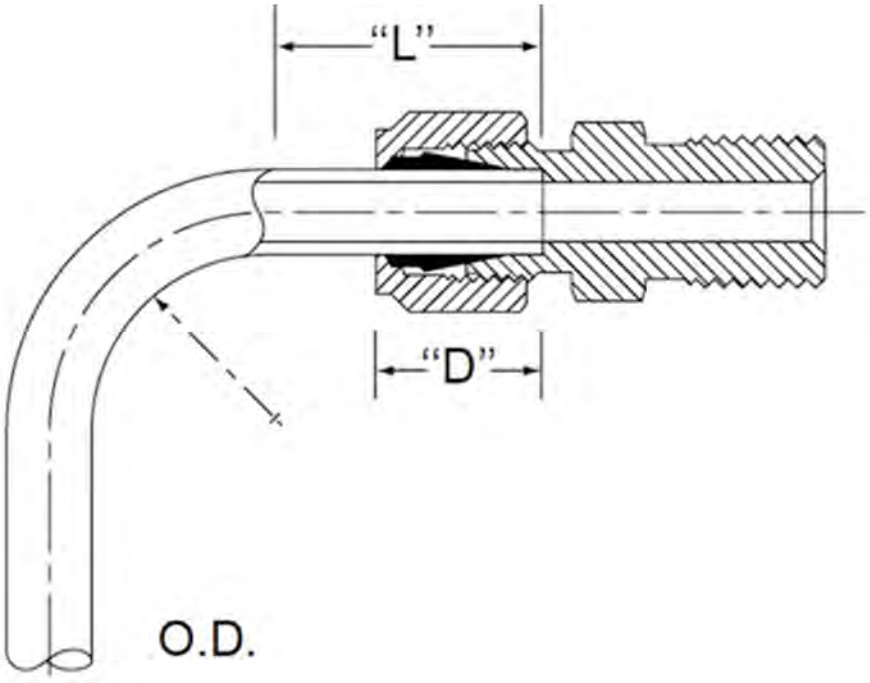
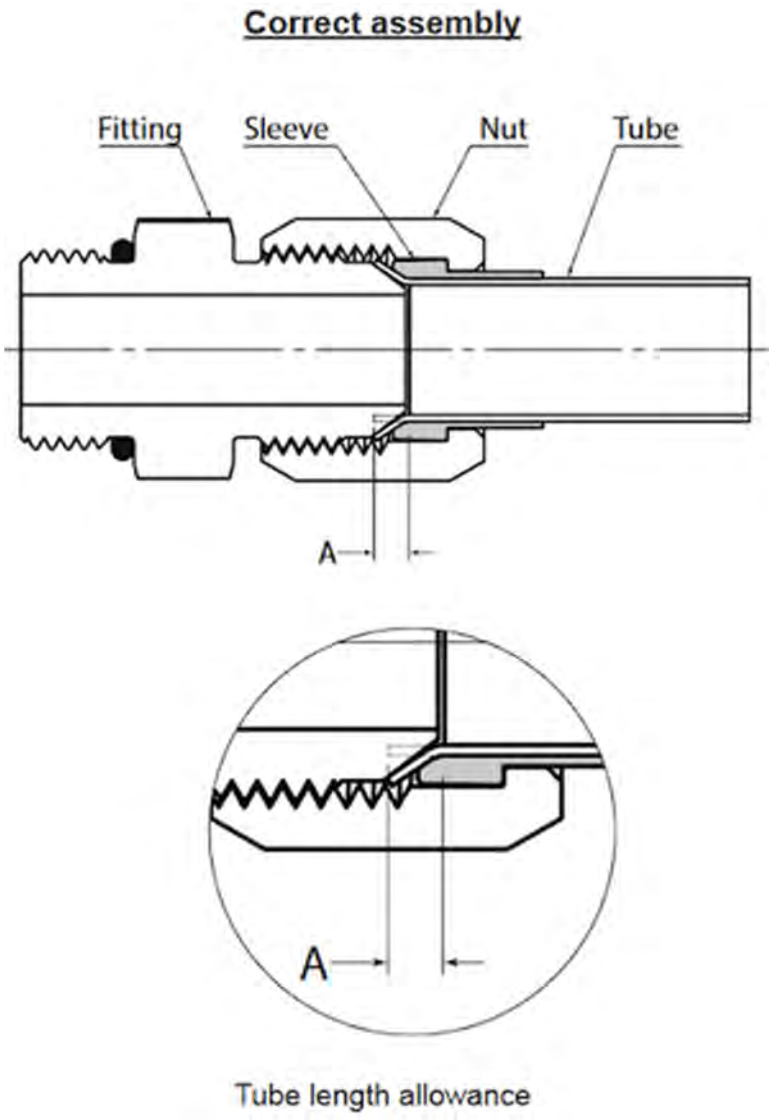


Figure from Parker-3 (Appendix D)

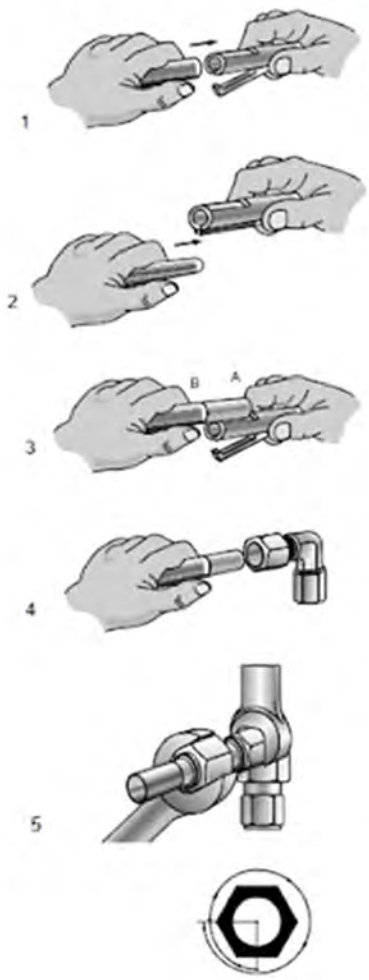
[75]. An alternative to the Parker-3-style tubing fitting is the JIC Flare shown below (from the World Wide Fittings Catalog (Appendix K)). Instead of a ferrule, the JIC Flare uses an external sleeve that is attached to the tubing to create the flange on the outer diameter. The union nut draws the two sides of the connection together to make a seal on the conical surface.



Figures from World Wide Fittings Catalog(Appendix K)

[76]. The Parker-3 installation manual describes the process of tightening the nut to make up the tubing connection. The Parker-3 example is shown below (Appendix D at pg. 37).

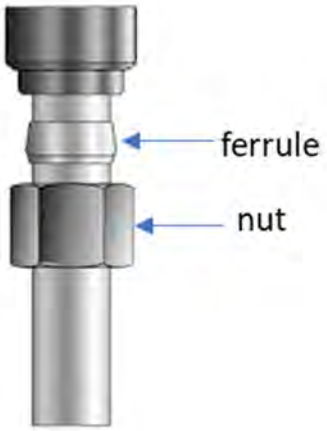
Using the Parker Tube Marker and Inspection Gauges, you can make precise, accurate tubing connections - even though you can't see inside the fitting. Here's how:



1. Put tube marker completely on to tube.
2. Press marking arm against tube and rotate marker 360°- to leave a burnish mark around the tube.
3. Check burnish mark position by butting flat (A) on marker against end of tube. Burnish marks is in correct position if it lines up with end of tube marker (B).
4. Now insert the tube into the fitting until tube bottoms inside. (If the fitting is disassembled, note that the small tapered end of the ferrule goes into the fitting body). Tighten nut finger tight.
5. From "finger tight" position, wrench 1-1/4 turns for 1/4" to 1" size fittings. (1/16", 1/8" and 3/16" size tube fittings only wrench 3/4 turn from finger tight position) hold fitting body hex with a second wrench to prevent body from turning as tighten. It is a good idea to mark the nut to help you count the turns.

Parker-3 (Appendix D)

[77]. The nut engages with the ferrule which protrudes radially from the end of the tubing, once it is installed. In the figure below from Parker-3 (Appendix D at pg. 39), the nut is shown before it is slid up and over the ferrule to engage the mating thread.



Annotated Figure from Parker-3

C. DISCLOSURE OF THE CHALLENGED PATENT

[78]. The ‘030 patent describes a connecting apparatus 10 for connecting a pressure measuring instrument to a pipeline, such as a natural gas pipeline. *See* Ex. 1001 at Abstract and col. 1, lines 28-31. The pressure measuring instrument is used to check the flow rate during operation of the pipeline. *Id*. The connecting apparatus 10 incorporates a connecting unit or nut 50 which allows the installer or “fitter” to assemble the pressure measuring instrument with the pipeline solely by rotation of the nut and not the associated connecting devices. *Id.* at col. 2, lines 55-67.

[79]. The associated connecting devices include a first or lower connecting device 30 and a second or upper connecting device 40. As seen in Fig. 6 (reproduced below), the first connecting device 30 connects to the

pipeline 16, and specifically to the pipeline's metering orifice device 18, and the second connecting device connects to a pressure measuring instrument 14 either directly or via the instrument's valve block 12. *Id.* at col. 6, lines 5-8.

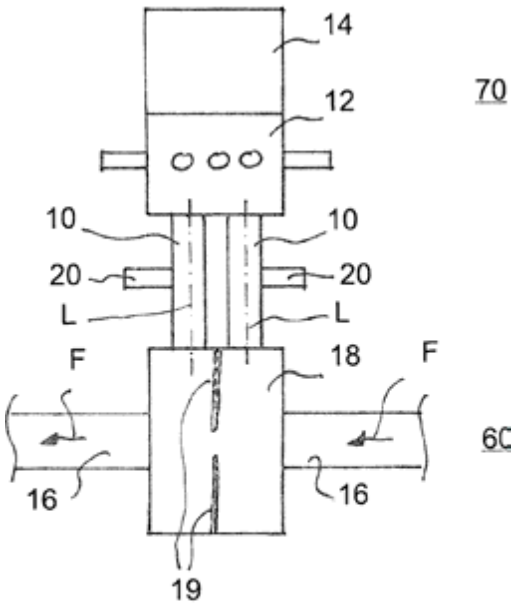


Fig. 6

Fig. 6 of the '030 Patent

[80]. The nut 50 interconnects the first and second connecting devices 30 and 40 with sealing effect. Fig. 1 of the '030 patent (shown below annotated with color) illustrates a cross-section through the connecting apparatus 10 with the first connecting device 30 (green) and the second connecting device 40 (lime) clamped together via the nut 50 (blue). *Id.* at col. 4, lines 51-55. A safety shutoff valve 20 (orange) is coupled to the second connecting device 40. *Id.*

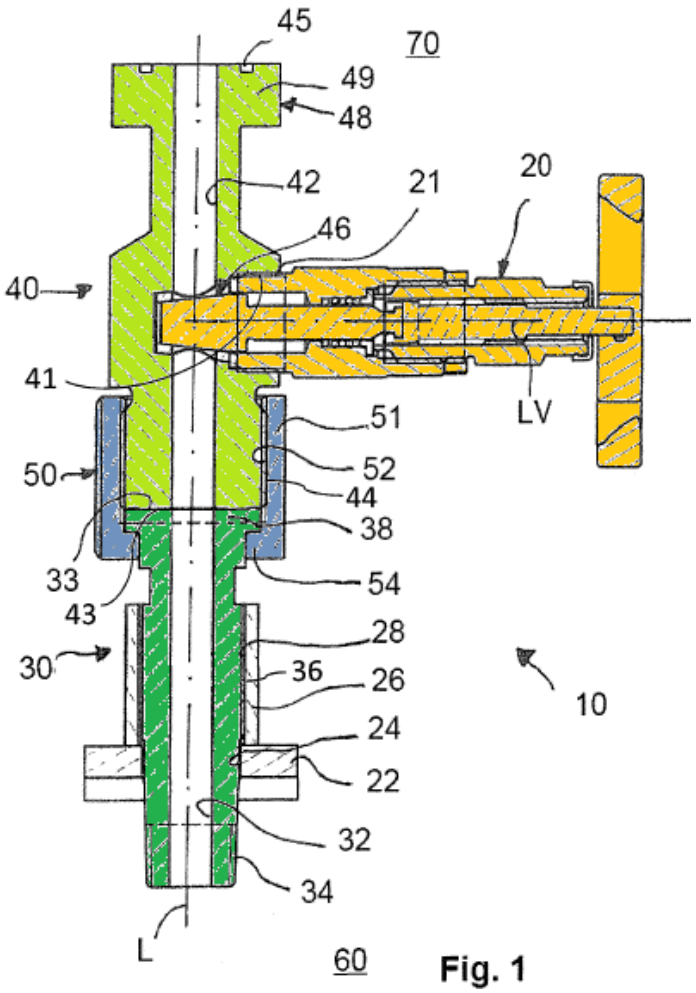


Fig. 1 of '030 Patent (annotated with color)

[81]. The first connecting device 30 includes a through-opening 32 in the longitudinal direction L and an "outwardly pointing, encompassing" connecting flange 38 at its upper end region. *Id.* at col. 3, lines 11-13. A base plate 22 and a clamping nut 26 are provided at its lower end region for clamping the first connecting device 30 to the pipeline's metering orifice device 18. *Id.* at col. 7, lines 25-31. The second connecting device 40 also includes a through-opening

42 in fluid communication with the through-opening 32 of the first connecting device 30. *Id.* at col. 6, lines 25-27. The lower end region of the second connecting device 40 has a male or outer thread 44. *Id*. The upper end region of the second connecting device 40 has an upper connecting unit 48 with a connecting flange 49 configured to engage the valve block 12 of the measuring instrument 14. *Id.* at col. 6, line 51-52.

[82]. The shutoff valve 20 threadably engages a connecting unit 46 of the second connecting device 40 such that the shutoff valve 20 extends at right angle to the longitudinal direction L of the connecting apparatus 10, as seen in Fig. 1. *Id.* at col. 6, lines 30-40. The shutoff valve 20 can selectively open and close the through-opening 42 of the second connecting device 40. *Id.*

[83]. The ‘030 Patent describes that the two connecting devices 30 and 40 are interconnected by the nut 50 with “sealing effect.” The “sealing effect” is accomplished by the outer flange 38 of the first connecting device 30 fitting behind the inner flange 54 of the nut 50 and the female thread 52 of the nut 50 being screwed onto the male thread 44 of the second connecting device 40 so that by “means of the inner flange and the outer flange”, the end-face sealing surfaces 33 and 43 are clamped to each other. *Id.* at col. 3, lines 19-34.

[84]. An O-ring made of a sealing material can be disposed between the

end-face sealing surfaces 33 and 43. *Id.* at col. 7, lines 46-49 ("In an embodiment variant, which is not shown, provision is made between the end-face sealing surface 43 and the end-face sealing surface 33 for sealing means which ensure a permanently reliable sealing function." *Id.* at col. 3, lines 59-66 ("These sealing means can [be] designed in a wide variety of forms. For example, provision can be made for O-rings consisting of sealing plastic such as PTFE, elastomer or graphite, which for example are arranged inside a groove.").

D. THE PROSECUTION HISTORY OF THE '745 PATENT

[85]. The '030 patent issued from U.S. Patent Application Serial No. 14/694,204 ("the '204 application"), which claims priority to German application no. DE 10 2014 005 783, which was filed on April 23, 2014. *See* Ex. 1003, pgs. 1-7 and 154. The '204 application was filed with 9 claims and published on October 29, 2015, as U.S. Publication No. 2015/0308592-A1. *Id*. at pgs. 27-29, and 99.

[86]. The Examiner issued a non-final Office Action on May 10, 2017 rejecting claims 1-9 under 35 U.S.C. §112(b) for indefiniteness and rejecting claims 1, 3, 6, 7, and 9 under 35 U.S.C. § 102(a)(1) as being anticipated by U.S. Patent No. 6,302,446 to Spears. *Id*. at pgs. 100-109. Original claim 1 ultimately issues as claim 1 in the patent. *Id*. at pg. 143. Regarding the §112(b) rejection,

the Examiner stated that the recitation of the phrase "a direct or indirect sealing connection to a pipeline" in claim 1 was unclear both in its meaning and as to whether the pipeline is part of the claimed invention. *Id.* at 104-105. Noticeably, dependent claims 2, 4, 5, and 8 were rejected only under §112 and not in view of any prior art. *Id.*

[87]. The applicant submitted an Amendment on August 10, 2017 in response to the non-final Office Action. *Id*. at pgs. 113-130. In the Amendment, the applicant amended claims 1, 6, 7, and 9, cancelled claims 2-5, and added two new dependent claims, claims 10 and 11. *Id*. at pgs. 124-125. More specifically, the applicant amended independent claim 1 to delete the recitation of "direct or indirect" regarding the first and second connecting devices and added that the first connecting device is "connectable" to a pipeline or to a metering orifice device "in a sealing manner" in response to the Examiner's rejection under §112(b) and lack of clarity concerns. *Id*. at 118-120, 124, and 125. Notably, the applicant confirmed for the Examiner that the pipeline and/or the metering orifice device thereof are not part of the claimed invention. *Id*. Instead, the applicant stated that claim 1 was amended to recite that the first connecting device has the "capability (function)" of being connected to a pipeline. *Id.*

[88]. Regarding the rejection of the claims under §102(b), rather than address the anticipation rejection of the claims by the Examiner in view of the Spear reference, the applicant chose to amend independent claim 1 to include the limitations of original dependent claims 2-5 and cancelled those claims. *Id.* at pgs. 124-126. The pending claims were subsequently allowed via a Notice of Allowance and a Corrected Notice of Allowance that issued on August 25, 2017 and September 8, 2017, respectively, without any statement of the reasons for allowance by the Examiner. *Id.* at pgs. 131-138.

VII. STATE OF THE ART

[89]. I understand that Petitioner has asserted four prior-art references in its challenge of the Challenged Claims:

- U.S. Publication No. 2013/01887075 to Craig ("Craig") - Ex. 1005;
- The AS Schneider 2008 Hook-ups Catalog - Ex. 1006;
- The AS Schneider 2012 Accessories Catalog - Ex. 1008; and
- The Parker Direct-Mount® Duo™ I.O.M. Manual ("Parker-1") - Ex. 1010.
- Parker Direct-Mount® Duo™ I.O.M. Manual ("Parker-2"). Ex. 1011.

Each prior-art reference was published prior to the earliest Effective Filing Date of the '030 patent. None of these prior-art references were cited during the prosecution of the of the '030 patent

[90]. Each of the references in the above list is from same field of endeavor, namely each pertains to the field of pipe fitting connections. Thus, in my opinion, each qualifies as analogous prior art. Additionally, it is my opinion that each of these references is reasonably pertinent to the problem faced by the inventor, namely the problem of non-rotating pipe fitting connections. This is because each reference relates to connecting pipe components using a union connection that allows connection of the two components without rotating either component.

A. SUMMARY OF THE PRIOR ART REFERENCES

1. CRAIG (U.S. PUBLICATION NO. 2013/0187075)

[91]. Craig discloses a system for delivering propane gas from an outdoor propane storage tank 5 to a building B, as seen in Fig. 1. *Id.* at ¶¶[0003] - [0004] and Fig. 1.

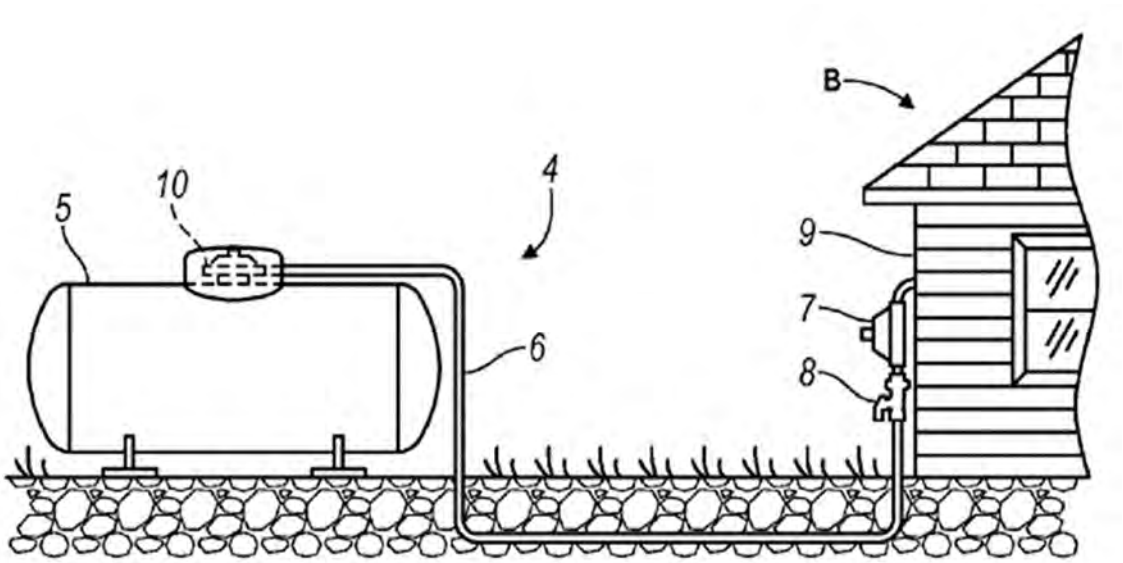


FIG. 1

Fig. 1 of Craig

[92]. An underground feed line 6 extends between the tank 5 and the building B for delivering the propane gas to the building. *Id*. at ¶[0007]. Because the propane must be maintained in the tank 5 at a high pressure, a pressure regulator 7 is connected to the feed line 6 at the building B for regulating and/or reducing the pressure of the propane gas entering the building when needed. *Id*. at ¶¶ [0003] and [0007]. The tank 5 can also include another pressure regulator 10 for supplying propane to the feed line 6 at a desired line pressure. *Id*. at ¶ [0003]. Union valve 8 is an assembly of a union part and a valve part. *Id*. at Fig. 2. A union valve 8 is mounted adjacent to the building pressure regulator 7 in the fluid flow path between the feed line 6 and the inlet of

the pressure regulator 7. *Id*. at ¶[0007]. Similar to the connecting apparatus of the '030 patent, the union valve 8 incorporates a rotatable connecting nut 12 for assembling the valve 8 between the feed line's inlet and the pressure regulator 7. *Id*. at ¶[0008]. The union valve 8 also has a shutoff feature that can be moved between ON and OFF positions to enable the propane gas being supplied to the building to be quickly turned off if needed. *Id*. at Abstract.

[93]. As seen in Fig. 2 of Craig (shown below annotated with color), the union part of the union valve 8 includes the end connector 11 (**lime**), the union end 13 (**green**), and the nut 12 (**blue**) which interconnects the end connector 11 and the union end 13. *Id*. at Fig. 2. The end connection 11 (**lime**) is associated with the inlet of the pressure regulator 7 (Fig. 1 above), and the union end 13 (**green**) is associated with the outlet of the feed line 6 (Fig. 1 above). *Id*. at Claim 1 and Fig. 2.

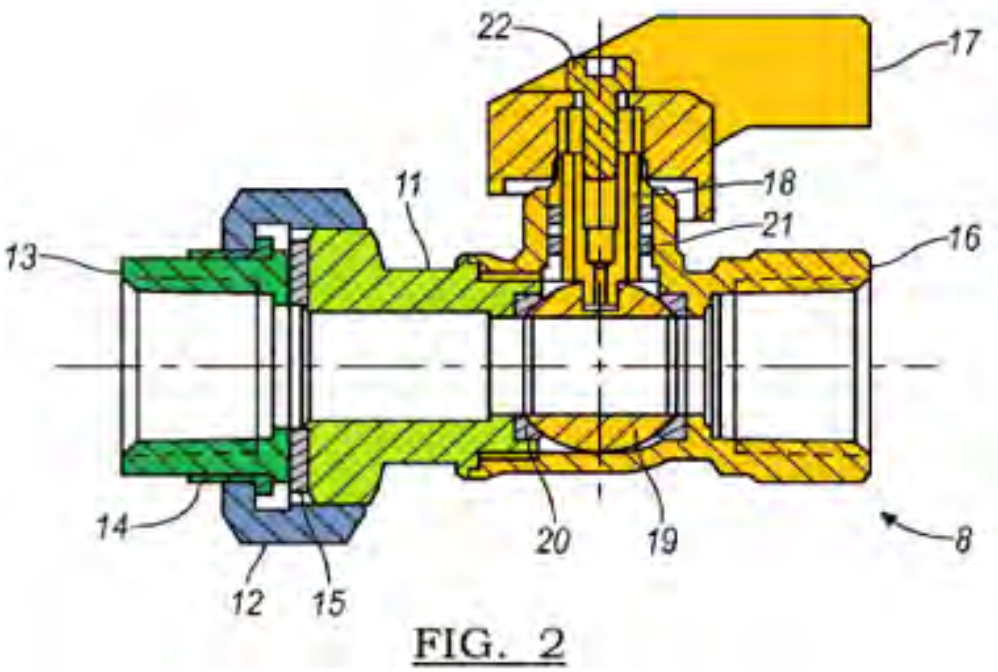


FIG. 2

Fig. 2 of Craig (shown annotated with color)

[94]. .The end connection 11 has an internal through-bore in fluid communication with the through-bore of union end 13. *Id*. at Fig. 2. The end connection 11 also has outer threads at one end that engage corresponding inner threads of the nut 12. *Id*. at ¶[0008]. The nut 12 retains the union end 13 in place "securely mounted" on the end connection 11. *Id*. A ring 14 is positioned on one end of the union end 13 and a gasket 15 is interposed between the end faces of the end connection 11 and union end 13, as seen in Fig. 2 above. *Id*. at

¶ [0008]. [1]

[95]. As seen in Fig. 2 above, the valve part (**orange**) of the union valve 8 includes a main body 16, and an external handle 17 connected to a valve stem 18 which rotates a ball 19 located within an internal cavity of the valve body 16. *Id*. at ¶[0009] and Fig. 2. The handle 17 is held in place by a spline connection and screw 22. *Id*. The ball 19 is designed to rotate 90 degrees between an open position, as shown in Fig. 2, to a closed position where all flow through the valve is blocked. *Id*.

2. AS SCHNEIDER HOOK-UPS CATALOG

[96]. The 2008 Hook-ups Catalog is Patent Owner's own catalog related to hook-ups for its Instrument Manifolds and Valves. *See* Ex. 1006 at pg. 1. The catalog qualifies as prior art under 35 U.S.C. § 102 because it was published in 2008, which is more than a year prior to the earliest possible effective filing date of the '030 patent. I found evidence of the publication of the Hook-ups Catalog in 2008 via the Wayback Machine®. *See* Ex. 1007. The 2008 Hook-ups Catalog (Ex. 1006) is a true and correct copy of the catalog I downloaded from the Wayback Machine®. Based on the information provided on the Wayback

[1] Craig discloses that the ring 14 and the gasket 15 of Craig can be made of a non-conductive material to provide a dielectric break in the system. *Id.* at Abstract and ¶[0004].

machine, I understand this catalog was publicly available at least as of October 9, 2008. *See* Ex. 1007.

[97]. The Hook-ups Catalog relates to the technical field of connecting apparatuses or "hook-ups", for mounting instrument valves/manifolds to a "process line" for pressure measurement including "differential pressure measurement" of the gas in the process line. *See* Ex. 1006 at pg. 1, 37, and 52.

[98]. The 2008 Hook-ups Catalog discloses several hook-up products including a PR08 hook-up (hereinafter "the PR08"). *See* Ex. 1006 at pg. 1 and 37. The PR08 is designed for connecting "pressure instruments" that are "mounted on racks or in enclosures etc." to a "process line". *Id*. As seen in the annotated figure below, the PR08 includes an "impulse line" 3 (**green**) that connects at one end to the process line via a "pressure tap" 1 and an "isolation valve" 2 and at the other end to a "pressure gauge valve" 7 (**lime**) via a "union nut" 4 (**blue**). *Id*.

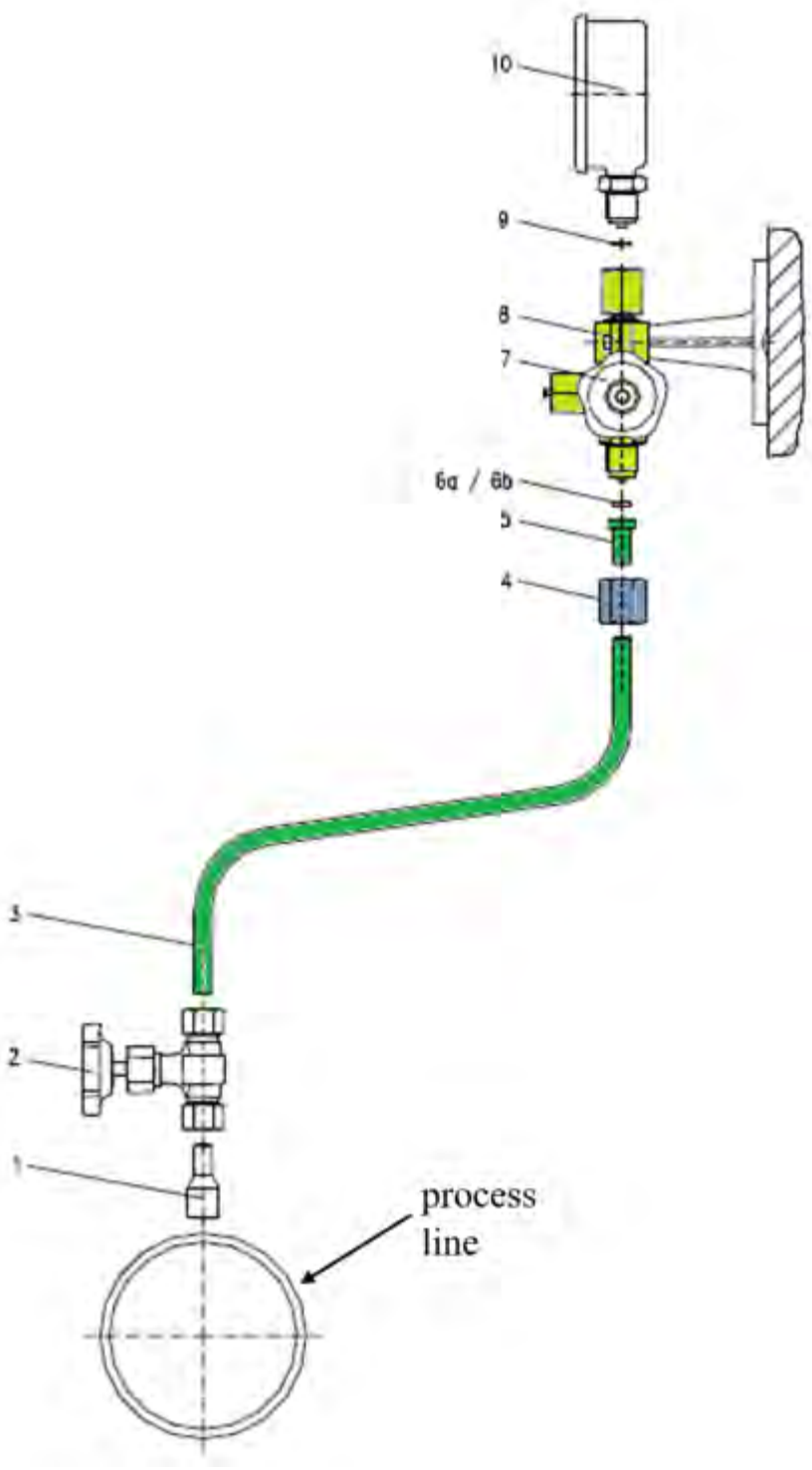


Figure from the 2008 Schneider Hook-Ups Catalog of exploded view of the PR08 (annotated with color and text)

[99]. The impulse line 3 includes a “nipple” 5 to facilitate engagement with the union nut 4. *Id*. The connection of the impulse line 3 and the valve 7 is sealed via the “sealing washer 6a/6b”. *Id*. The valve 7 connects to a measuring “instrument” 10 in a sealing manner via a “sealing washer” 9. *Id*. Below is an exploded front view of the PR08 showing the pressure gauge/measuring instrument above the valve (shown in **lime**). The valve 7 includes two outwardly extending side valves, as seen in the figure below. A POSITA would understand that at least one of the side valves is a shutoff valve (shown in **orange** in the figure below as the side valve on the left side of the valve 7 for illustrative purposes). A POSITA would understand that the other side valve (at the right side of the valve 7) is a type of bleed or relief valve.

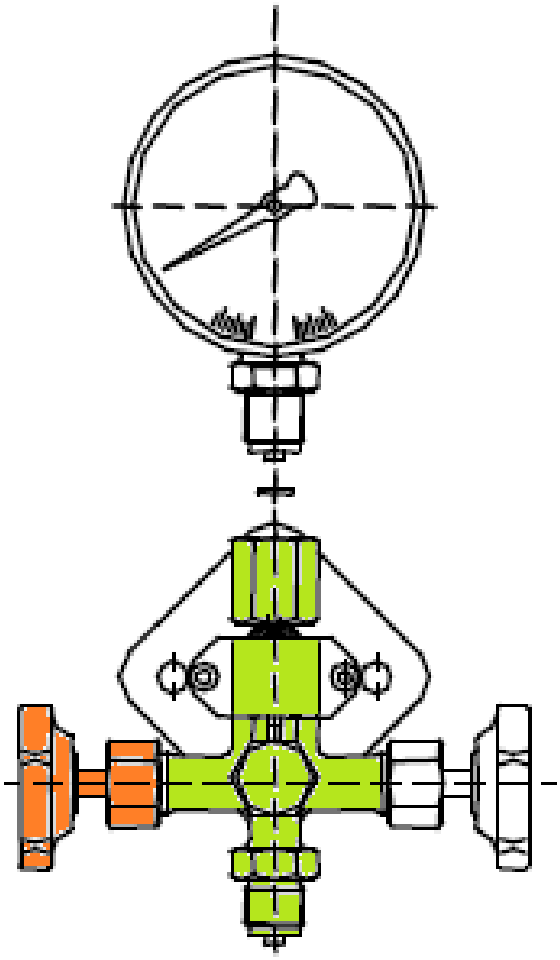
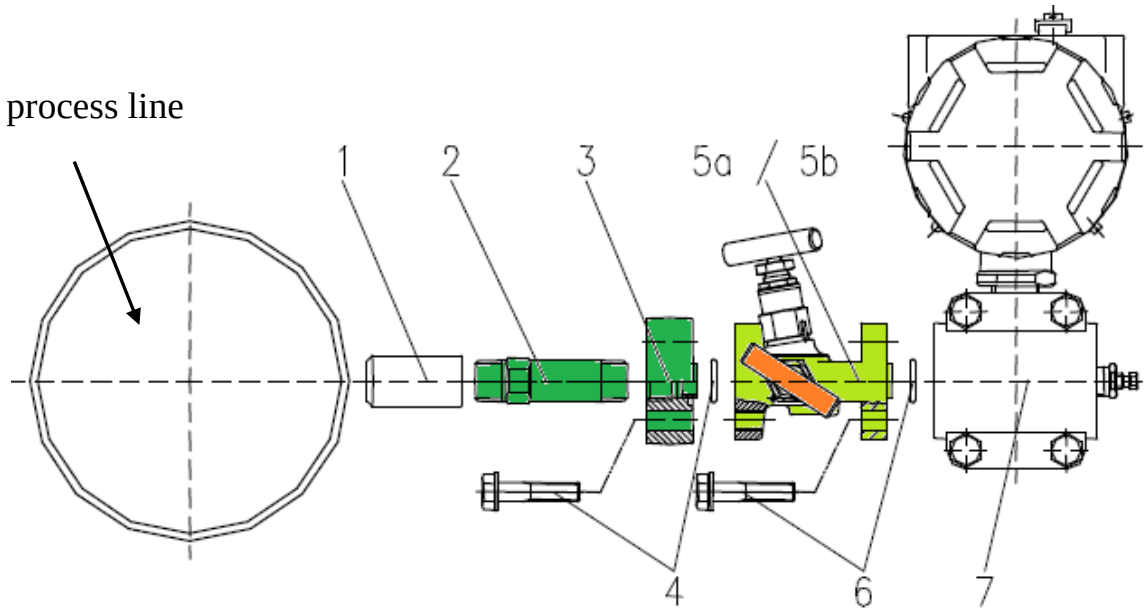


Figure from the 2008 Schneider Hook-Ups Catalog of a front view of the valve PR08 (annotated with color)

[100]. Another hook-up product (hereinafter "the DPD") disclosed in the Hook-ups Catalog is designed for "directly" mounting a differential pressure measurement instrument on the process line, as seen in the figure below. *Id*.

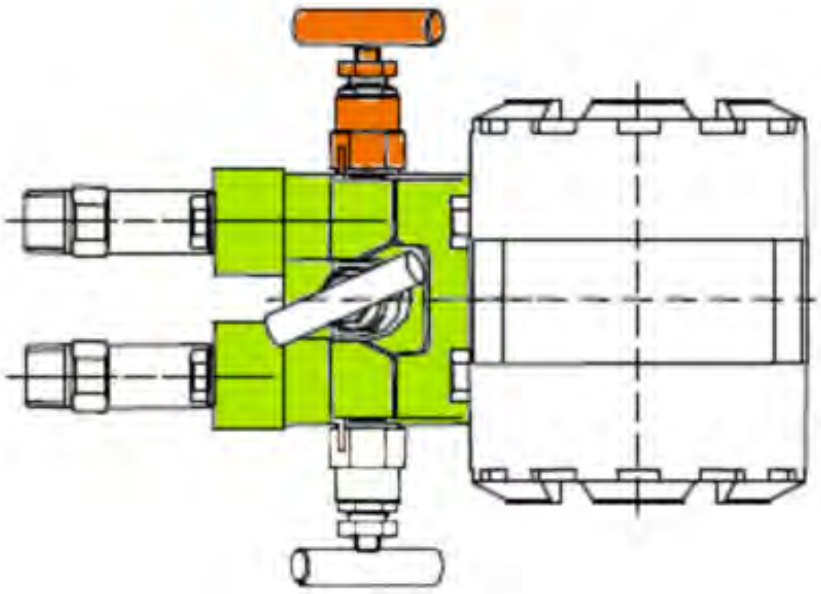


Exploded view of the DPD from the 2008 Hook-Ups Catalog

[101]. This hook-up product includes a pressure tap 1, a hex nipple 2 (**green**), a flange 3 (**green**), a valve block 5a/5b (**lime**), sealing rings 4 and 6, and a pressure instrument 7. *Id*. A cross-section of a process line (or pipeline) on which the differential pressure instrument is mounted is shown to the left of the pressure tap 1 in the view above. *Id*. An assembled view of the hook-up product is shown below.

[102]. The outer thread at the lower end of the hex nipple 2 is an NPT (National Pipe Thread) which is the most commonly used for process line attachments and is found in the Schneider catalogs. An NPT is a tapered or

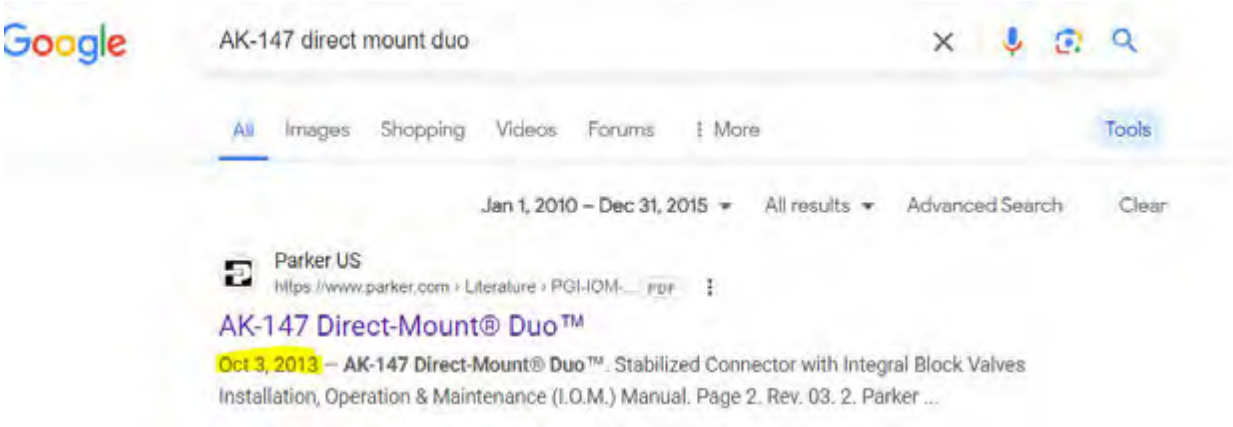
conical type of thread.



Assembled elevational view of the DPD from the 2008 Schneider Hook-Ups Catalog shown without the process line

3. PARKER DIRECT-MOUNT ® DUO™ I.O.M. MANUALS

[103]. The Parker Direct-Mount® Duo™ I.O.M. Manual, dated October 2013, (hereinafter "Parker 1") and The Parker Direct-Mount® Duo™ I.O.M. Manual ("Parker-2) are manuals for installation, operation, and maintenance of block valves. *See* Ex. 1010 at pg. 1 ("Stabilized Connector with Integral Block Valves Installation, Operation & Maintenance (I.O.M.) Manual); Ex. 1011. Parker 1 has a Copyright date of 2013. Ex. 1010. The below screenshot of a Google search for Parker-1 shows that it was publicly available as of October 2013.



The tool described in Parker-1 is the AK-147 Direct Mount Duo. That exact same tool with identical components is also described in Parker-2. Parker-2 has a Copyright date of 2013. I also found evidence of the publication of Parker 2 as a catalog in March 2014 via the Wayback Machine. *See* Ex. 1011. Parker-2 is a true and correct copy of the catalog I downloaded from the Wayback Machine®. Based on the information provided on the Wayback machine, I understand this catalog was publicly available at least as of March 27, 2014. *See* Ex. 1012.

[104]. Parker-1/Parker-2 relate to the technical field of connecting apparatuses for "mounting block valves to an "orifice fitting" of a pipeline for pressure measurement of the gas in the pipeline. *See* Ex. 1010 at Fig. 2 and pgs. 1-7 ("2.1 Installation without dielectric isolators to Jr./Sr. Orifice Fittings or Other"); Ex. 1011. The connecting apparatus of Parker-1 includes a "stabilized connector" (shown in **green** in Figure 2 below), an "integral block valve"

(shown in **lime** in Figure 2 below), and a "union nut" (shown in **blue** in Figure 2 below) for interconnecting the stabilized connector and the integral block valve. *See* Ex. 1010 at Fig. 2 and pgs. 4-9.

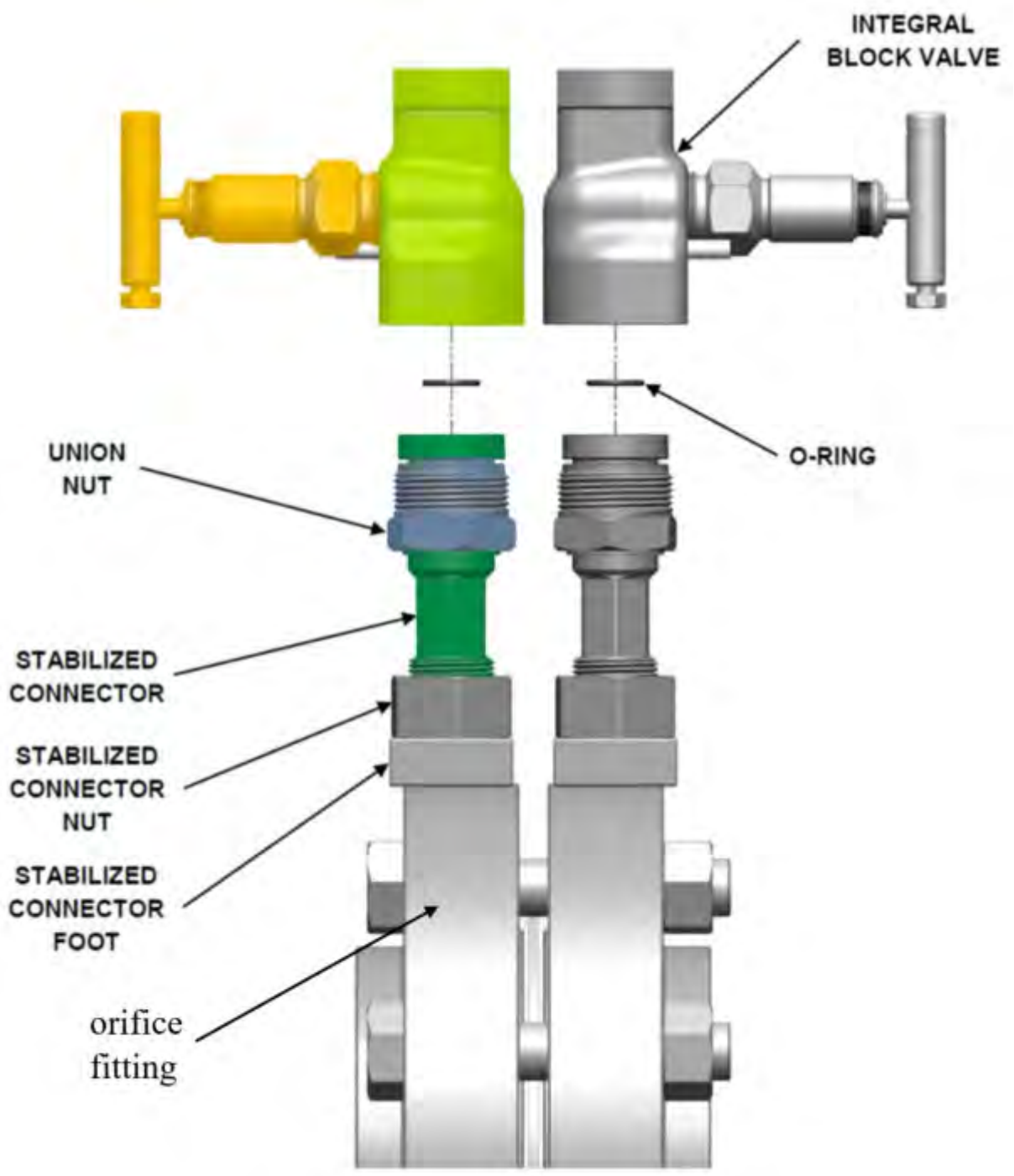


Figure 2

*Figure 2 of Parker-*1 *(annotated with text and color)*

[105]. An o-ring is provided between the connection of the stabilized connector and the integral block valve, as seen in Figure 2 above. The o-ring of Parker-1 is specifically positioned in grooves at the connection or end face of the stabilized connector to enable a “face seal”, which is a technical term for this type of seal. A shutoff valve (shown in **orange** in Figure 2 above) is provided with the integral valve block that extends outwardly therefrom at a right angle. Figure 4 of Parker-1 (shown below with annotations) is a side view showing the stabilized connector threadably mounted to the orifice fitting and showing the block valve with an outer flange at its upper end on which a measuring instrument can be attached.

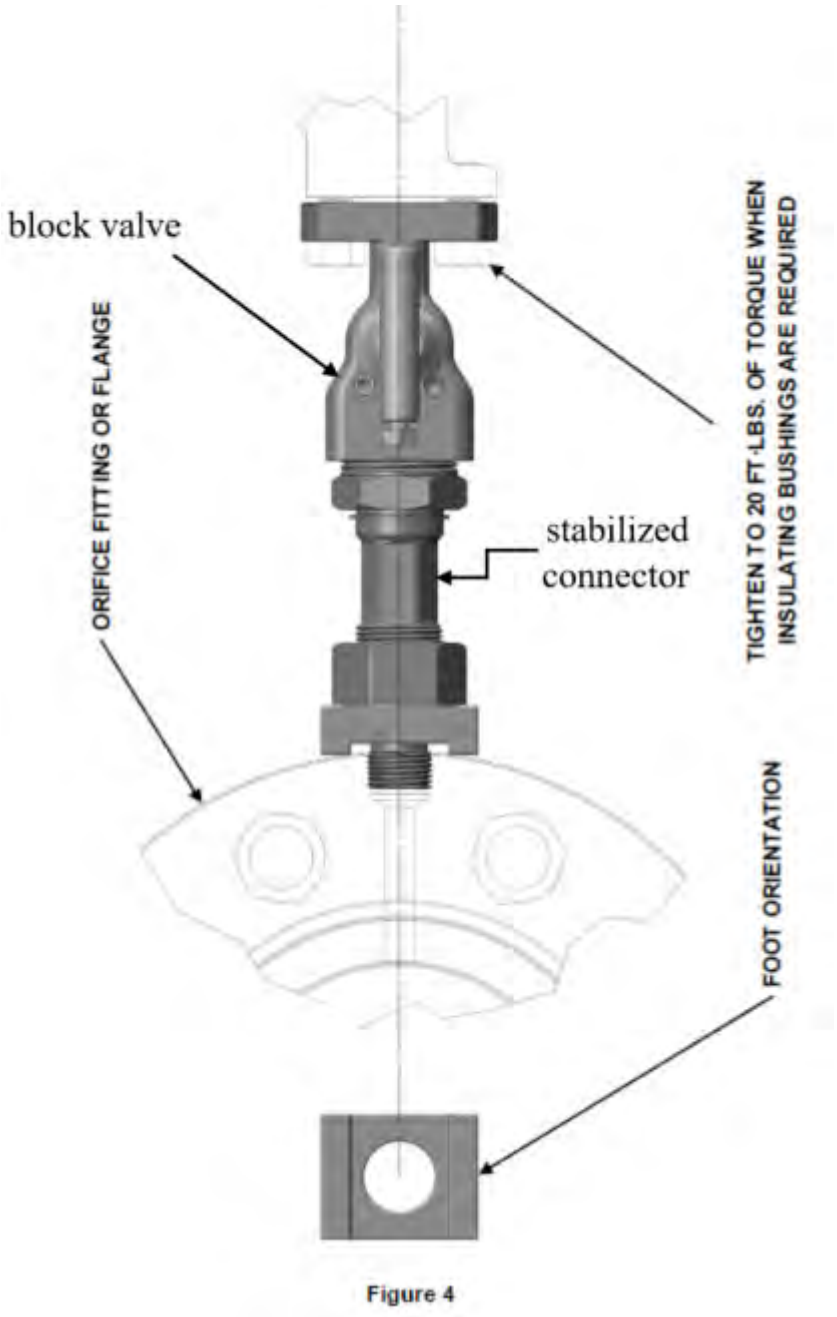


Figure 4 of Parker-1 (annotated with text)

[106]. The stabilized connector mounts directly to the orifice fitting via a "stabilized connector nut" and a "stabilized connector foot", as seen in Figures 2

and 4. *Id.* And the integral block valve is configured to connect to a pressure measuring instrument via the outer flange (that has "slotted holes to accommodate 2-1/8" – 2-1/4" bolt spacing), as seen in Figure 5 of Parker-1, shown below.

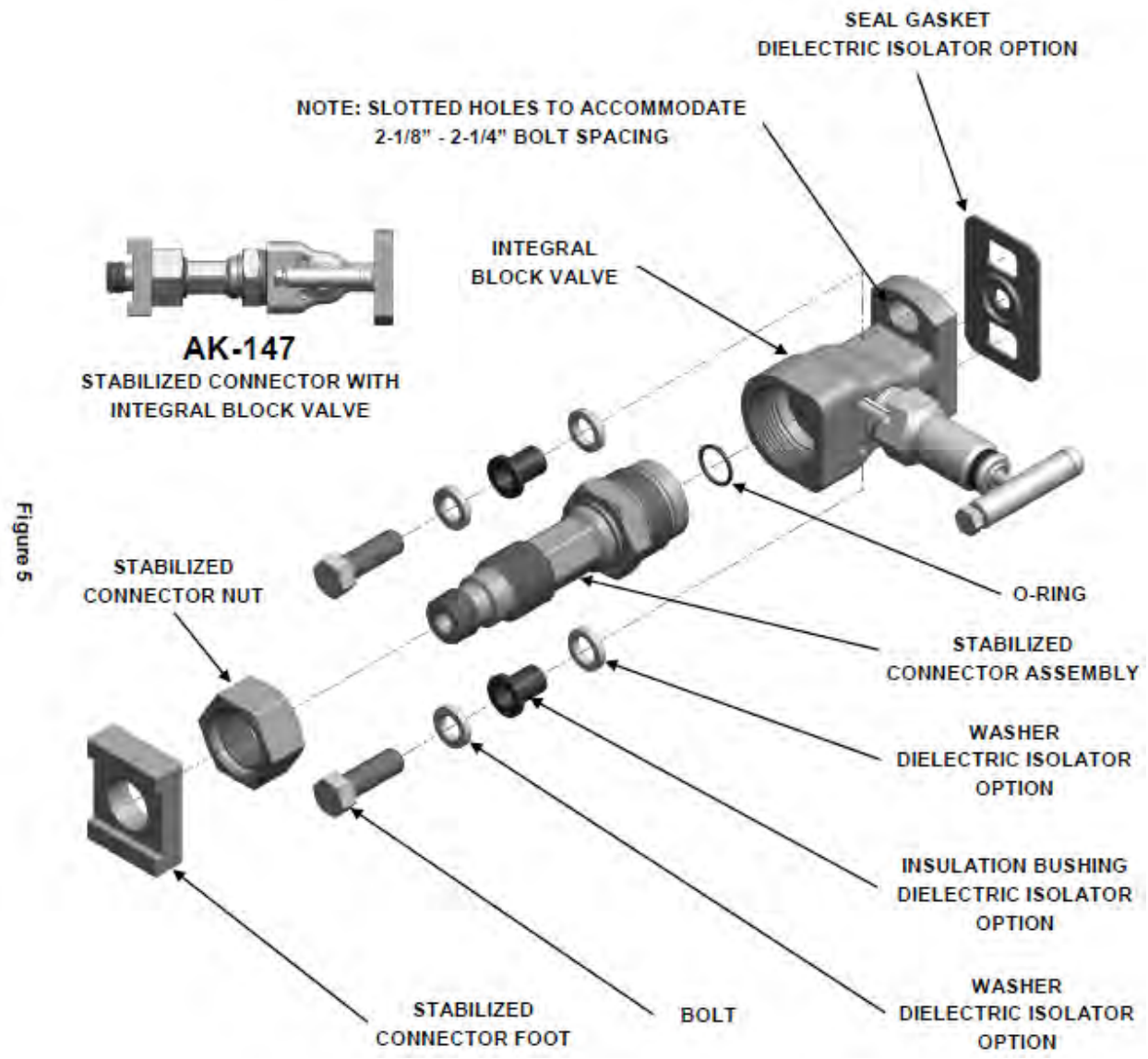


Figure 5 of Parker-1

The components illustrated above in Figs. 2, 4, and 5 of Parker-1 are identical to those in Parker-2. *Compare* Ex. 1010, Figs. 2, 4, and 5, *with* Ex. 1011.

4. AS SCHNEIDER 2012 ACCESSORIES CATALOG

[107]. The 2012 Accessories Catalog is also Patent Owner's own catalog and it relates to its Instrumentation Products and accessories. *See* Ex. 1008 at pg. 1. I found evidence of the publication of the Instrumentation Products Catalog in 2008 is evidenced by the Wayback Machine. *See* Ex. 1009. The 2012 Accessories Catalog (Ex. 1008) is a true and correct copy of the catalog I downloaded from the Wayback Machine®. Based on the information provided on the Wayback machine, I understand this catalog was publicly available at least as of October 9, 2008. *See* Ex. 1009.

[108]. The 2012 Accessories Catalog relates to valves, fittings, and manifolds associated with pressure measurement instruments. *See* Ex. 1008 at pg. 1. Notably, the 2012 Accessories Catalog includes an accessory product that is a swivel gauge adapter. *Id*. at pg. 111. Like the connecting nut of the '030 patent, the swivel gauge adapter employs a union nut designed to interconnect first and second connecting devices. *Id*. For example, the "Type 2b" swivel gauge adapter of the 2012 Accessories Catalog includes a union nut (**blue**) that has an inner flange for engaging the first connecting device (**green**) and inner

threads for engaging the second connecting device (**lime**), as seen in the figure below annotated with color. *Id*.

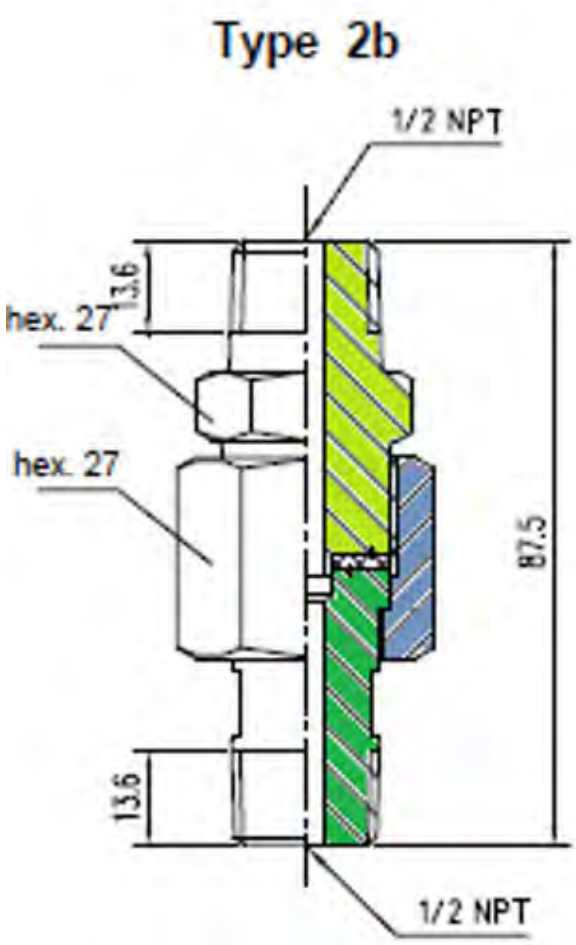


Figure from 2012 Accessories Catalog
(shown annotated with color)

[109]. More specifically, the inner flange of the nut engages an outer flange located at an upper region of the first connecting device, and the inner threads of the nut engage outer threads at a lower region of the second connecting device. *Id*. A sealing ring or gasket is provided between the

respective end faces of the first and second connecting devices, as seen in the figure above. *Id*.

VIII. OPINIONS ON CLAIM CONSTRUCTION

[110]. I have also been informed that the United States Patent and Trademark Office and the Patent Trial and Appeal Board ("PTAB") only construe claims when it is necessary to resolve an underlying controversy between a petitioner and the patent owner. Given the disclosure of the prior-art references asserted by Petitioner, it is my opinion that none of the claim terms in the Challenged Claims require construction to resolve the patentability determinations presented in the Petition.

IX. OPINIONS ON VALIDITY

[111]. In my opinion, all of the features and elements of the Challenged Claims were well known in the art as of the Effective Filing Date. As I explain in more detail below, in my opinion, the Challenged Claims are anticipated by and/or obvious in view of one or more of the four prior-art references summarized above.

1. Claims 1, 2, 6 and 7 are Anticipated by Craig.

[112]. Craig teaches every element of independent claim 1 and dependent

claims 2, 6, and 7 of the ’030 patent. As discussed in more detail below, each and every element of independent claim 1 is identically found in Craig, including a connecting apparatus that is the union connection valve 8, used in association with a pressurized gas feed line. *See* Ex. 1005 at ¶[0007] and [0008]. Each element of independent claim 1 followed by each of dependents 2, 6, and 7 is listed below with the corresponding teaching in Craig.

[113]. Craig discloses a connecting apparatus comprising a union valve 8 that has a first connecting device 13 (shown in **green** in annotated Fig. 2 below), a second connecting device 11 (shown in **lime** in annotated Fig. 2 below), and a connecting nut 12 (shown in **blue** in the annotated Fig. 2 below). *Id.* at ¶¶[0007] and [0008] and Fig. 2.

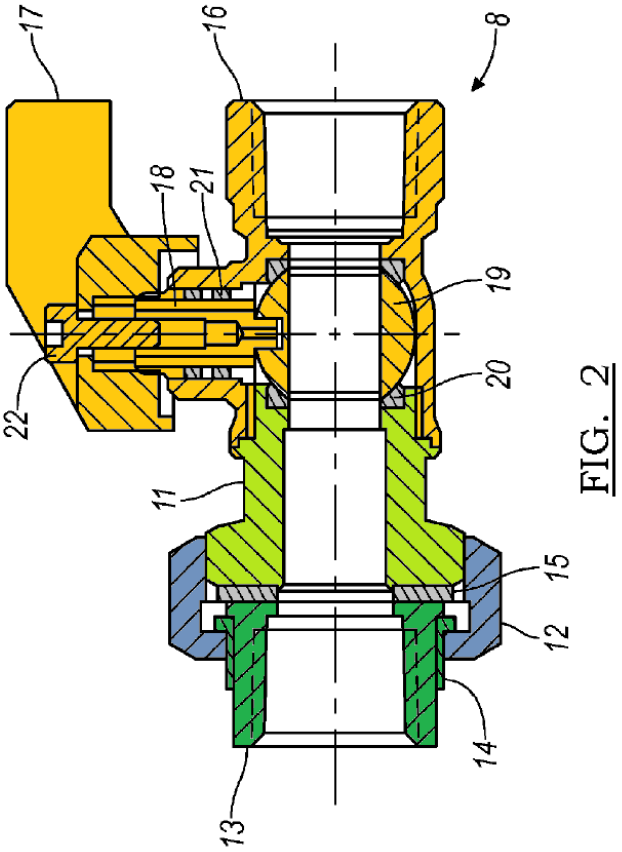


Fig. 2 of Craig (annotated with color and rotated counter-clockwise 90º)

[114]. For ease of comparison, the union valve assembly of Fig. 2 of Craig is shown above rotated counter-clockwise 90 degrees (which is rotated 180 degrees from the orientation of the union valve assembly shown in Fig. 1). A POSITA would understand that the union valve assembly of Craig could be rotated and work in either orientation.

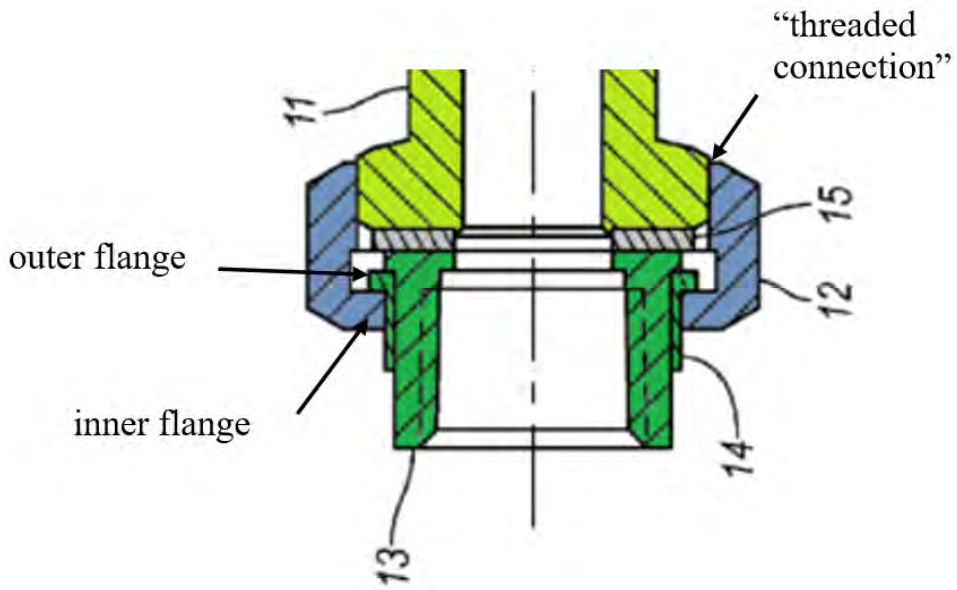
[115]. Craig teaches a "threaded union end 13" which is a first connecting device that has a through-opening, as seen in Fig. 2. *Id*. at ¶[0008]. As

explained above, the pipeline/metering orifice device is not part of this claim limitation 1[a]. The union end 13 is a threaded end that is connectable to a pipeline in a sealing manner.

[116]. Craig teaches an "end connection 11" which is a second connecting device that has a through-opening complementary to the through-opening of the union end 13 (first connecting device), as seen in Fig. 2. A POSITA would understand that the end connection 11 of Craig necessarily provides a sealing connection to a valve by virtue of the assembly of the union valve 8 in which the end connection 11 of the union part connects to the main body 16 and also seals to the ball 19 of the valve part of the union valve 8. More specifically, the main body 16 of the union valve 8 surrounds the end of the end connection 11, thereby inherently providing a sealing connection between the end of the end connection 11 and the valve . The union valve 8 would not work for its intended purpose if that was not a sealing connection. A POSITA would recognize that there must be sealing to avoid leaks and ensure gas flow through the union valve 8. Also, the union valve 8 can shutoff or seal off the gas flow to the pressure regulator by rotating the ball 19 via the stem 18 and valve handle 17. *Id*. at ¶[0009].

[117]. Craig teaches a nut 12 which is a connecting unit that connects the

union end 13 (first connecting device) with the end connection 11 (second connection device). *Id* at ¶[0008]. The nut 12 provides a sealing connection between the two connecting devices 11 and 13 in the same manner as taught by the ’030 patent. More specifically, as seen in Fig. 2 below, the sealing connection is created when the inner flange of the nut 12 and the outer flange of the union end 13 of the first connecting device are interlocked, along with the threaded engagement between the nut 12 and the end connection 11 of the second connecting device. *Id*. at ¶[0008] and Fig. 2.



Partial view of Fig. 2 of Craig (annotated with color and text)

[118]. The connecting apparatus of Craig also includes a rubber gasket 15 between the end-face surfaces of the union end 13 and the connection 11. *Id*. A POSITA would understand that such a rubber gasket 15 would inherently

provide sealing between the two connecting devices 11 and 13 when clamped together by tightening the nut 12.

[119]. The valve part of the union valve 8 of Craig, which is connected to the end connection 11 (second connecting device), includes a shutoff feature comprising the handle 17, the stem 18, and the rotating ball 19, which can be moved between ON and OFF positions. *Id*. at ¶[0009] and Claim 1. The axis of the shutoff feature extends obliquely with respect to the longitudinal axis of the connecting apparatus of Craig because, as seen in Fig. 2 (shown annotated below), at least the stem 18 thereof extends at a right angle with respect to the longitudinal axis L of the assembled union valve 8, the end connection 11, and the union end 13. *Id*. at Fig. 2.

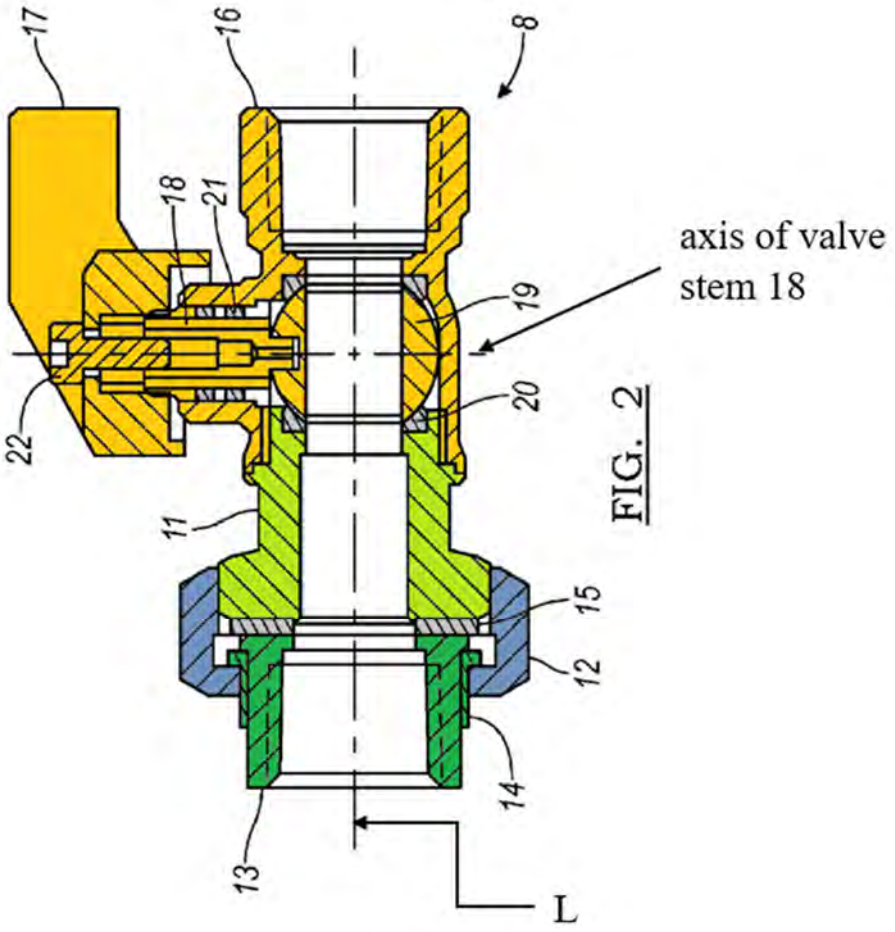


Fig. 2 of Craig (annotated with text and color)

[120]. Patent Owner defines extending obliquely as including extending at a right angle. As such, I interpret the term "obliquely" as being the same as extending at a right angle.

[121]. The nut 12 of Craig retains the union end 13 (first connecting device) "securely mounted" on the end connection 11 (second connecting device), thereby interconnecting the two connecting devices 11 and 13. *Id*. at

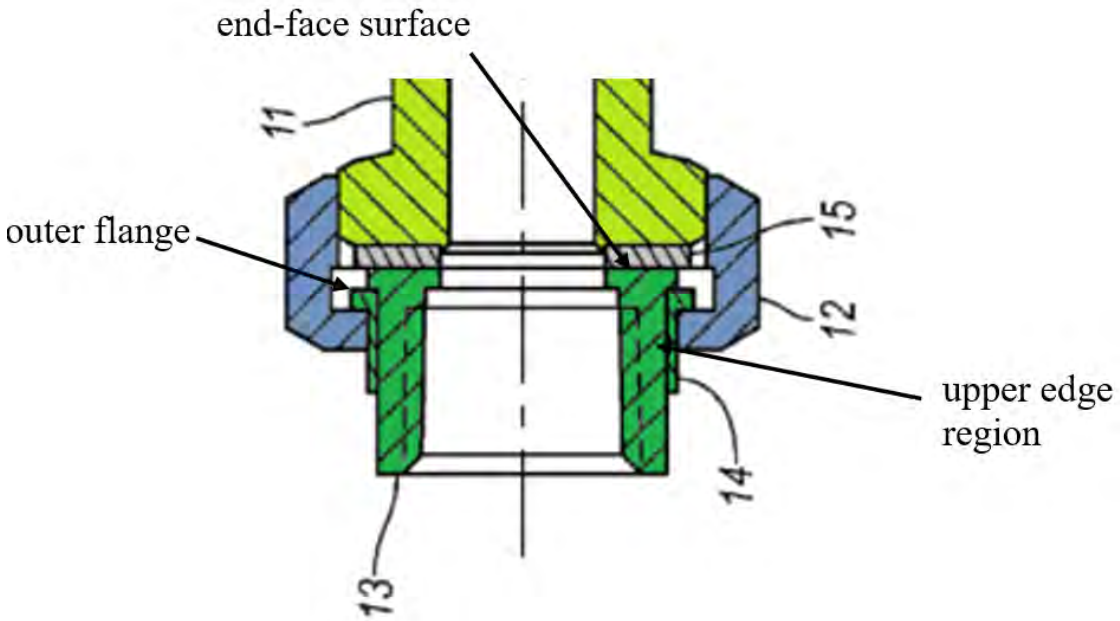
¶[0008]. The nut 12 interconnects the two connecting devices 11 and 13 with "sealing effect" in the same manner as taught by the '030 patent. The sealing effect is provided by the interlocking of the inner flange of the nut 12 and the outer flange of the union end 13 (first connecting device), along with the threaded engagement between the nut 12 and the end connection 11 of the second connecting device causing the respective end faces of the union end 13 and the end connection 11 to be clamped together and seal. *Id*. at ¶[0008] and Fig. 2.

[122]. In addition, the connecting apparatus of Craig includes a gasket 15 between the end-face surfaces of the union end 13 and the connection 11. *Id*. A POSITA would understand that such a gasket 15 would inherently provide sealing between the two connecting devices 11 and 13 when clamped together by tightening the nut 12.

[123]. A POSITA would recognize that nut 12 of Craig sealingly interconnects the union end 13 (first connecting device) with the end connection 11 (second connecting device) by rotation of the nut 12; that is by solely rotating the nut 12 to threadably engage the end connection 11.

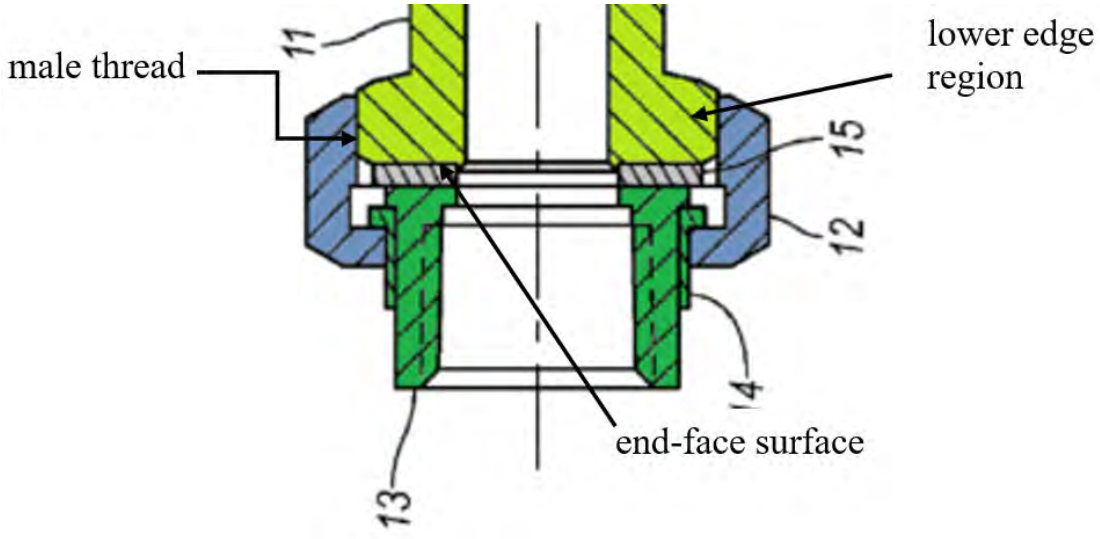
[124]. As shown in Fig. 2 below, Craig teaches that the union end 13 (first connecting device) of Craig has a ring 14 at an end region thereof, such as an

upper edge region, and the ring 14 includes an outwardly pointing outer flange. *Id*. at ¶[1008] and Fig. 2. Although the union end 13 and the dielectric ring 14 are two pieces assembled together, a POSITA would understand that such is equivalent to a single integral construction. A POSITA would also recognize that the union end 13 (first connecting device) of Craig has an end-face sealing surface (as seen in annotated Fig. 2 below) that can seal with an end-face surface of the end connection 11 (second connecting device) when the nut 12 is tightened by virtue of the gasket 15. A POSITA would understand that such a gasket 15 would inherently provide sealing between the end-face sealing surfaces of the first and second connecting devices 11 and 13 when clamped together by screwing the nut 12 on to the end connection 11 (second connecting device).



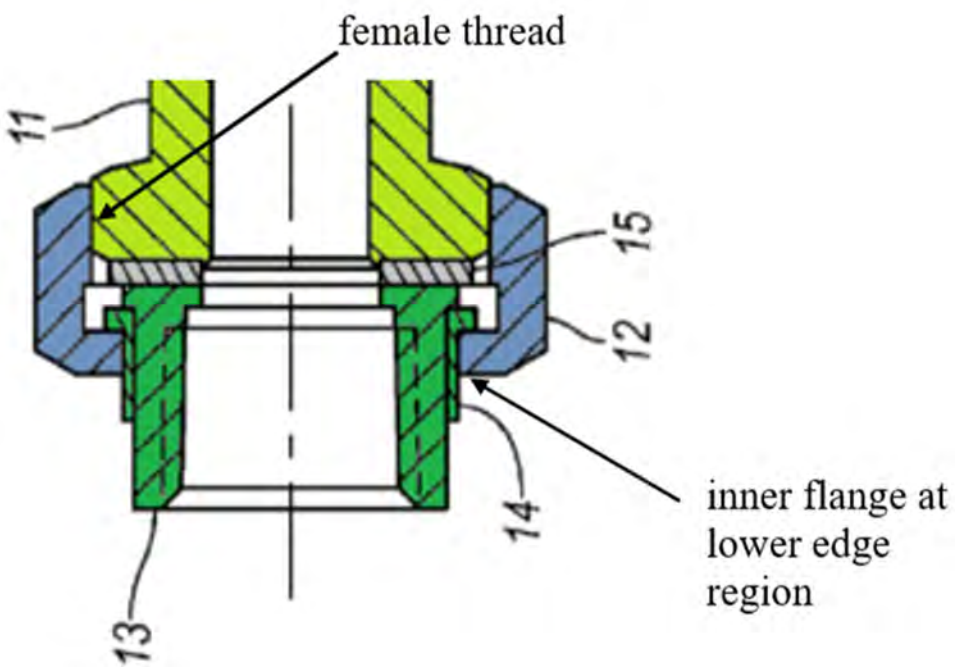
Partial view of Fig. 2 of Craig (annotated with color and text)

[125]. Craig teaches a "threaded connection" between the end connection 11 (second connecting device) and the nut 12. *Id*. at ¶[0008]. As shown in Fig. 2 below, the nut 12 threads onto the end of the end connection 11. *Id*. at Fig. 2. As such, a POSITA would recognize that the end connection 11 necessarily has a male or outer thread which engages an inner thread of the nut 12. And, the thread of the end connection 11 (second connecting device) is at the lower end region thereof, as seen in Fig. 2 below. *Id*. at Fig. 2. A POSITA would also recognize that the end connection 11 (second connecting device) of Craig has an end-face sealing surface (shown below in annotated Fig 2). that can seal with the end-face surface of the union end 13 (first connecting device) when the nut 12 is tightened by virtue of the gasket 15. *Id*. at ¶[1008] and Fig. 2.



Partial view of Fig. 2 of Craig (annotated with color and text)

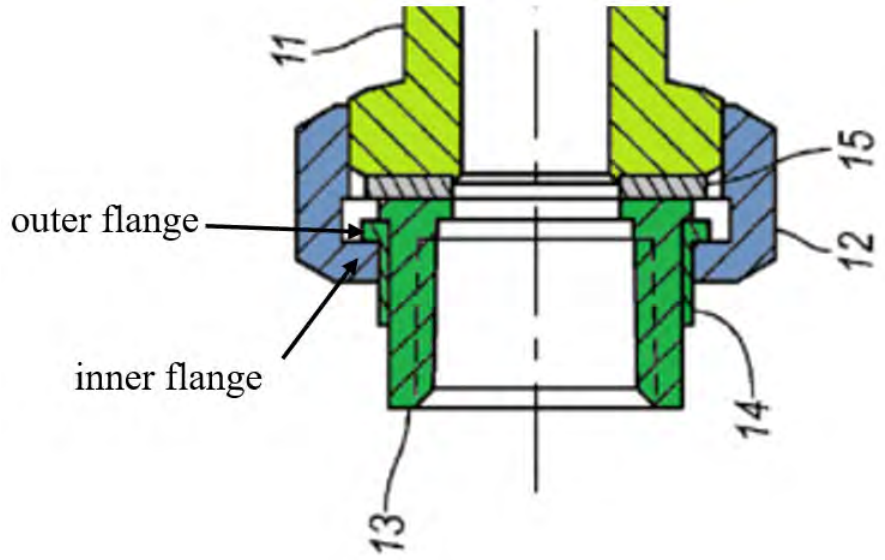
[126]. As shown in Fig. 2 below, the nut 12 of Craig necessarily has a female thread. Craig teaches a "threaded connection" between the nut 12 and the end connection 11 (second connecting device). *Id*. at ¶[0008]. The nut 12 of Craig includes an inwardly pointing inner flange (see annotated Fig. 2 below) arranged at second connecting device 11's lower edge region. A POSITA would understand that because the nut 12 threads onto the end connection 11, the nut 12 necessarily has a female or inner thread on its inwardly pointing inner flange which engages the male or outer thread of the end connection 11.



Partial view of Fig. 2 of Craig (annotated with color and text)

[127]. As shown in Fig. 2 below, Craig discloses the outer flange of the ring 14 of the union end 13 (first connecting device) fits behind the inner flange

of the nut 12.



Partial view of Fig. 2 of Craig (annotated with color and text)

[128]. A POSITA would recognize that the nut 12 taught by Craig interconnects the two connecting devices 11 and 13 with "sealing effect" in the same manner as taught by the '030 patent. As shown in Fig. 2 above, the sealing effect is provided by means of the inner flange of the nut 12 interlocking with the outer flange of the union end 13 (first connecting device), along with the threaded engagement between the nut 12 and the end connection 11 or the second connecting device. Ex. 1005 at ¶[0008]. The threaded engagement (or "threaded connection") is accomplished by screwing the nut 12 onto the end

connection 11 (second connecting device), as seen in Fig. 2. *Id*. And screwing the nut necessarily brings the two end-face sealing surfaces together to make the seal. A POSITA would understand that because the nut 12 is screwed onto the end connection 11, the nut 12 necessarily has the female or inner thread and the end connection 11 (second connecting device) has the male or outer thread of the threaded engagement between the two. *Id*.

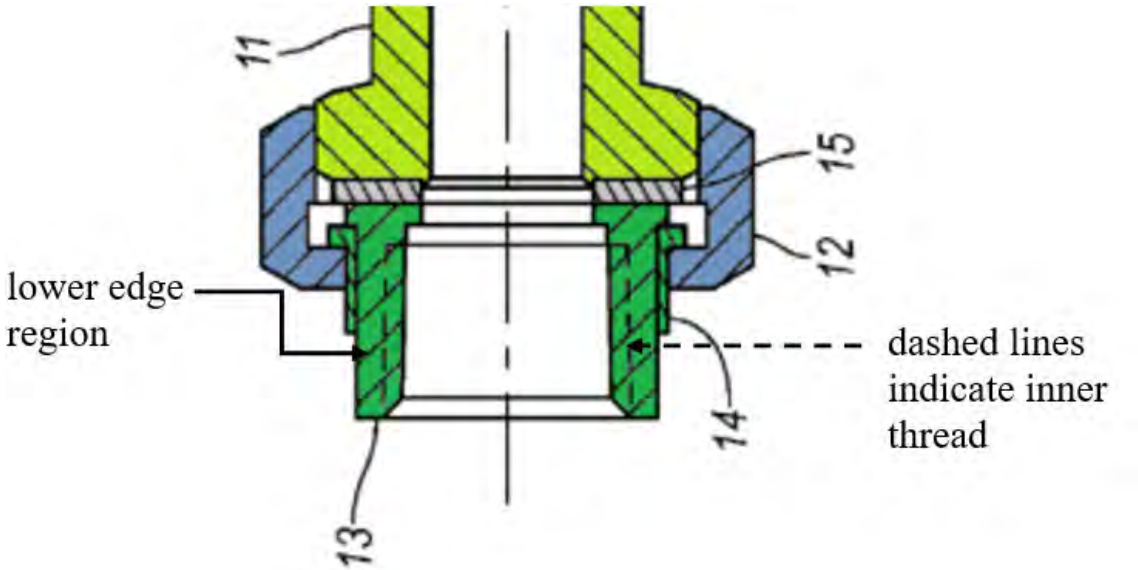
[129]. Notably, Craig teaches providing a gasket 15 between the end-face surfaces of the union end 13 and the connection 11 or first and second connecting devices, respectively. *Id*. A POSITA would understand that such a gasket 15 would inherently provide sealing between the end-face sealing surfaces of the first and second connecting devices 11 and 13 when clamped together by screwing the nut 12 on to the end connection 11 (second connecting device).

[130]. A POSITA would recognize that the outer flange of the ring 14 of the union end 13 (first connecting device) and the inner flange of the nut 12 taught by Craig are provided in an encompassing manner because each extends circumferentially around the first connecting device to accomplish the connection between the union end 13 and the end connection 11.

[131]. Craig teaches providing a gasket 15 between the end-face surfaces

of the union end 13 and the connection 11 or first and second connecting devices, respectively. *Id*. at ¶[0008]. A POSITA would understand that such a gasket 15 would inherently provide a sealing means between the end-face surfaces of the two connecting devices 11 and 13 when clamped together by screwing the nut 12 on to the end connection 11 (second connecting device).

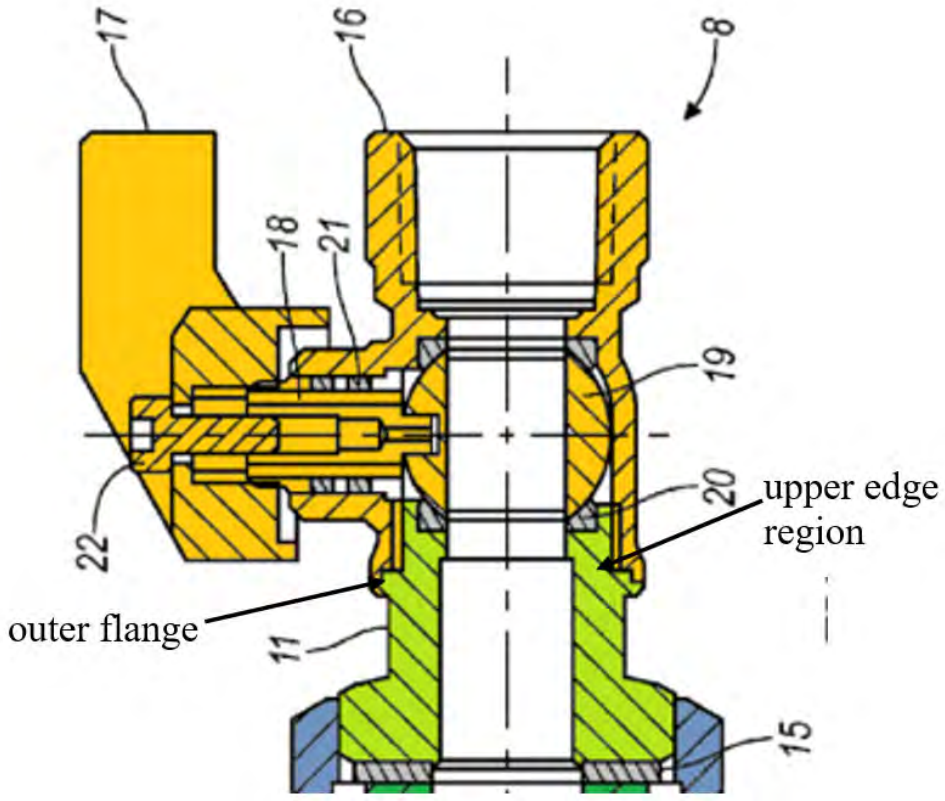
[132]. Regarding claim 2, Craig teaches that the union end 13 (first connecting device) is a "threaded" union end 13. *Id*. at ¶[0008]. A POSITA would recognize that the dashed lines illustrated in Fig. 2 below show that the thread of the union end 13 extends to the end, or lower edge region, of the union end 13. *Id*. at Fig. 2.



Partial view of Fig. 2 of Craig (annotated with color and text)

[133]. Regarding claim 6, Fig. 2 of Craig (partial view reproduced below

with annotations) shows that the end connection 11 (second connecting device) has an outer flange at the upper end region thereof, as seen in Fig. 2 below. *Id*. at Fig. 2.



Partial view of Fig. 2 of Craig (annotated with text and color)

[134]. As seen in Fig. 2 above, the axis of the handle 17 and the stem 18 of the union valve 8 is at a right angle to the longitudinal axis of the connecting apparatus of Craig. *Id*. at Fig. 2.

2. Claims 1 and 7 are Anticipated by the 2008 Schneider Hook Ups Catalog

[135]. The 2008 Schneider Hook-Ups Catalog includes the PR08

("PRO8") designed for connecting pressure instruments to a process line, which teaches all of the elements of independent claim 1 and dependent claims 6 and 7 of the ´030 patent. As discussed in more detail below, the PR08 is a connecting apparatus that includes a union nut or connecting unit for interconnecting first and second connecting devices with sealing effect, where the first connecting device is connectable to a process/pipe line and the second connecting device is sealingly connected to a pressure measuring instrument, as recited in independent claim 1. *See* Ex. 1006 at 37.

[136]. As shown in the figure below, the PR08 as shown in the 2008 Schneider Hook-Ups Catalog is a connecting apparatus that comprises a "union nut" 4 (shown in **blue** in the annotated figure below) which interconnects a first connecting device (shown in **green** in the annotated figure below), that is the impulse line 3, with a second connecting device (shown in **lime** in annotated figure below), that is the valve 7. *See* Ex. 1006 at 37. As also seen in the figure below, the impulse line 3 connects to the process line and the valve 7 connects to the pressure measuring instrument 10, like in the `030 patent.

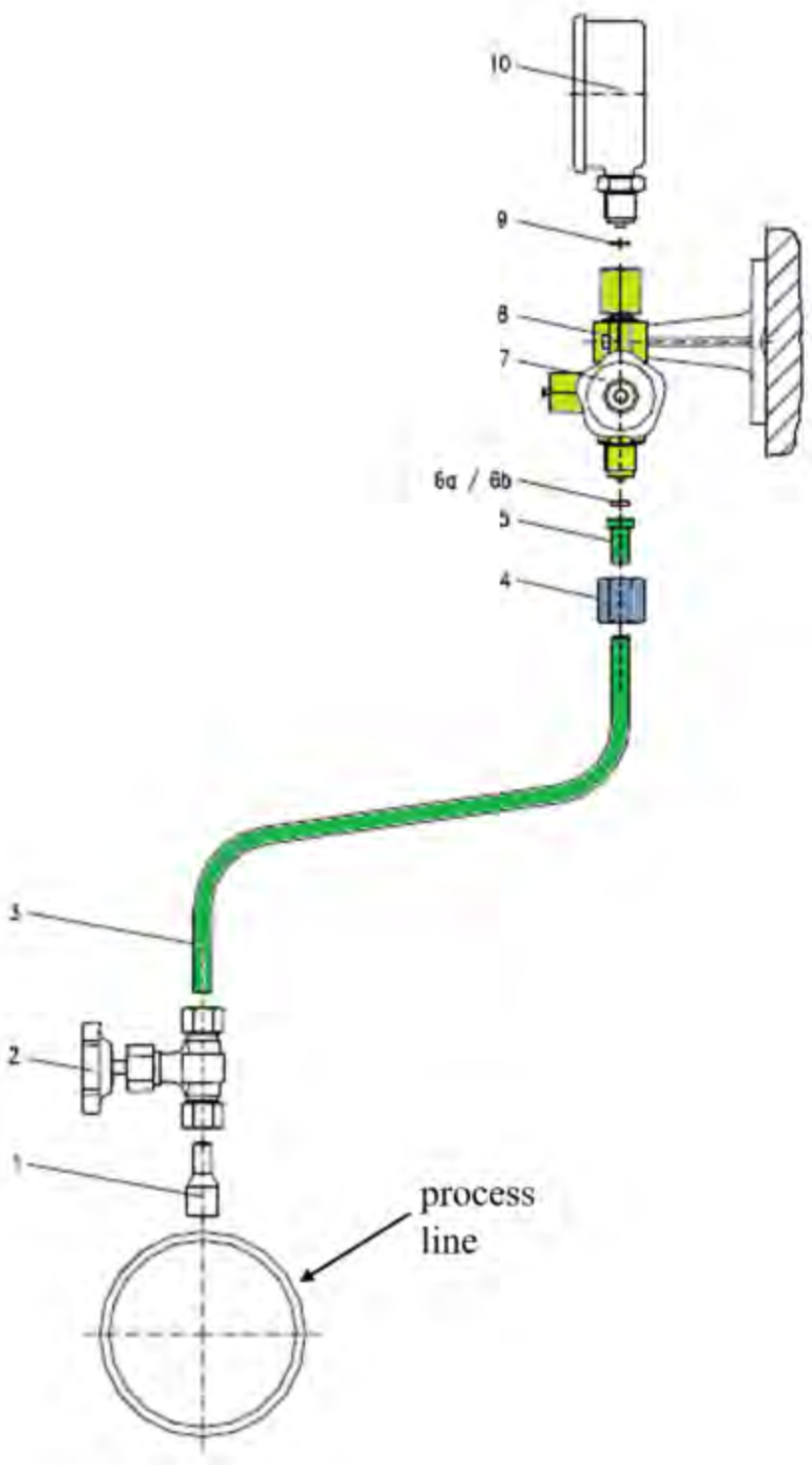


Figure from the 2008 Schneider Hook-Ups Catalog of exploded view of the PR08 (annotated with color and text)

[137]. As mentioned above, the PR08 includes a first connecting device that is the impulse line 3 (shown in **green** in the annotated figure above),which connects to the process line at its lower end and has a "nipple" 5 at its upper end for assembly to the union nut 4. *See* Ex. 1006 at pg. 37. Although the nipple 5 is a separate piece that is attached to the end of the impulse line 3, a POSITA would understand that such is equivalent to a single integral construction. In any event, the claim does not require the first connecting device be a single integral construction. The impulse line 3, which connects to the process line, inherently includes a through-opening in a longitudinal direction necessary for fluid communication from the process line to the valve 7 and ultimately to a pressure measuring instrument.

[138]. As mentioned above, the PR08 includes a second connecting device that is the valve 7 (shown in **lime** in the figure above). *See* Ex. 1006 at pg. 37. A POSITA would understand that the structure of the valve 7 is a connecting device because it connects at its lower end to the nut and its upper end to the instrument 10.

[139]. A POSITA would recognize that the valve 7 provides a sealing connection to a measuring instrument, that is instrument 10, via a "sealing washer" 9 (shown in the figure above). *See* Ex. 1006 at pg. 37. The valve 7

inherently includes a through-opening in a longitudinal direction for fluid communication with both the impulse line 3 and the instrument 10 necessary for conducting the pressure measurement by the instrument 10. *Id*.

[140]. The union nut 4 of the PR08 (shown in **blue** in the figure above) is a connecting unit that connects the impulse line 3 (first connecting device) which includes nipple 5, with the valve 7 (second connecting device). *See* Ex. 1006 at pg. 37. A POSITA would recognize that the union nut 4 of the PR08 provides a sealing connection to the impulse line 3 and the valve 7 (i.e. the first and second connecting devices) via the ”sealing washer” 6a/6b (shown in the figure above) when clamped together by tightening the union nut 4. *Id.*

[141]. The valve 7 (second connecting device) of the PR08 (shown in **lime** in the annotated figure below) includes the shutoff valve (shown in **orange** in the annotated figure below). *Id*.

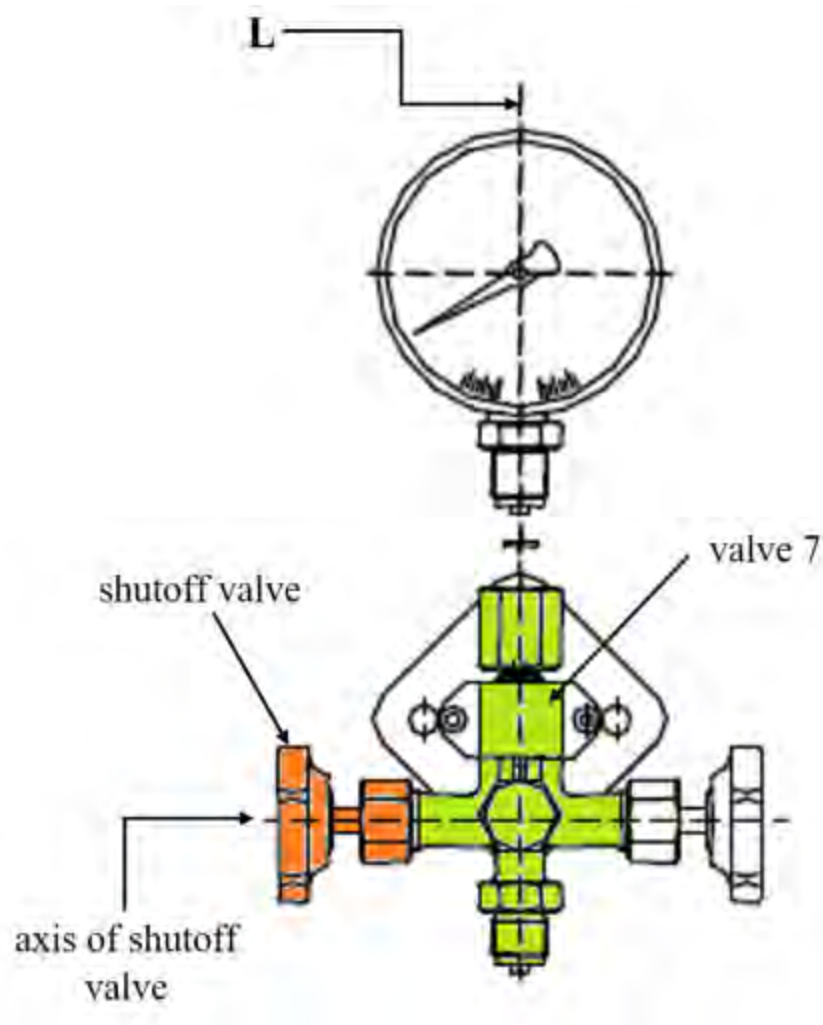


Figure from the 2008 Schneider Hook-Ups Catalog of the PR08 (annotated with text and color)

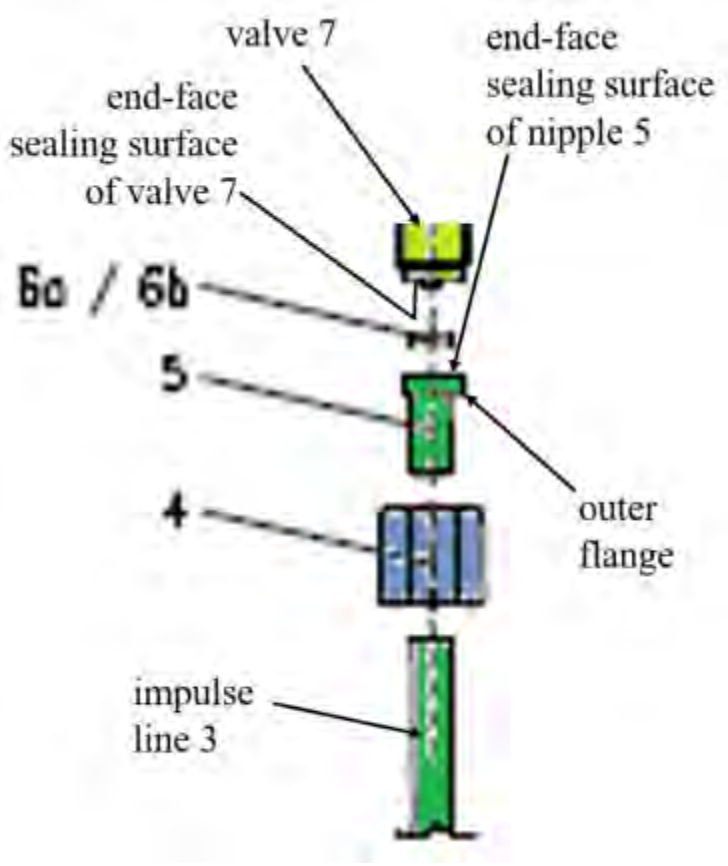
[142]. The axis of the shutoff valve extends obliquely, and more specifically at a right angle, with respect to the longitudinal axis L of the connecting apparatus, as seen in the figure above. *Id*.

[143]. A POSITA would recognize that the union nut 4 of the PR08 interconnects the impulse line 3 and the valve 7, or first and second connecting

devices, respectively, with "sealing effect" via the sealing washer 6a/6b. A POSITA would readily understand that the sealing washer 6a/6b of the PR08 would be received in the union nut 4 and arranged between the nipple 5 of the impulse line 3 and the valve 7 to provide a seal when the impulse line 3 and the valve 7 are clamped together by tightening the union nut 4.

[144]. A POSITA would recognize that the union nut 4 of the PR08 interconnects the impulse line 3 (first connecting device) with the valve 7 (second connecting device) by rotating the union nut 4, that is by solely rotating the union nut 4 to threadably engage the valve 7 without rotating either the impulse line 3 or the valve 7.

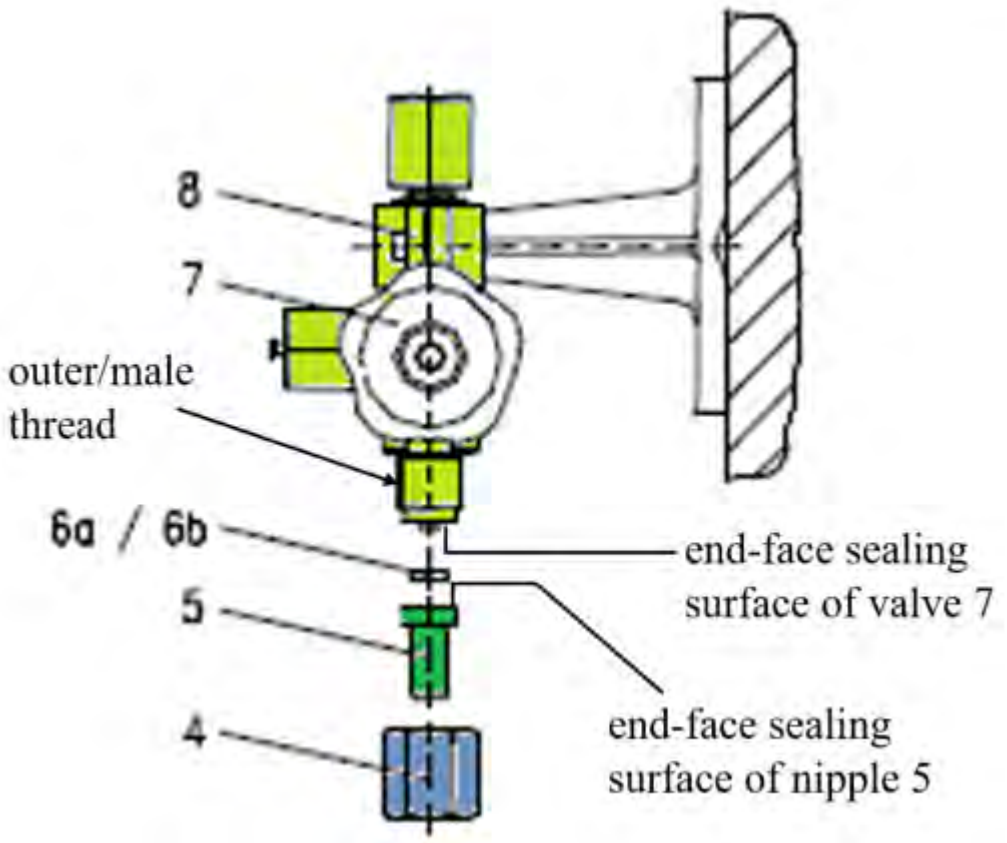
[145]. The nipple 5 of the impulse line 3 (first connecting device) of the PR08 has an outwardly pointing outer flange at its upper edge region, as seen in the annotated figure below. *See* Ex. 1006 at pg. 37.



Partial enlarged view of figure from the 2008 Schneider Hook-Ups Catalog of the PR08 (annotated with color and text)

[146]. A POSITA would recognize that the nipple 5 of the impulse line 3 has an end-face surface (see annotated figure above) that can seal with a corresponding end-face surface (see annotated figure above) of the valve 7 (second connecting device) when the union nut 4 is tightened on the valve 7. A POSITA would also understand that the sealing washer 6a/6b provides sealing between those end-face sealing surfaces of the impulse line 3 and the valve 7, when they are clamped together by screwing the union nut 4 onto the valve 7.

[147]. The valve 7 (second connecting device) of the PR08 includes an outer or male thread at its lower edge region, as seen in the annotated figure below. *See* Ex. 1006 at pg 37.



Partial enlarged view of figure from the 2008 Schneider Hook-Ups Catalog of the PR08 (annotated with color and text)

[148]. A POSITA would recognize that the valve 7 necessarily includes a male or outer thread (see annotated figure above) to threadably engage the union nut 4. Also, a POSITA would understand that the valve 7 has an end-face surface (see annotated figure above) that can seal with the corresponding end-face surface (see annotated figure above) of the nipple 5 of the first connecting

device when the union nut 4 is tightened on the valve 7.

[149]. The union nut 4 of the PR08 is a connecting unit designed as a nut unit. A POSITA would understand that the union nut 4 of the PR08, being a conventional union-type nut, inherently includes both an inwardly pointing inner flange and an inner or female thread, so that the nut 4 can engage the impulse line 3 and the valve 7, respectively, to interconnect 3 and 7.

[150]. A POSITA would understand that the union nut 4 of the PR08 must include an inner flange for cooperating with the outer flange of the nipple 5 of the impulse line 3. addition, a POSITA would recognize that the union nut 4 of the PR08 inherently has an inner flange based on the structure and assembly of the components of the PR08. More specifically, the exploded view of the PR08 (reproduced below) shows the nipple 5 of the impulse line 3 above the union nut 4 which would indicate to a POSITA that the nipple 5 is assembled with the union nut 4 by sliding the union nut 4 up and over the nipple 5. *Id*.

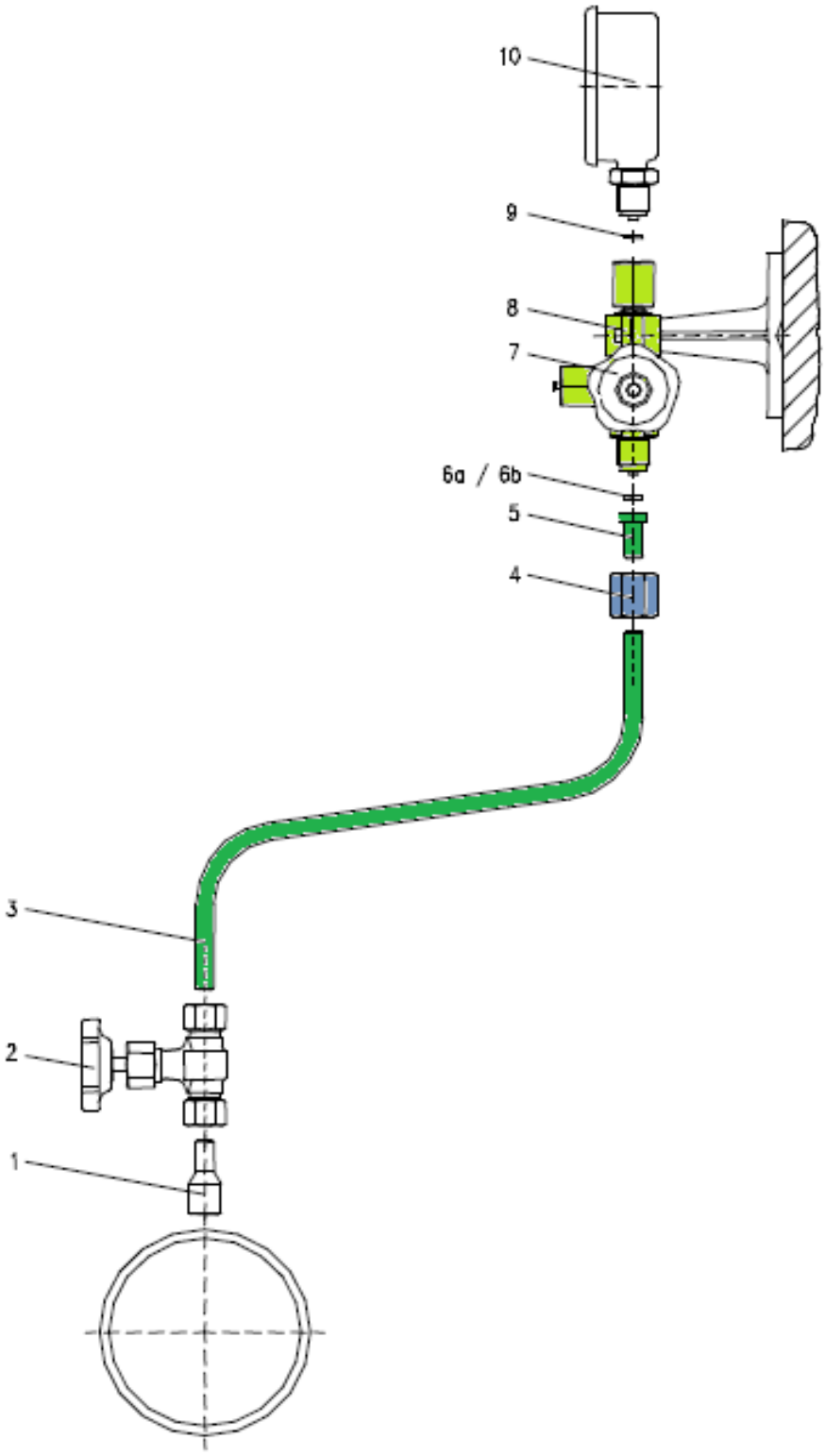


Figure from the 2008 Schneider Hook-Ups Catalog of exploded view of the PR08 (annotated with color)

[151]. As such, the union nut 4 must have an inner flange to catch the outer flange of the nipple 5 of the first connecting device when it is received therein, otherwise the nipple 5 would pass through the union nut 4.

[152]. Moreover, the inner flange of the union nut 4 of the PR08 would be located at the lower edge region thereof (rather than an upper edge region) so that the union nut 4 can connect with the impulse line 3 (first connecting device), which is positioned below the union nut 4, as seen in the exploded view. In other words, a POSITA would understand that the inner flange must be in the lower region of the union nut 4 so that the inner threads can be above in the upper region of the union nut 4 in order to engage the outer threads of the valve 7, which is located above the union nut 4. This is necessary so that the threaded engagement is above and out of the way of the end-face to end-face sealing engagement between the nipple 5 and the valve 7.

[153]. A POSITA would further understand that the union nut 4 of the PR08 must include an inner thread for engaging the corresponding outer thread of the valve 7 to allow the union nut 4 to be threadably tightened onto the valve 7 to accomplish the connection of the impulse line 3 to the valve 7.

[154]. A POSITA would understand that the union nut 4 of the PR08 has an inner flange that cooperates with the outer flange of the nipple 5 of the

impulse line 3. Additionally, the exploded view of the PR08 (shown above) shows the nipple 5 of the impulse line 3 above the union nut 4 which would indicate to a POSITA that the nipple 5 is assembled with the union nut 4 by sliding the union nut 4 up and over the nipple 5 In other words, when assembling the apparatus, the union nut 4 is first positioned on the impulse line 3 below the nipple 5, then the nipple 5 is attached to the upper end of the impulse line 3, and then the union nut 4 is slid back up such that the nut's inner flange engages or catches the outer flange of the nipple 5. As such, the union nut 4 must have an inner flange to catch the outer flange of the nipple 5 of the first connecting device when it is received therein such that the outer flange of the nipple 5 fits behind the inner flange of the union nut 4. Otherwise, the nipple 5 would pass through the union nut 4 when assembling the union nut 4 with the nipple 5, which would result in no connection between the two.

[155]. A POSITA would recognize that the union nut 4 of the PR08 interconnects the impulse line 3 and the valve 7 with "sealing effect" in the same manner as taught by the '030 patent. This sealing effect is provided by means of the inner flange of the union nut 4 interlocking with the outer flange of the nipple 5 of the impulse line 3 along with the threaded engagement between the union nut 4 and the valve 7. This threaded engagement is accomplished by

screwing the union nut 4 onto the valve 7 which necessarily brings the two end-face sealing surfaces of the impulse line 3 and the valve 7 together to make the seal.

[156]. Additionally, the PR08 provides the sealing washer 6a/6b between the nipple 5 of the impulse line 3 and the valve 7 and a POSITA would understand that the sealing washer 6a/6b would inherently provide sealing between the end-face sealing surfaces of the first and second connecting devices, that is the impulse line 3 and the valve 7, when clamped together by screwing the union nut 4 onto the valve 7.

[157]. A POSITA would recognize that the outer flange of the nipple 5 of the impulse line 3 and the inner flange of the union nut 4 of the PR08 are provided in an encompassing manner because each extends circumferentially around the first connecting device to accomplish the connection between the nipple 5 of the impulse line 3 and the valve 7.

[158]. The PR08 includes a sealing means that is the sealing washer 6a/6b. *See* Ex. 1006 at pg. 37. A POSITA would understand that the sealing washer 6a/6b of the PR08 would be arranged between the end-face sealing surfaces of the impulse line 3 and the valve 7 to affect the sealing. A POSITA would understand that the sealing washer 6a/6b inherently provides a sealing means

between the end-face sealing surfaces of the two connecting devices, that is impulse line 3 and valve 7, when they are clamped together by screwing the union nut 4 onto the valve 7.

[159]. Regarding claim 7, the shutoff valve of the valve 7 extends at a right angle to the longitudinal axis of the connecting apparatus of the PR08.

3. Claims 1, 2, 6, and 7 are Obvious Over Craig in view of the Common Knowledge Of a Person of Ordinary Skill in the Art

[160]. Craig teaches each element of independent claim 1 and dependent claims 2-7. To the extent that Craig is considered not to anticipate any element of these claims, Craig renders those elements obvious in view of the common knowledge of a POSITA and the known benefits thereof. For example, if it is considered that Craig requires the orientation of union valve 8 as specifically shown in Fig. 1 of Craig, which Petitioner does not believe it does, a POSITA would have understood that union valve 8 of Craig could be rotated 180° and still function in the same way and manner as required by Craig.

[161]. The union valve assembly 8 of Craig is shown in Fig. 1 with the threaded union end 13 connected to the regulator 7 and the main valve body 16 connected to the feed line 6. *See* Ex. 1005 at Fig. 1. Figure 2 shows that the orientation of Figure 2 is not significant. The union valve assembly in Figure 2 is rotated clockwise 90 degrees from what is shown in Figure 1 and is also

flipped in the horizontal direction from Figure 1. In order to show the valve assembly orientation as shown in Figure 1, in the view below Fig. 2 of Craig but rotated clockwise 90 degrees and reversed or flipped horizontally. The differences in vertical orientation and horizontal orientation between Figures 1 and 2 show that the specific orientation in Figure 1 is not important.

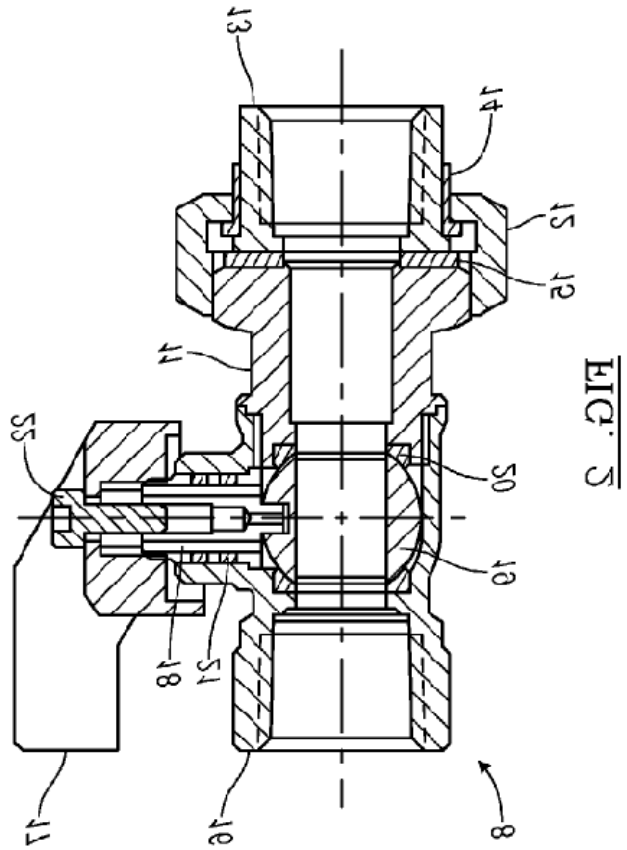


FIG. 2

Fig. 2 of Craig (rotated 90 degrees and flipped horizontally)

[162]. As seen in the view above, the union end 13 (first connecting device) is shown located above the end connection 11 or second connection device. A POSITA would have understood, however, that the specific orientation of the union valve assembly 8 shown by Craig in Fig. 1 is simply a choice of the installer and would have no impact on the function of the union valve assembly 8 to feed gas to the building. In other words, a POSITA would recognize that the union end 13 (first connecting device) could just as easily been connected to the feed line 6 (instead of the regulator 7) and the main valve body 16 connected to the regulator 7 (instead of the feed line 6), such that the union end 13 is below the end connection 11, and still operate in the same manner.

[163]. It would have been obvious to a POSITA to try the Craig union valve in the reverse orientation, because it is a basic connection mechanism, the only purpose of which is to connect two pipes, thus rendering the orientation of the union valve immaterial. *Id*. Indeed, a POSITA would readily understand that the Craig union valve would work the same in either orientation because nothing about its function or the purpose of its use changes when it is oriented in any particular direction—fluid will flow through the valve when open and will not flow when closed and the union will allow the connection to be broken

without needing to rotate one pipe with respect to the other. *Id*. Orienting the Craig union valve in a reverse orientation would lead to a predictable result and reasonable expectation of success because the tool is a simple connection device between two pipes, the orientation of which does not matter to its function or purpose. A POSITA would have been motivated to use the Craig tool in the reverse orientation because its orientation is irrelevant to its use, and a POSITA knows by the simplicity of the design of the tool that it would be useful to connect devices in any orientation. The orientation is simply a matter of convenience in the application.

[164]. Consequently, if Craig is not deemed to anticipate claim 1, then it would have been obvious to a POSITA to arrange the union valve assembly 8 in any chosen orientation, including an orientation where the union end 13 is below the end connection 11 and coupled to the feed line 6.

4. Claims 1, 2, and 4-7 are Obvious in View of Parker-1 or Parker-2 Combined with the 2012 Accessories Catalog And the Common Knowledge of a Person of Ordinary Skill in the Art

[165]. As explained below, independent claim 1 and dependent claims 2 and 4-7 are obvious over Parker-1/Parker-2 in view of the 2012 Accessories Catalog and the common knowledge of a POSITA at the time of the effective filing date of the application for the ’030 patent. Briefly, Parker-1/Parker-2

disclose a connecting apparatus that comprises a “stabilized connector” (first connecting device), an “integral block valve” (second connecting device), and a “union nut” (connecting unit/nut) that sealingly connects the stabilized connector to the integral block valve, as recited in claim 1. *See* Ex. 1010 at pgs. 4-9; Ex. 1011. The stabilized connector mounts directly to a pipeline, the integral block valve sealingly connects to a pressure measuring instrument, and the union nut interconnects the first and second devices such that the sealing connection therebetween is created solely by rotating the nut without rotating the stabilized connector or the block valve, as recited in claim 1. *Id*.

[166]. Although the union nut of Parker-1/Parker-2 provides a threaded engagement between the stabilized connector and the block valve (solely by rotating the nut) like in claim 1, the union nut does not couple to each of the stabilized connector and the block valve in the identical manner to the connecting apparatus of claim 1 of the ’030 patent, as set forth in more detail below. In short, the union nut of Parker-1/Parker-2 has outer or male threads rather than inner or female threads for engaging the second connecting device (i.e. the block valve). As such, it also does not have an inner flange that engages an outer flange of the first connecting device (i.e. the stabilized connector). However, it would have been obvious to a POSITA to modify the connecting

apparatus of Parker-1/Parker-2 such that the union nut and its connection to the stabilized connector and the block valve thereof has the identical structure as in claim 1, as a mere design choice of known equivalents. A POSITA would have recognized that such a modification of Parker-1/Parker-2 is a simple substitution of one known configuration for another, as discussed below, to obtain predictable results, i.e. of a union connection, and maintain the benefits thereof.

[167]. Patent Owner's own swivel gauge adaptor from its 2012 Accessories Catalog (hereinafter "the Schneider adaptor"), which similarly provides a union nut sealing connection for first and second connecting devices, has an inner flange that engages an outer flange of the first connecting device and has inner or female threads for engaging the second connecting device, as claimed. *See* Ex. 1008 at pg. 111. It would have been obvious to a POSITA to modify the connecting apparatus of Parker-1/Parker-2 such that the union nut thereof has (a) inner threads, as taught by the Schneider adaptor, instead of outer threads, that can engage outer or male threads, instead of inner threads, of the block valve, and (b) an inner flange, as taught by the Schneider adapter, that can engage the outer flange of the stabilized connector, as a predictable variation based on a POSITA's design choice of known equivalents. Such is a mere design choice to a POSITA given the union nut arrangement of Parker-1/Parker-

2 and the Schneider adaptor were well known equivalents for providing that same threaded engagement without having to rotate either of the first and second connecting devices.

[168]. Parker-1/Parker-2 disclose a connecting apparatus for connecting a "stabilized connector" (first connecting device) with "integral block valves" (second connecting device). *See* Ex. 1010 at pgs. 1, 5, and 6; Ex. 1011.

[169]. As seen in Figure 2 of Parker-1 (shown below with annotations), the "stabilized connector" (shown in **green**) is a first connecting device that connects to an "orifice fitting" (or metering device) of a pipeline via a "stabilized connector nut" and a "stabilized connector foot". *See* Ex. 1010 at pgs. 5 and 6.

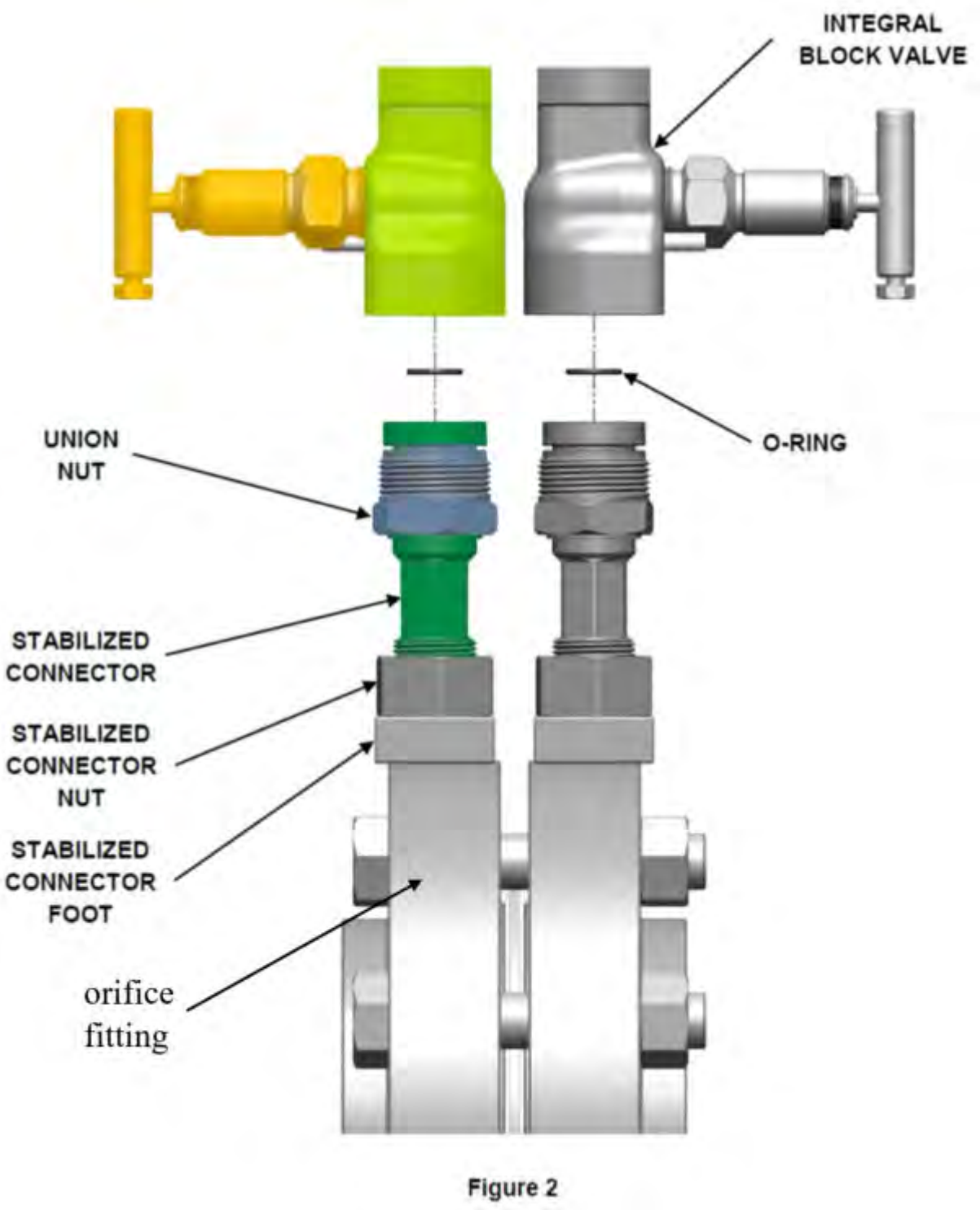


Figure 2 of Parker-1 (annotated with color and text)

[170]. A POSITA would have recognized that the stabilized connector of Parker-1 necessarily has a longitudinal through-opening to allow a fluid connection to the "integral block valve" for measuring the differential pressure of the gas flow in the pipeline via the orifice fitting.

As shown below, the stabilized connector of Parker-1 is identical to the stabilized connector of Parker-2. Thus, the above-mapping is identical for each reference.

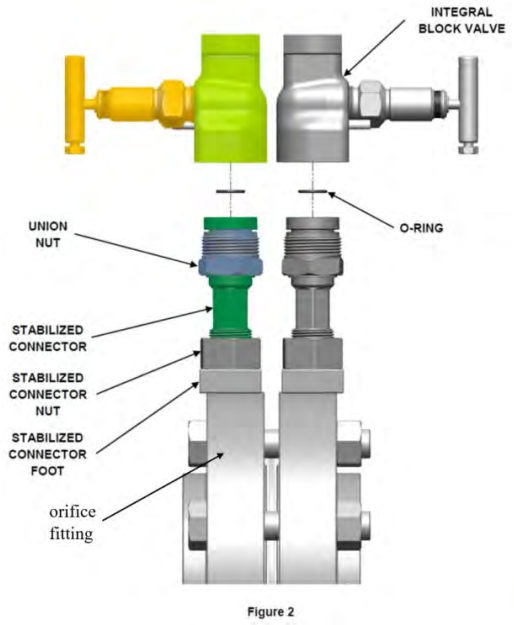
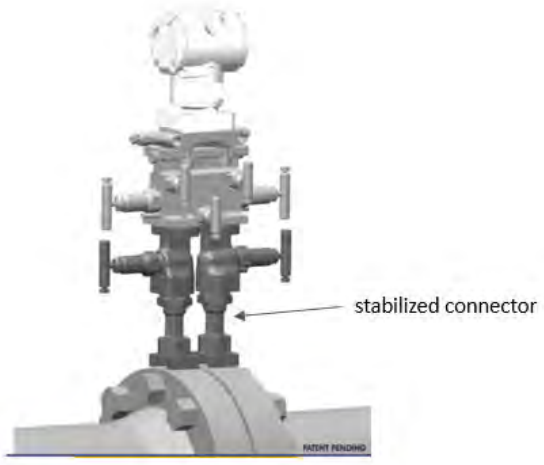


Figure 2 of Parker-1 (annotated with color/text)



Parker-2 (annotated with text)

Exhibit 1010, Fig. 2; Exhibit 1011.

[171]. The “valve block” of Parker-1 is a second connecting device, shown in **lime** in annotated Figure 2 above. A POSITA would have understood that the valve block is a connecting device because it connects to a pressure measuring instrument via an outwardly pointing flange at its upper end (identified in annotated Figure 4 of Parker-1, shown below).

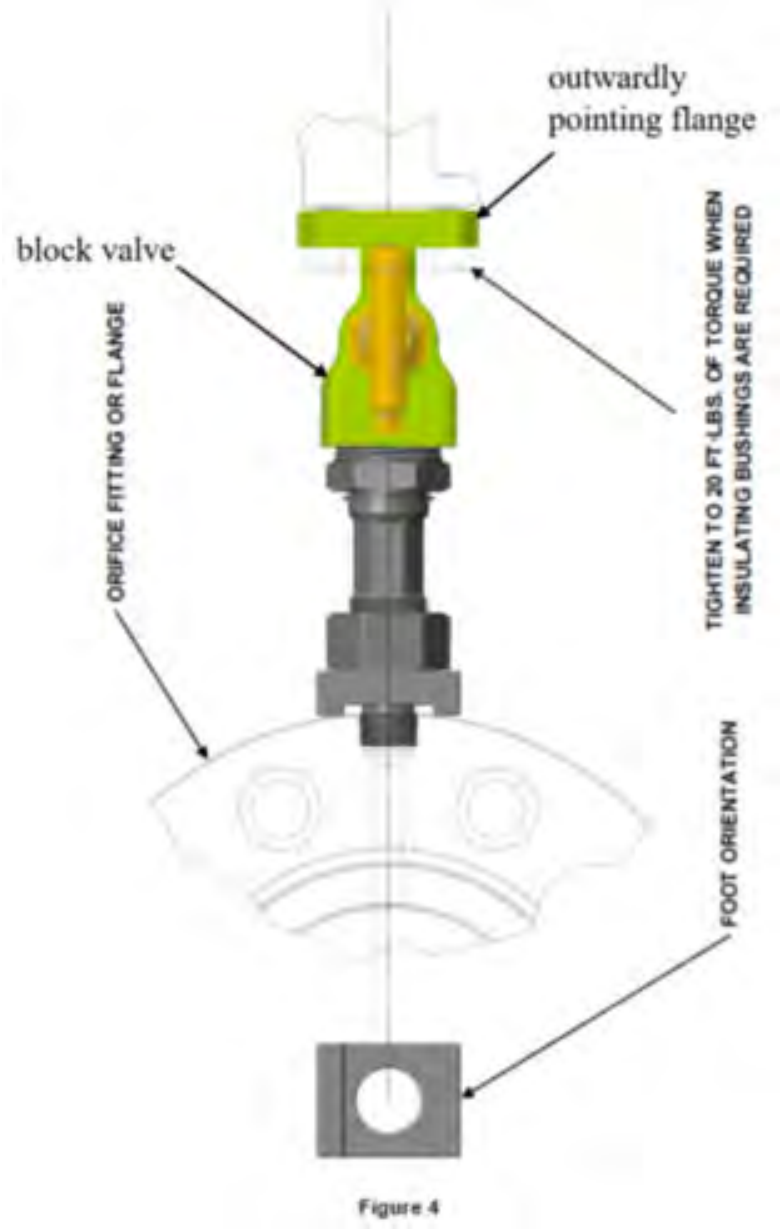


Figure 4 of Parker-1 (annotated with text)

[172]. A POSITA would have also recognized that the integral block valve of Parker-1 necessarily has a longitudinal through-opening for maintaining the fluid connection to the pressuring measuring instrument from the orifice fitting of the pipeline. The pressure in the pipeline could not be measured by the

instrument without such a through-opening.

As shown below, the block valve of Parker-1 is identical to the block valve of Parker-2. Thus, the above-mapping is identical for each reference.

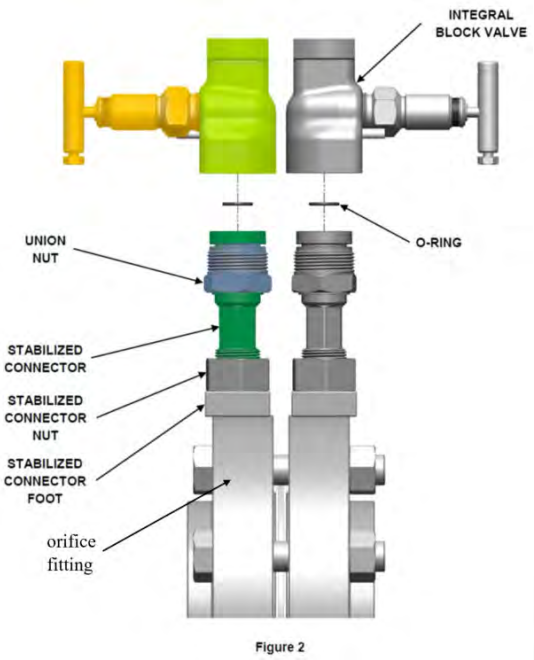
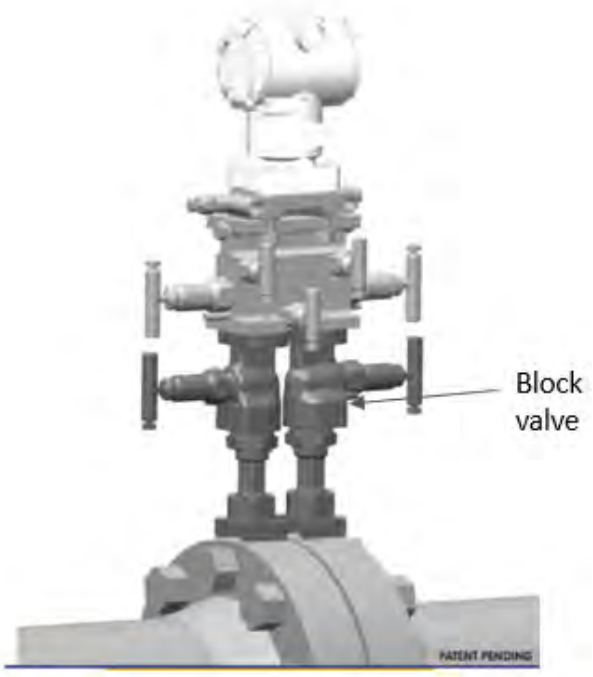


Figure 2 of Parker-1
(annotated with color/text)



Parker-2
(annotated with text)

Exhibit 1010, Fig. 2; Exhibit 1011.

[173]. The "union nut" of Parker-1, shown in **blue** in Figure 2 above, is a connecting unit that interconnects the stabilized connector (first connecting device) with the block valve (second connecting device). *See* Ex. 1010 at pgs. 5-7. The union nut of Parker-1/Parker-2 provides a sealing connection to the stabilized connector and the block valve via an "o-ring". *Id* at Fig. 2. A

POSITA would have understood that the o-ring would be clamped between the stabilized connector and the block valve when the union nut threadably engages the block valve upon installation to the block valve. *Id*. At pg. 7 ("2.1.7 Install the valve bodies onto the stabilized connectors and tighten the unit nut per Figure 3").

As shown below, the union nut of Parker 1 is identical to the union nut of Parker 2. Thus, the above-mapping is identical for each reference.

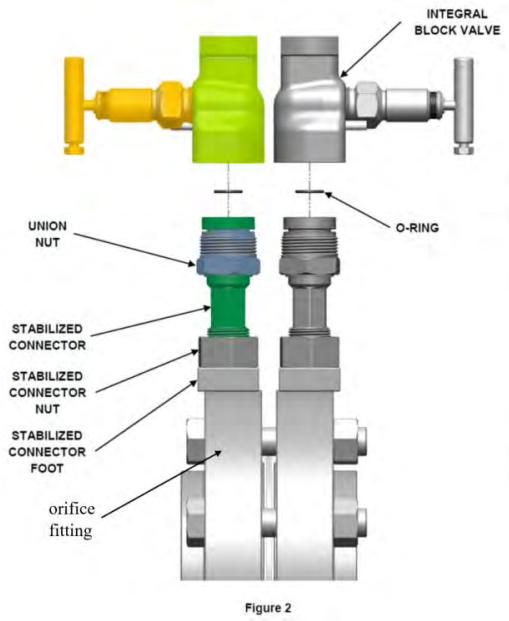
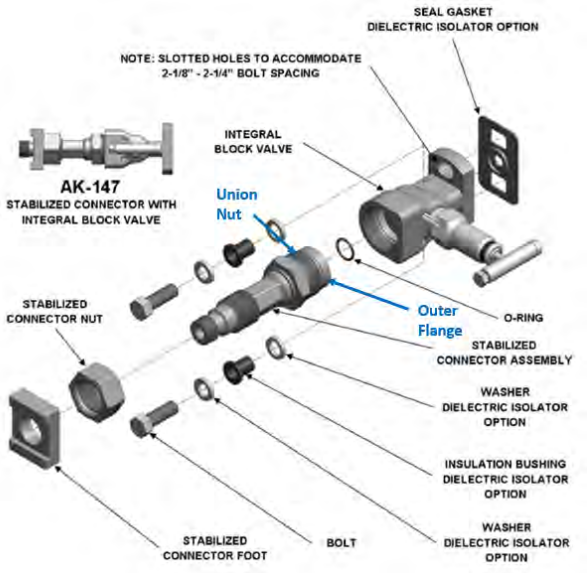


Figure 2 of Parker-1 (annotated with color/text)



Parker-2 (annotated with text)

Exhibit 1010, Fig. 2; Exhibit 1011.

[174]. As seen in Figure 2 of Parker-1 (shown below with annotations), the

block valve (second connecting device) (shown in **lime**) has a shutoff valve (shown in **orange**).

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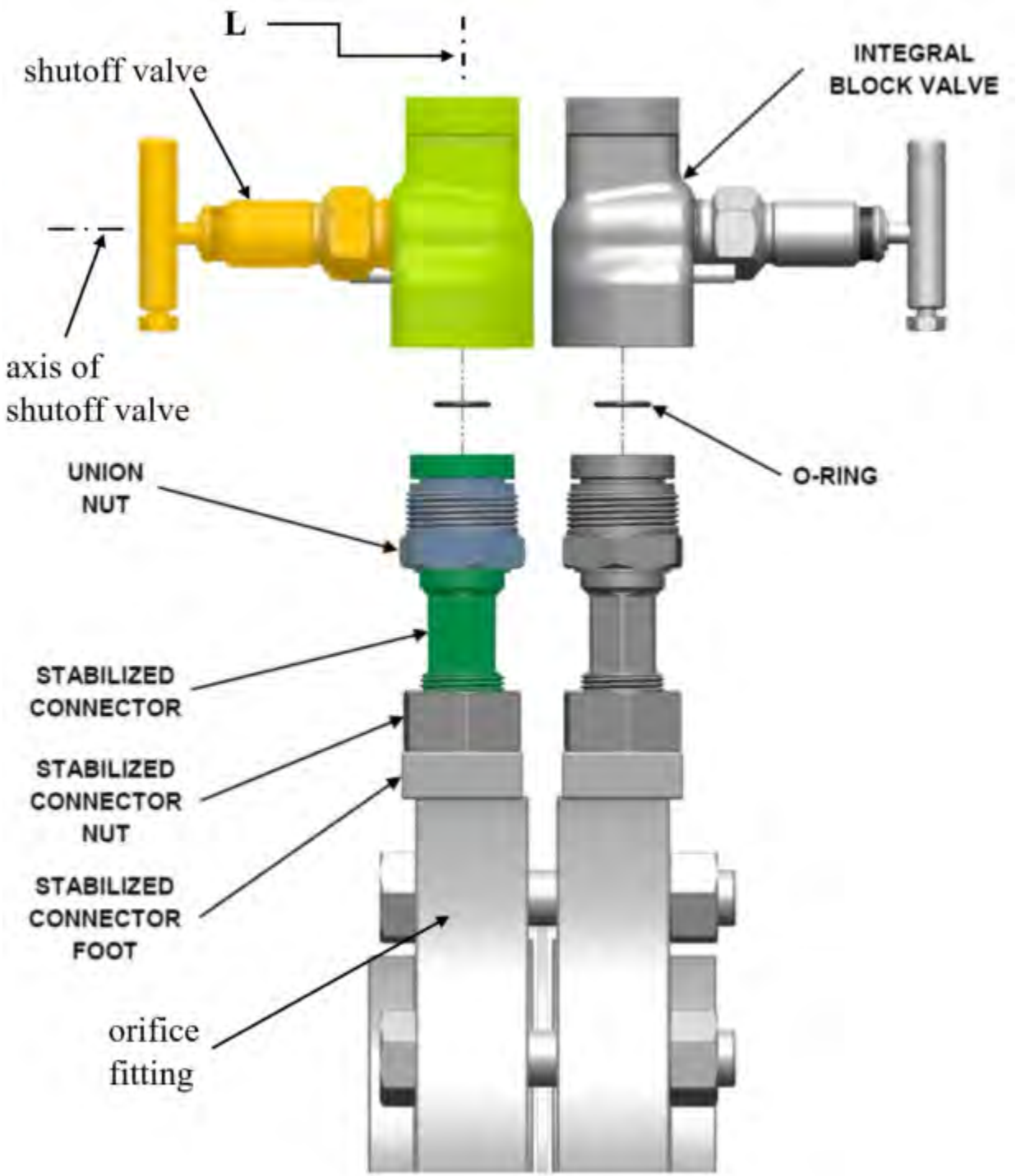


Figure 2 of the Parker-1 (annotated with color and text)

[175]. The axis of the shutoff valve extends obliquely, and more specifically at a right angle, with respect to the longitudinal axis L of the connecting apparatus, as seen in the figure above.

As shown below, the shutoff valve of Parker-1 is identical to the shutoff valve of Parker-2. Thus, the above-mapping is identical for each reference.

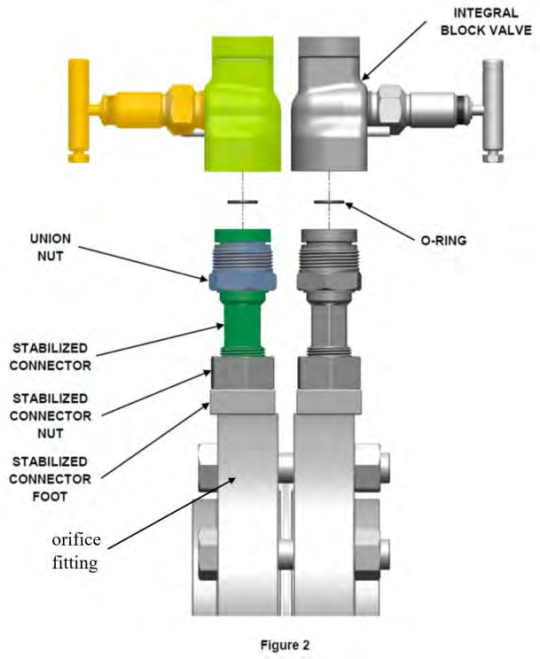
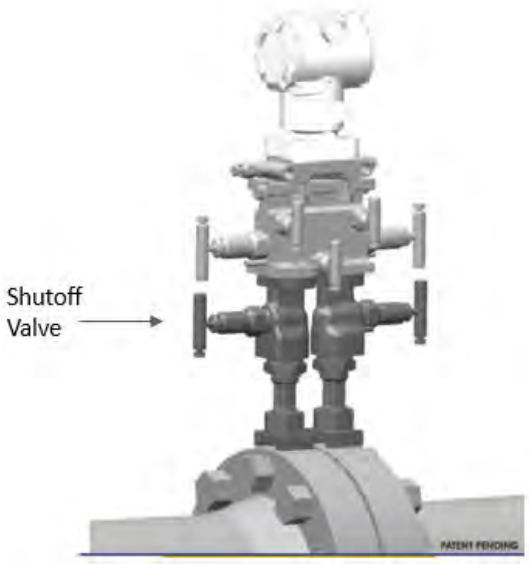


Figure 2 of Parker-1 (annotated with color/text)



Parker-2 (annotated with text)

Exhibit 1010, Fig. 2; Exhibit 1011.

[176]. A POSITA would have recognized that the union nut of Parker-

1/Parker-2 (see paragraph 173) interconnects the stabilized connector (first connecting device) and the block valve (second connecting device) with "sealing effect" via the o-ring that is arranged between them. Indeed, the o-ring of Parker-1/Parker-2 is specifically positioned in grooves at the connection or end face of the stabilized connector to enable a face seal. *See* Ex. 1010 at pg. 6 ("2.1.5 Insert the O-rings into the grooves on the stabilized connector according to Figure 2"); Ex. 1011. A POSITA would have understood that the o-ring of Parker-1/Parker-2 would provide a seal between the stabilized connector and the block valve when they are clamped together by tightening the union nut onto the valve block.

[177]. A POSITA would have recognized that the union nut of Parker-1/Parker-2 (see paragraph 173) interconnects the stabilized connector (first connecting device) with the valve block (second connecting device) by rotating the union nut, that is by rotating the union nut to threadably engage the block valve without rotating either the stabilized connector or the block valve.

[178]. The stabilized connector (first connecting device) of Parker-1 has an outwardly pointing outer flange at an upper edge region thereof, as seen in annotated Figure 2, shown below. *See* Ex. 1010 at pg. 6 and Fig. 2.

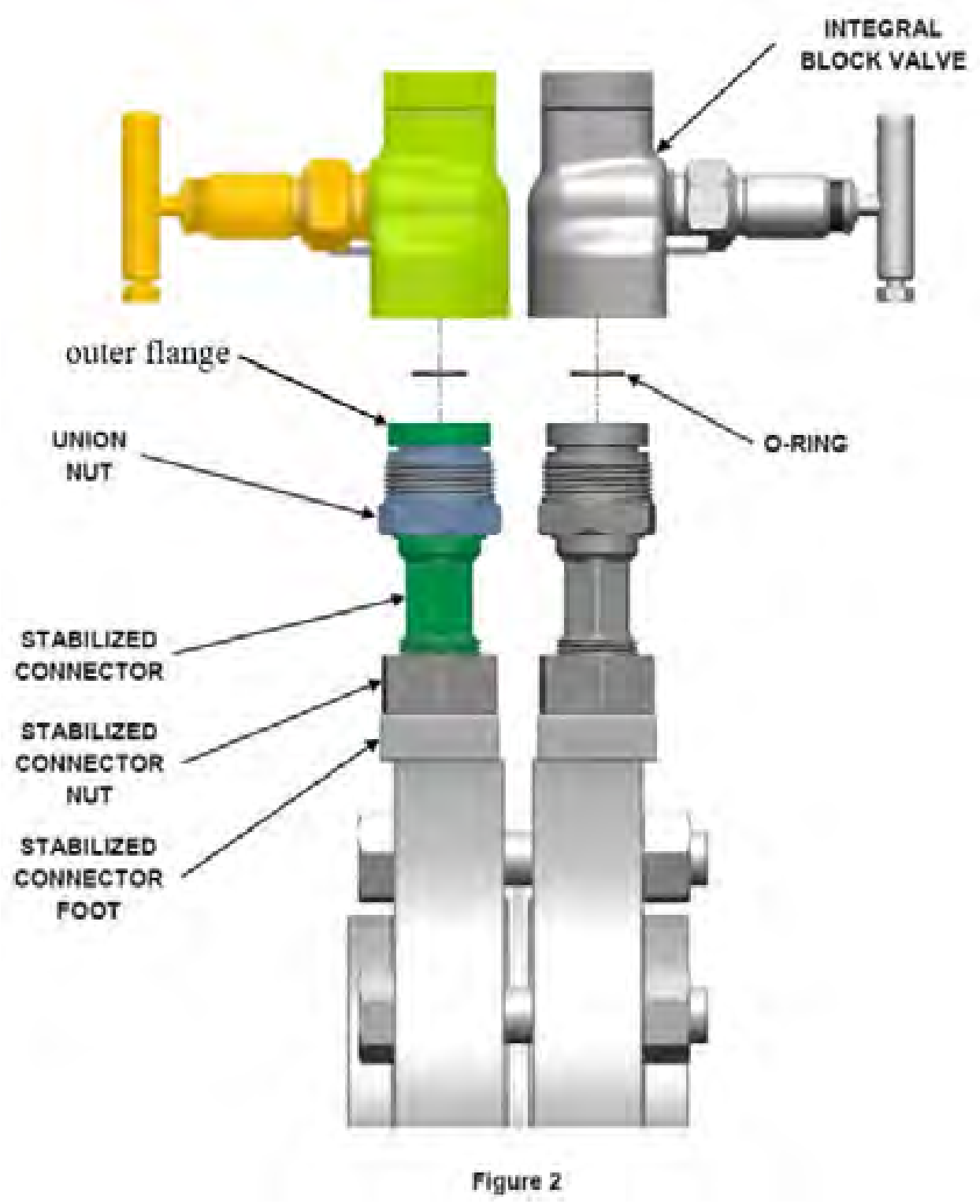


Figure 2 of Parker-1 (annotated with text and color)

[179]. A POSITA would have recognized that the stabilized connector also has an end-face sealing surface which includes grooves for receiving one or more of the o-rings. *Id.* at pg. 6 ("2.1.5 Insert the O-rings into the grooves on the stabilized connector according to Figure 2"). A POSITA would have understood that the o-ring of Parker-1 would provide a seal between the stabilized connector and the block valve when they are clamped together by tightening the union nut onto the valve block.

[180]. A POSITA would also understand that the sealing washer 6a/6b provides sealing between those end-face sealing surfaces of the impulse line 3 and the valve 7, when they are clamped together by screwing the union nut 4 onto the valve 7.

As shown below, the above-described flange of Parker-1 is identical to the flange of Parker-2. Thus, the above-mapping is identical for each reference.

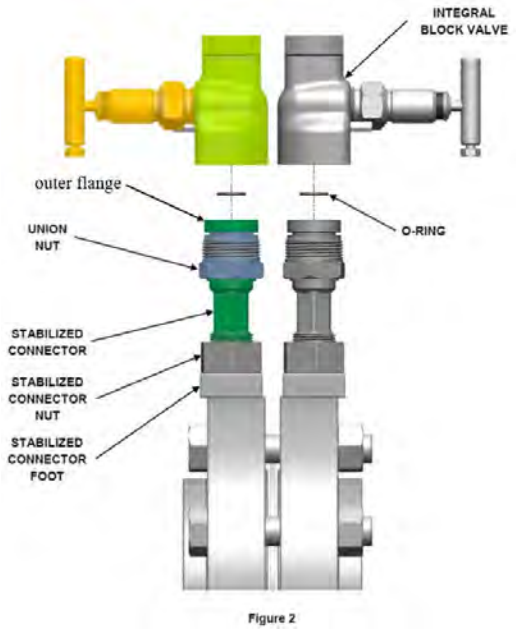
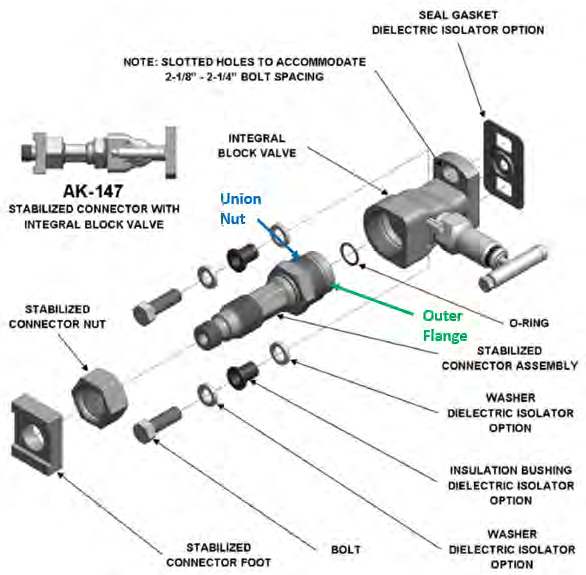


Figure 2 of Parker-1
(annotated with color/text)



Parker-2
(annotated with text)

Exhibit 1010, Fig. 2; Exhibit 1011.

[181]. It would have been obvious to a POSITA to modify Parker-1 or Parker-2 to incorporate the union connection of the Schneider adaptor. The Schneider adaptor is a union connection that, similar to the connecting apparatus of Parker-1/Parker-2, includes a nut which interconnects first and second connecting devices such that they can be connected together without rotating either connecting device. *See* Ex. 1008 at pg. 111 and the annotated figure below.

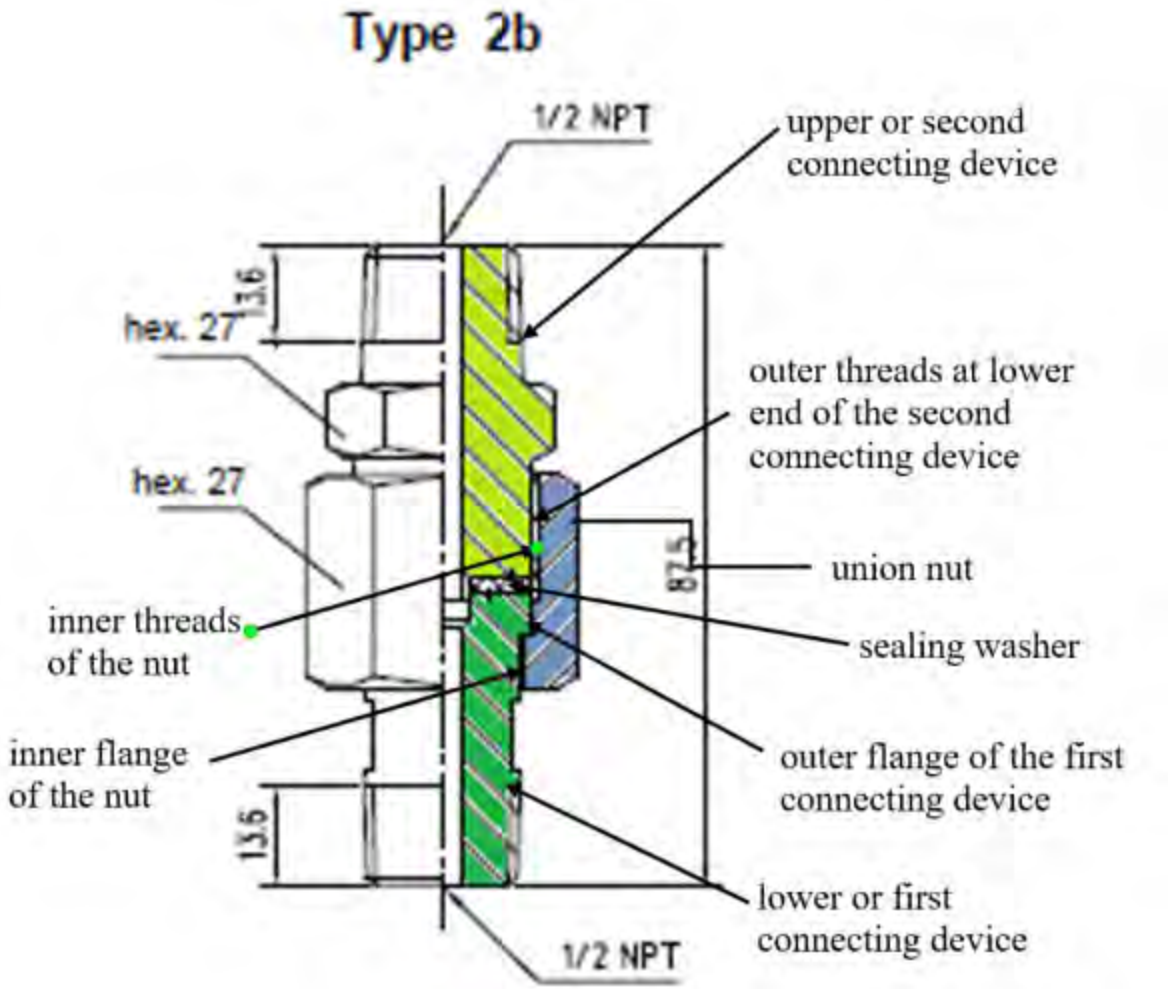
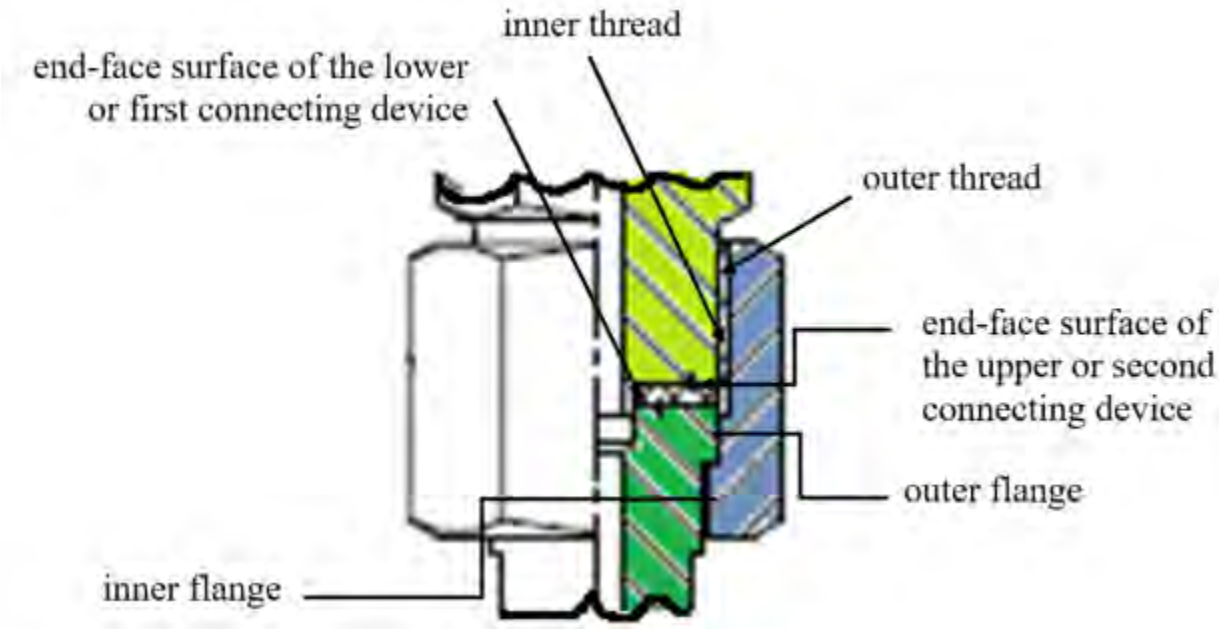


Figure of the Schneider adaptor from the 2008 Instrumentation Products Catalog (annotated with text and color)

[182]. The Schneider adaptor comprises a lower connection that can be a first connecting device (**green**), an upper connection that can be a second connecting device (**lime**), and a union nut (**blue**) interconnecting the two devices in a sealing manner. *Id*. As seen above, the nut (**blue**) of the Schneider adaptor has an inner surface with inner or female threads and an inner flange at the lower

edge region of the nut that points inwardly. *Id*. The inner flange is designed to engage an outer or outwardly pointing flange at the upper edge region of the first connecting device (**green**) in a manner such that, when assembled, the outer flange sits behind the inwardly pointing flange. *Id*. Also, the inner or female threads of the nut (**blue**) of the Schneider adaptor are designed to engage corresponding outer or male threads on the second connecting device (**lime**), as seen in the annotated partial view below of the Schneider adaptor. *Id.*



Partial view of the Schneider adaptor (with text and color annotations)

[183]. A POSITA would have recognized that the connecting apparatus of Parker-1/Parker-2, as modified in view of the Schneider adaptor, would have a male thread on the valve block (second connecting device), instead of the female

thread, and the male thread would be located at a lower edge region of the block valve, in order to be in position to engage the union nut which is located below the block valve. To that end, the union nut of the connecting apparatus of Parker-1/Parker-2, as modified in view of the Schneider adaptor, would have the corresponding inner or female thread for engaging the male thread of the modified valve block. The modified union nut of Parker-1/Parker-2 would also have an inner flange arranged at a lower edge region thereof, such that the outer flange of the stabilized connector can fit behind the inner flange. Moreover, a POSITA would have understood that the inner flange of the modified union nut would extend around the inner circumference of the nut's inner surface and thus would be provided in an encompassing manner. Likewise, a POSITA would have understood that the outer flange of the stabilized connector extends around the outer circumference of the stabilized connector and would be provided in an encompassing manner.

[184]. Furthermore, a POSITA would have understood that when the modified union nut of Parker-1/Parker-2 is screwed onto the modified block valve (second connecting device), that is when the inner and outer threads engage one another, the respective end-face surfaces of the stabilized connector and the block valve (see partial view above of the Schneider adaptor) are pulled

and clamped together via the inner and outer flanges to create a seal, therebetween, that is with “sealing effect”, as seen in the view above.

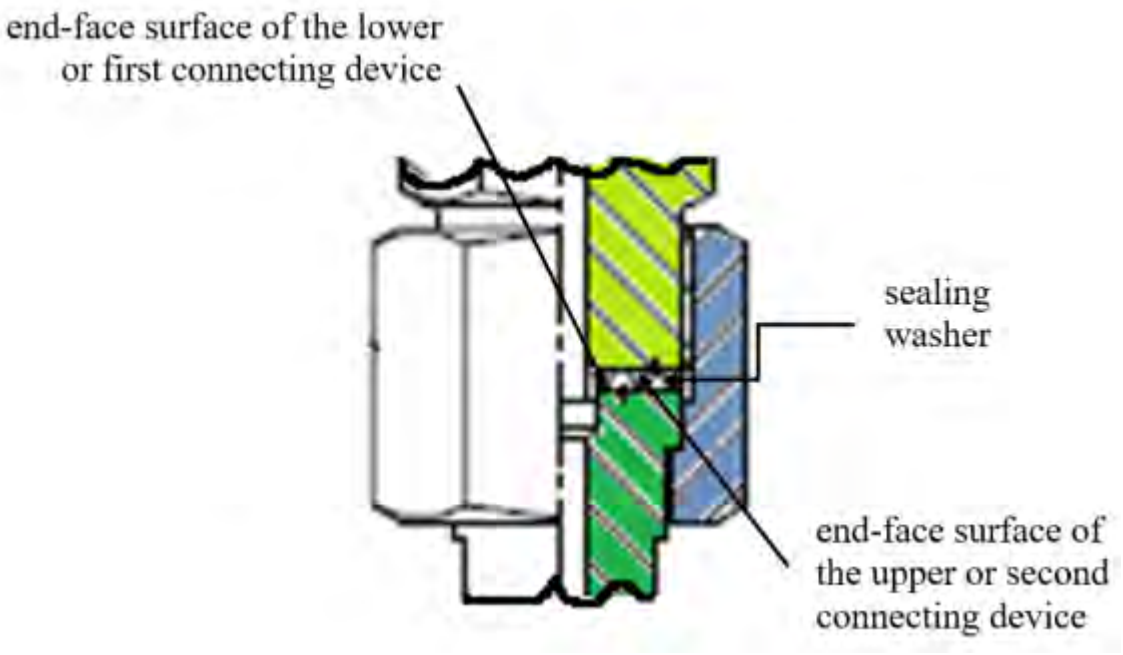
[185]. It would have been obvious to a POSITA to modify Parker-1/Parker-2 to incorporate the union connection of the Schneider adaptor. A POSITA understood that union nuts can have one of two different and basic configurations, i.e. a male thread configuration, as in Parker-1/Parker-2, or a female thread configuration, as in the Schneider adaptor. This is a simple substitution of one union connection configuration (i.e. Parker-1/Parker-2) for another (i.e. the Schneider adaptor) that would yield predictable results, i.e. of a union connection, and maintain the benefits thereof, such as connecting the first and second connecting devices without having to rotate either device.

[186]. It would have been obvious to a POSITA to try the Schneider adaptor in Parker-1/Parker-2, because, as stated above, there are a finite number of predictable solutions with a reasonable expectation of success. A POSITA would have understood that a union nut with male threads and a union nut with female threads are no different in purpose, function, or utility as it relates to connecting pipes or device ends. The union nuts work exactly the same way, regardless of the minor difference in thread orientation. Nothing about their function or purpose is related to their male of female thread design. The thread

orientation is a mere design choice and a POSITA would be familiar with the fact that the female-style nut is much more common in the industry. Using a female thread in place of a male thread would lead to a predictable result and reasonable expectation of success because the purpose of the threads is simply to mate the first and second connecting devices. Furthermore, union nuts are simple hardware, and a POSITA would have chosen thread orientation based on economic factors such as cost or accessibility. Thus, these finite variations in use are based on market forces and the uses are predictable to a POSITA. Finally, there is a teaching, suggestion, or motivation to combine Parker-1/Parker-2 and Schneider, because Parker-1/Parker-2 teaches using a union nut to connect process lines to a valve block, and the Schneider catalog teaches various types of hardware that can be substituted or adapted to tools in this industry for making connections especially for process line connections.

[187]. The connecting apparatus of Parker-1/Parker-2 includes a sealing means, that is the o-ring, which is arranged on the end face of the stabilized connector. The Schneider adaptor also illustrates this common positioning of a sealing washer between end faces of the first and second connecting devices that is the lower (first connecting device) (**green**) and the upper (second connecting device) (**lime**), as seen in the partial view of the Schneider adaptor below. *Id*. at

pg. 111.



Partial view of the Schneider adaptor (with annotations)

[188]. Therefore, a POSITA would have recognized that the sealing means provided by Parker-1/Parker-2 would be maintained if modified to incorporate the structure of the Schneider adaptor, as described above

[189]. A POSITA would also have a reasonable expectation of success in making the above modification of the connecting apparatus of Parker-1/Parker-2 because it merely involves choosing a known equivalent union connection, like the Schneider adaptor, for the same intended purpose of allowing connection of two components without the need to rotate those components. Thus, the

combination of Parker-1/Parker-2 and the Schneider adaptor of the 2012 Accessories Catalog renders challenged claim 1 obvious and unpatentable.

[190]. Regarding claim 2, the stabilized connector or first connecting device (**green**) has a male thread in a lower edge region thereof, as seen in Figure 4 of Parker-1 (annotated view shown below). *See* Ex. 1010 at pg. 6 and Fig. 4.

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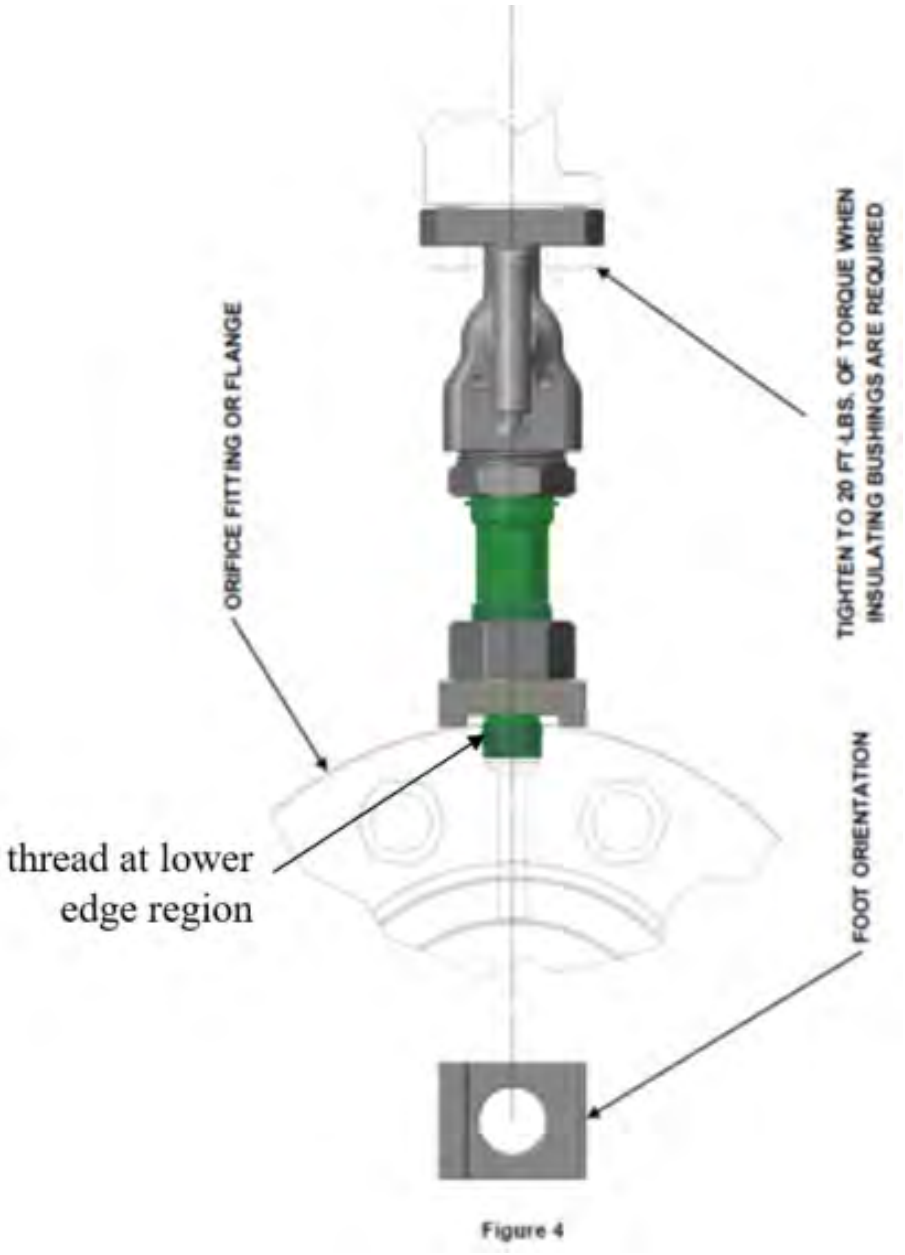


Figure 4 of Parker-1 (annotated with text)

As shown below, the above-described lower thread of Parker-1 is identical to the lower thread of Parker-2. Thus, the above-mapping is identical for each reference.

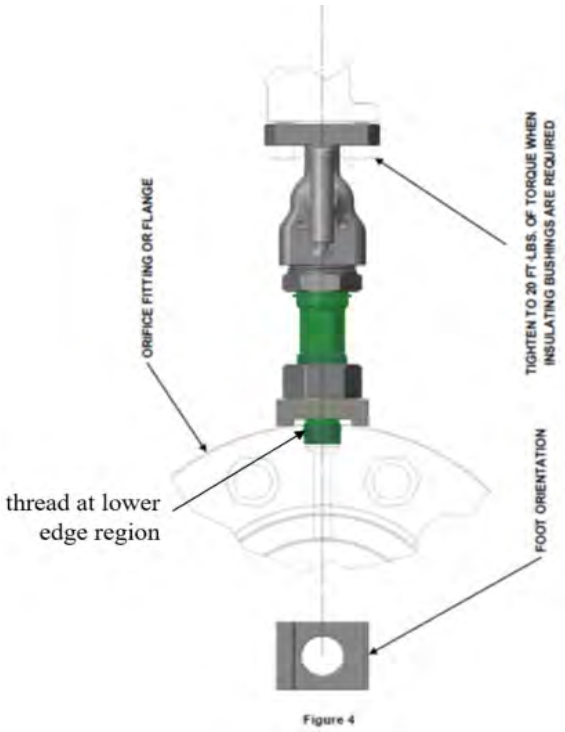
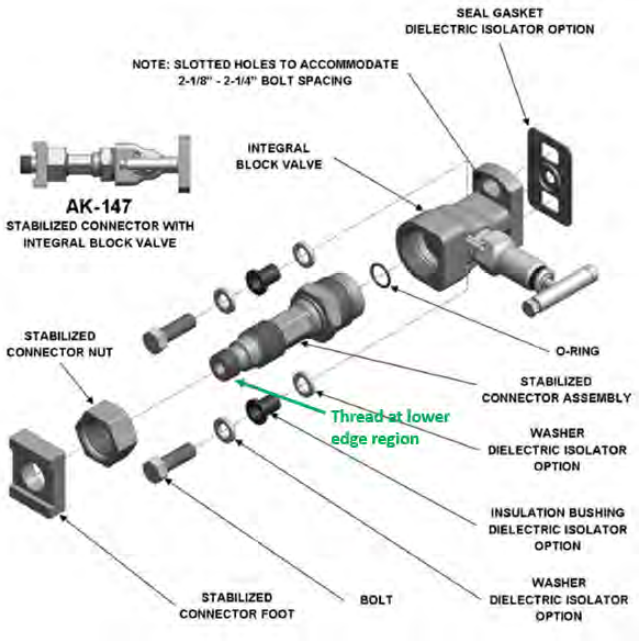


Figure 2 of Parker-1 (annotated with color/text)



Parker-2 (annotated with text)

Exhibit 1010, Fig. 2; Exhibit 1011.

[191]. Regarding claim 4, the stabilized connector (first connecting device) of Parker-1 has a male thread, as seen in Figure 2 (partial view shown below with annotation). *See* Ex. 1010 at pg. 5 and Fig. 2. As seen in Figure 2 below, a clamping nut or "stabilized connector nut" is screwed onto the male thread of the stabilized connector. *Id*.

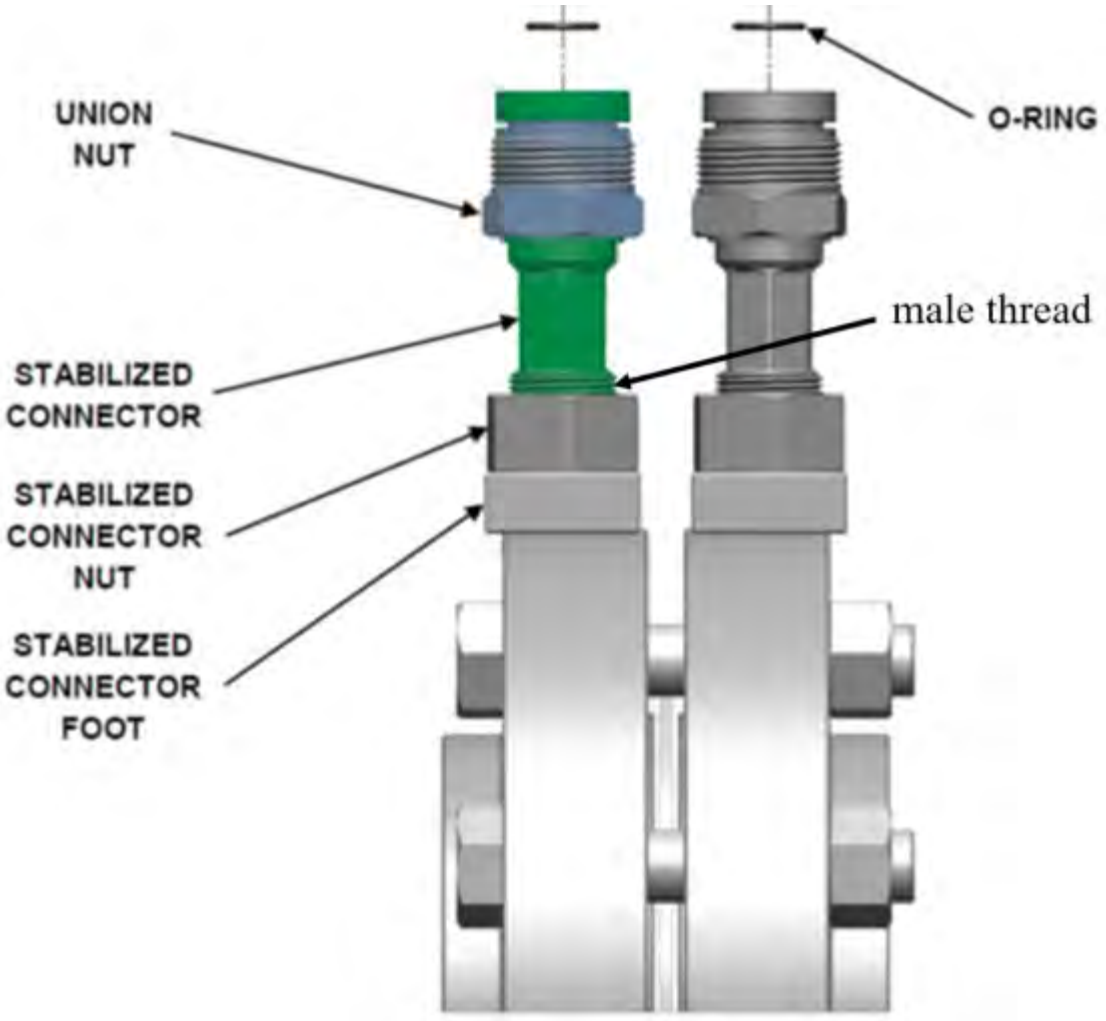
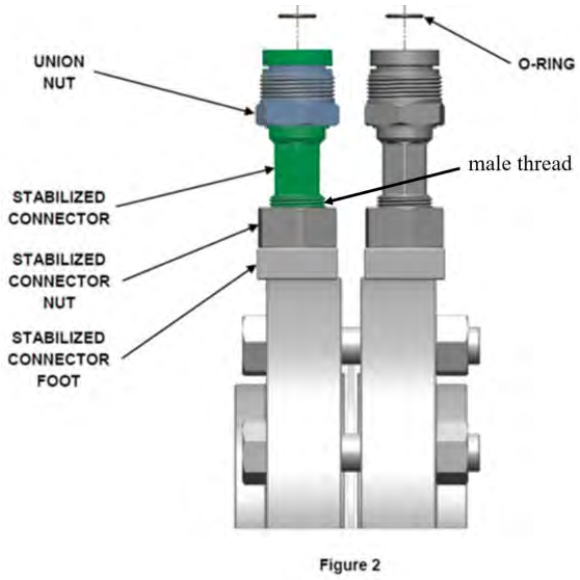


Figure 2 of Parker-1 (with annotation)

As shown below, the above-described male thread and clamping nut of Parker-1 are identical to the male thread and clamping nut of Parker-2. Thus, the above-mapping is identical for each reference.



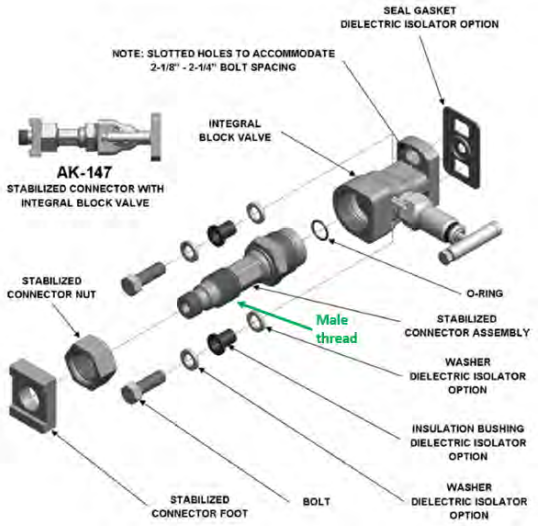


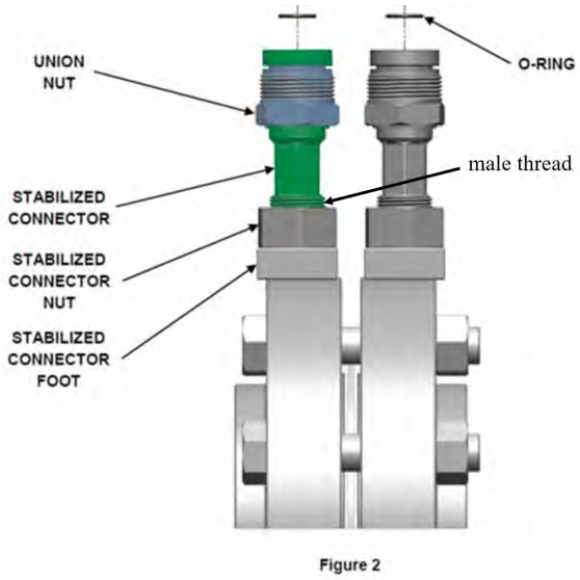
Figure 2 of Parker-1
(annotated with color/text)

Parker-2
(annotated with text)

Exhibit 1010, Fig. 2; Exhibit 1011.

[192]. Regarding claim 5, the connecting apparatus of Parker-1 includes a baseplate or "stabilized connector foot", as seen in annotated Figure 2 that has a through-opening through which the stabilized connector (first connecting device) passes in a longitudinal direction. *See* Ex. 1010 at pg. 5 and Fig. 2. A POSITA would have understood that the stabilized connector foot of Parker-1 is clamped by the clamping nut or "stabilized connector nut" on the surface of the pipeline.

As shown below, the "stabilized connector foot" of Parker-1 is identical to the "stabilized connector foot" of Parker-2 Thus, the above-mapping is identical for each reference.



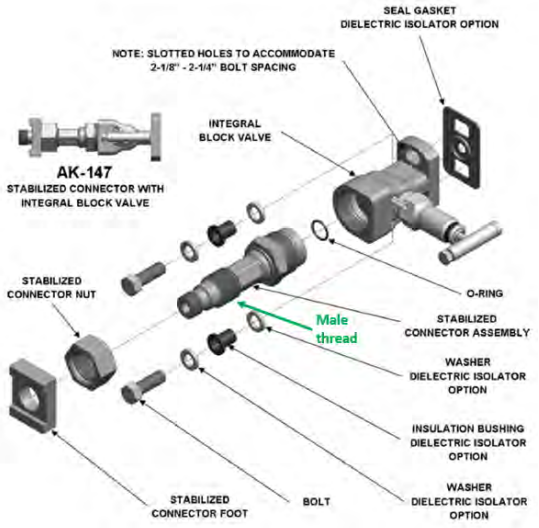


Figure 2 of Parker-1 (annotated with color/text)

Parker-2 (annotated with text)

Exhibit 1010, Fig. 2; Exhibit 1011.

[193]. Regarding claim 6, the block valve (second connecting device) of Parker-1 has an outwardly pointing outer flange at its upper edge region for connecting to a measuring instrument, as seen in Figure 4 (shown below with annotations). *See* Ex. 1010 at pg. 6 and Fig. 4.

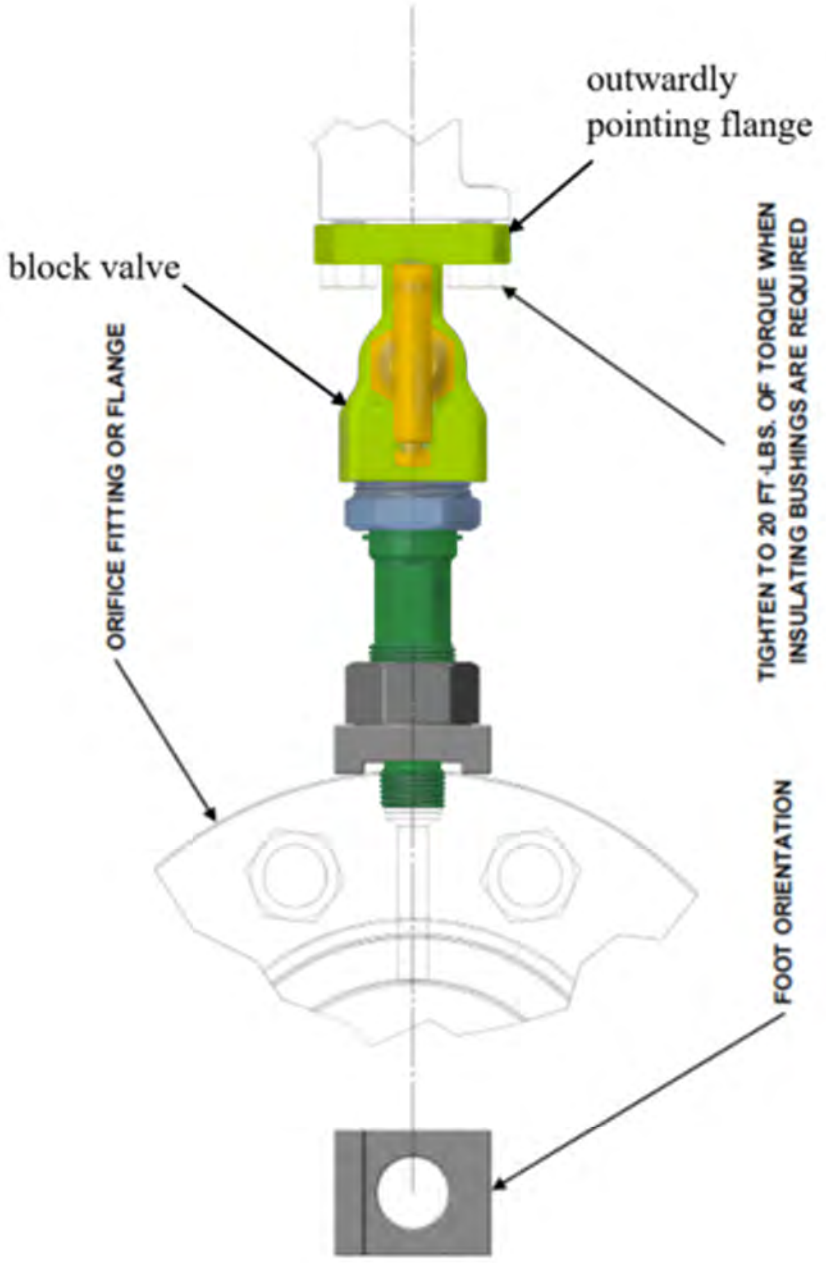
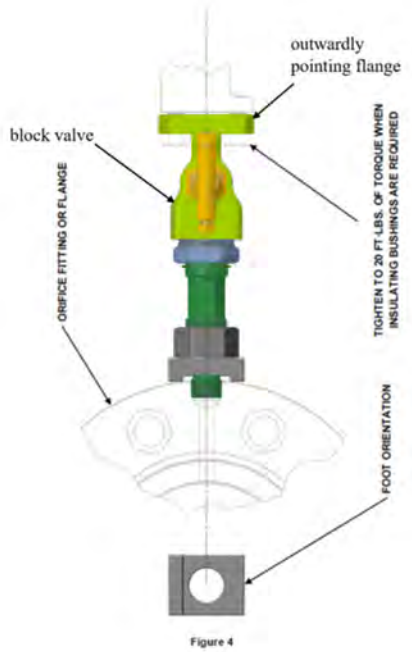


Figure 4 of Parker-1 (annotated with text)

[194]. A POSITA would have recognized that the slotted holes of the flange are designed to receive bolts to attach the measuring instrument to the block valve.

As shown below, the outwardly pointing outer flange of Parker-1 is identical to the outwardly pointing outer flange of Parker-2. Thus, the above-mapping is identical for each reference.



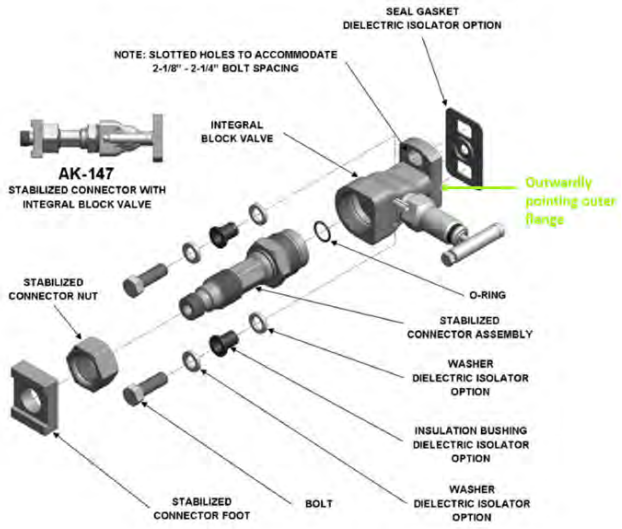


Figure 2 of Parker-1 (annotated with color/text) *Parker-2 (annotated with color/text)*

Exhibit 1010, Fig. 4; Exhibit 1011.

[195]. Regarding claim 7, the shutoff valve of the block valve (second connecting device) of Parker-1/Parker-2 has a longitudinal axis that extents at a right angle with respect to the longitudinal axis of the connecting apparatus.

5. Claims 1, 2, 3, 6, and 7 are Obvious Under 35 U.S.C. § 103 in view of the 2008 Hook-Ups Catalog Combined with the 2012 Accessories Catalog and the Common Knowledge of a Person of Ordinary Skill in the Art

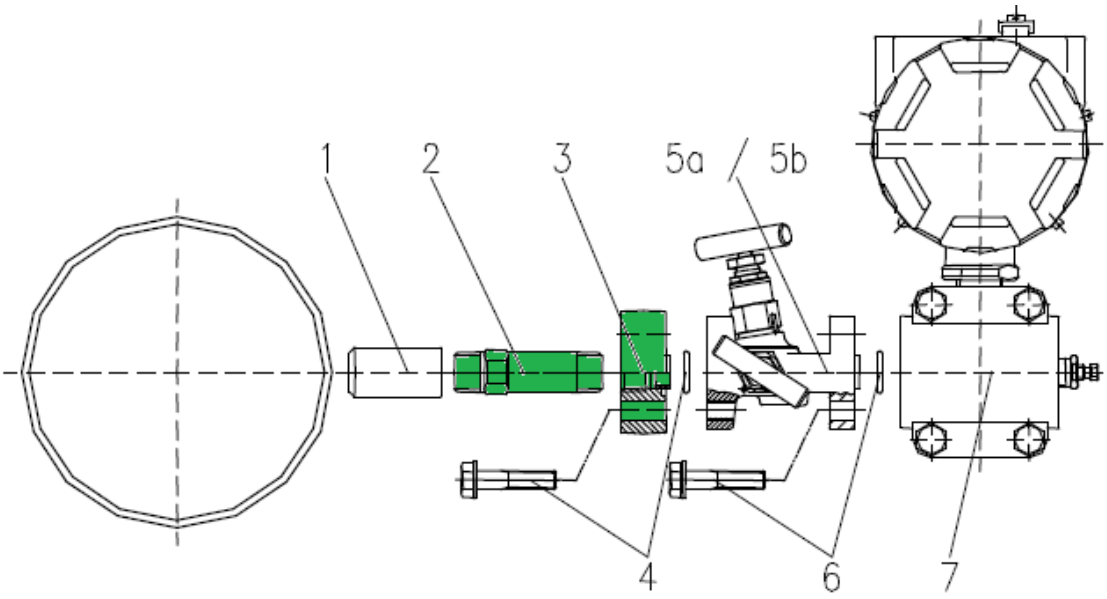
[196]. As discussed in more detail below, independent claim 1 and dependent claims 2-7 are obvious over the 2008 Hook-ups Catalog in view of the 2012 Accessories Catalog and the common knowledge of a POSITA at the time of the effective filing date of the application for the ’030 patent. Briefly, similar to the connecting apparatus of the ’030 patent, the 2008 Hook-ups Catalog advertises a hook-up product for “Differential pressure instruments mounted directly to the process line (DPD)” (hereinafter “the DPD”). *See* Ex. 1006 at pgs. 51-52. Like the’030 patent, the DPD connects a first connecting device of the process line with a second connecting device of a pressure measuring instrument in a sealing manner, as recited in claim 1.

[197]. The only feature of claim 1 of the ’030 patent not found in the DPD is a union nut connection between the first and second connecting devices. That

feature, however, is taught by Patent Owner's own 2008 Installation Products Catalog, which advertises a "swivel gauge adaptor" (hereinafter "the Schneider adaptor") which is structured as a conventional union connection. *See* Ex. 1008 at pg. 111. Union connections and the benefits thereof were well known at the time of the filing of the application for the '030 patent. Thus, it would have been obvious to a POSITA to modify the connection between the first and second connecting devices of the DPD to be the union connection of the Schneider adaptor as combining prior art elements to yield predictable results of a sealed connection between the first and second connection devices without requiring rotation of either device.

[198]. A POSITA would have recognized that the DPD of the 2008 Hook-ups Catalog is a connecting apparatus because it is configured for directly mounting, i.e. connecting, an instrument for "differential pressure measurement" on a gas "process line." *See* Ex. 1006 at pgs. 51-52.

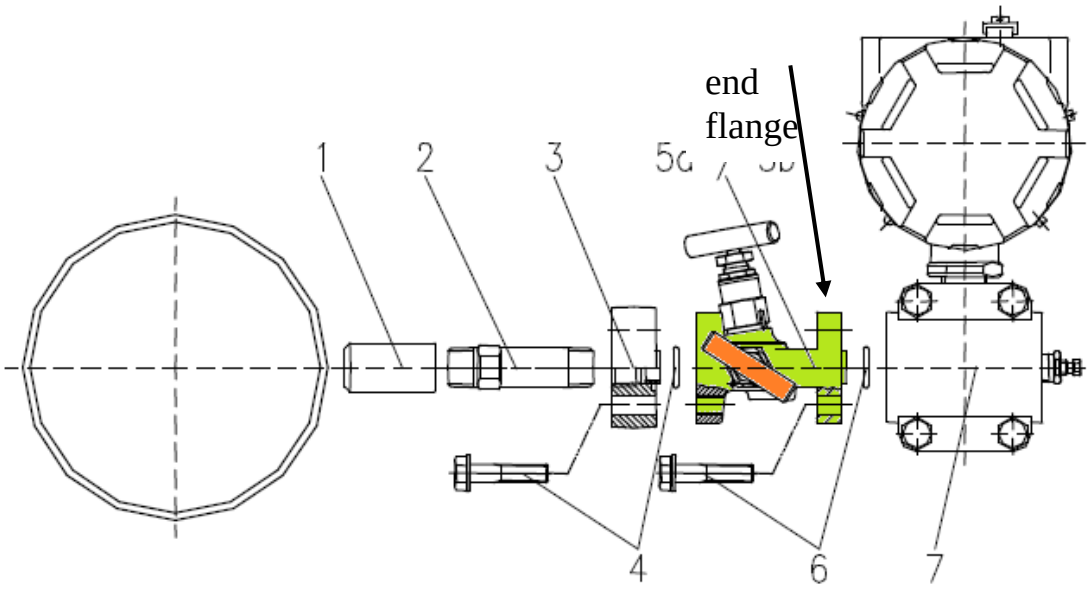
[199]. The DPD includes a "hex nipple 2" (**green**) (and its associated flange 3) that connects with the process line, as shown in the annotated view below of the DPD. *See* Ex. 1006 at pg. 52.



Exploded view of the DPD (annotated with color)

[200]. A POSITA would have understood that the hex nipple 2 of the DPD is a connecting device because it connects to the process line. A POSITA would have also understood that the hex nipple 2 necessarily has a longitudinal through-opening to allow a fluid connection to the "instrument 7" for measuring the differential pressure of the gas flow in the process.

[201]. The DPD includes a "valve manifold" 5a/5b (**lime**) that connects to the instrument 7 in a sealing manner via a seal ring 6, as shown in the annotated exploded view below of the DPD. *See* Ex. 1006 at pg. 52.

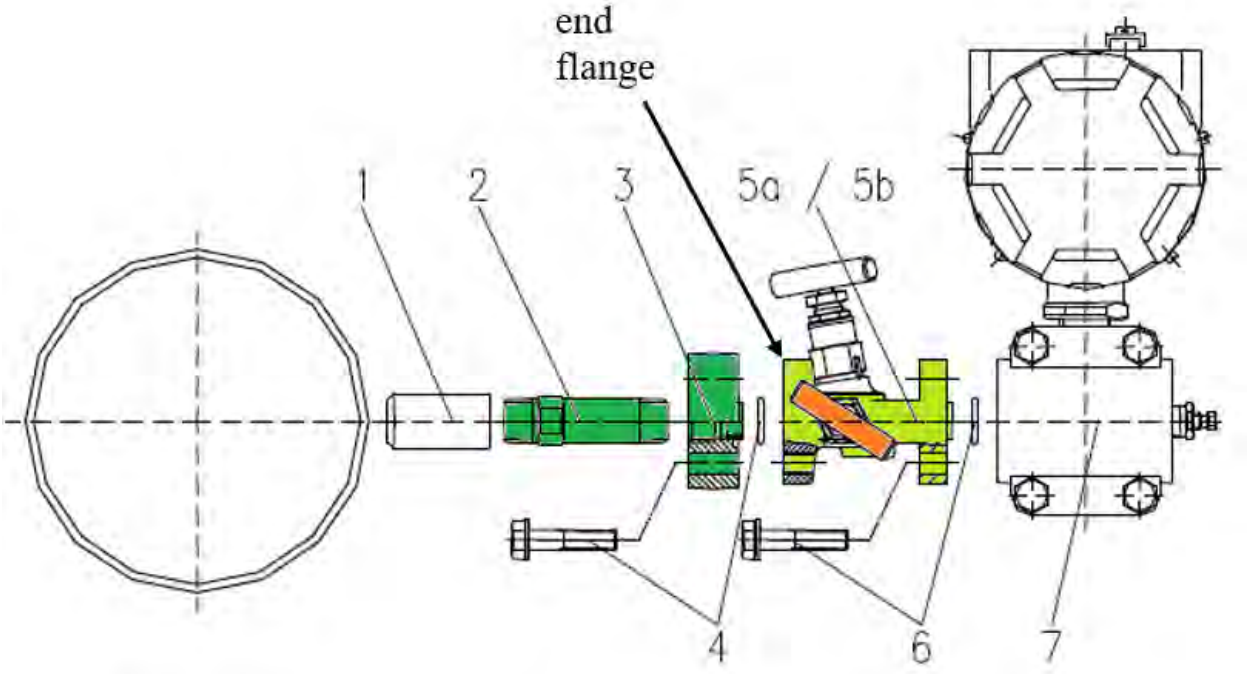


Exploded view of the DPD (annotated with text and color)

[202]. A POSITA would have recognized that the valve manifold 5a/5b is a connecting device because it connects to the instrument 7 via an end flange thereof that is bolted to the instrument 7, as seen in the annotated view above. A POSITA would have also recognized that the valve manifold 5a/5b of the DPD necessarily has a longitudinal through-opening for maintaining the fluid connection to the instrument 7 from the process line. The pressure in the process line could not be measured by the instrument 7 without such a through-opening.

[203]. The DPD does not have a connecting unit that is specifically a nut connection. Instead, the DPD employs a bolted flange connection. More

specifically, the bolted flange connection of the DPD includes an "oval flange 3" (**green**) of the hex nipple 2 (**green**) that is bolted to a corresponding end flange of the valve manifold 5a/5b, as seen in the annotated view below. *See* Ex. 1006 at pg. 52.



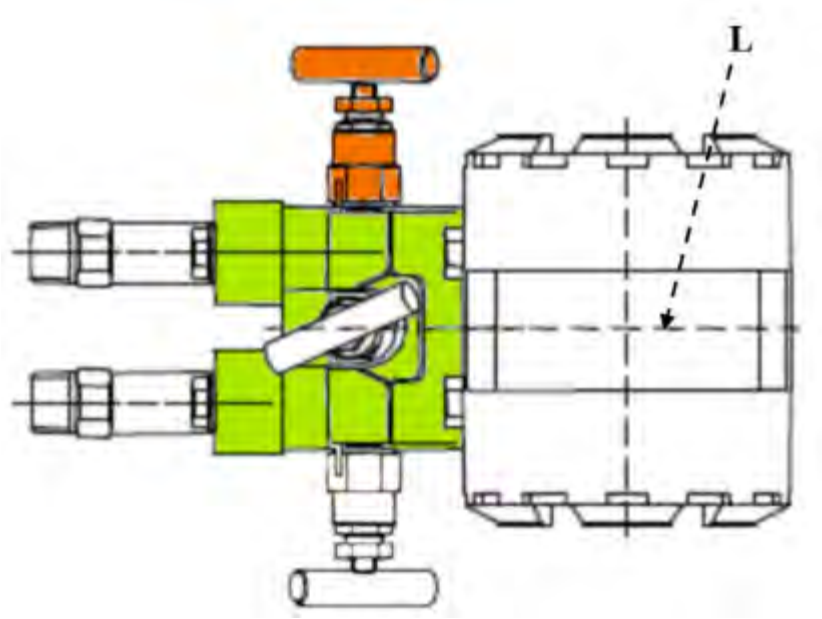
Exploded view of the DPD (annotated with color and text)

[204]. Union connections were well known in the art at the time of the filing of the 030 patent. Patent Owner's own product from its 2012 Accessories Catalog, i.e. the Schneider adaptor, is such a conventional union connection. A POSITA would have found it obvious to substitute the bolted flange connection of the DPD with a conventional union connection, like the Schneider adaptor, in

view of the known benefits of a union connection. Moreover, a POSITA would have recognized that modifying the DPD to incorporate its own Schneider adaptor would have been a mere design choice with no impact on the operation of the hook-up.

[205]. Other reasons a POSITA would prefer a conventional union connection, like the Schneider adaptor, over the bolted flange connection of the DPD include the ability to install two such units in close proximity without rotation of the shutoff valves which would otherwise interfere, the ability to maintain a close coupling environment, and the added tolerance and flexibility in connecting the instrument to the process line.

[206]. A POSITA would have recognized that the DPD includes two shutoff valves, one for each line. The shutoff valve is integrated into the valve block 5a/5b (second connecting device) (**lime**), as seen in the view below of the DPD (annotated to show the shutoff valve in **orange**).



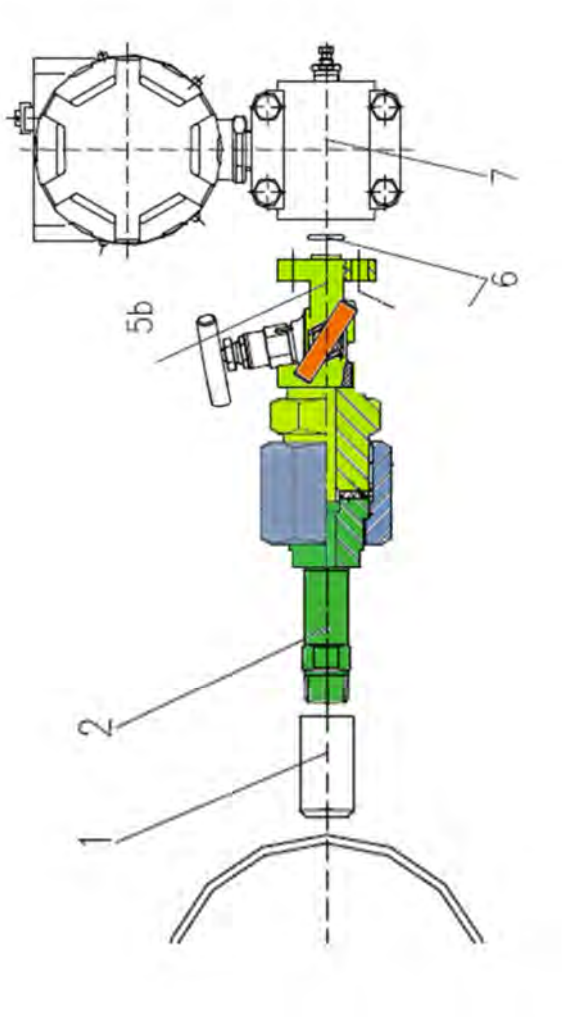
Assembled elevational view of the DPD (annotated with text and color)

[207]. As seen above, the shutoff valve is at a right angle to the longitudinal axis (designated as L) of the DPD and thus extends obliquely.

[208]. The hex nipple 2 (first connecting device) (**green**) and the valve manifold 5a/5b (second connecting device) (**lime**) of the DPD, as modified to incorporate the structure of a conventional union connection, as discussed in more detail below, would be connected with sealing effect because they are clamped together with a seal ring 4 arranged therebetween, when the union nut is rotated and screwed onto the valve manifold 5a/5b to pull the two connecting devices together.

[209]. A POSITA would have understood that the DPD, as modified to incorporate the Schneider adaptor, would maintain the seal between the first and second connecting devices (provided by the seal ring 4) solely by rotating the union nut of the modified DPD and without rotating either of the first and second connecting devices.

[210]. As explained above, it would have been obvious to a POSITA to modify the DPD to employ the Schneider adaptor instead of the bolted flange connection. The Schneider adaptor is a conventional union connection that includes a nut that interconnects first and second connecting devices. *See* Ex. 1008 at pg. 111. For clarity, see the figure below, created by replacing the bolted flange connection of the DPD with the union connection of the Schneider adaptor.



[211]. The Schneider adaptor and the union connection both allow two pressure lines to be connected together without rotating those lines.

[212]. The Schneider adaptor comprises a lower connection (**green**) which can be a first connecting device, an upper connection (**lime**) which can be a second connecting device, and a union nut (**blue**) interconnecting the two

devices in a sealing manner, as seen in the annotated figure below of the Schneider adaptor.

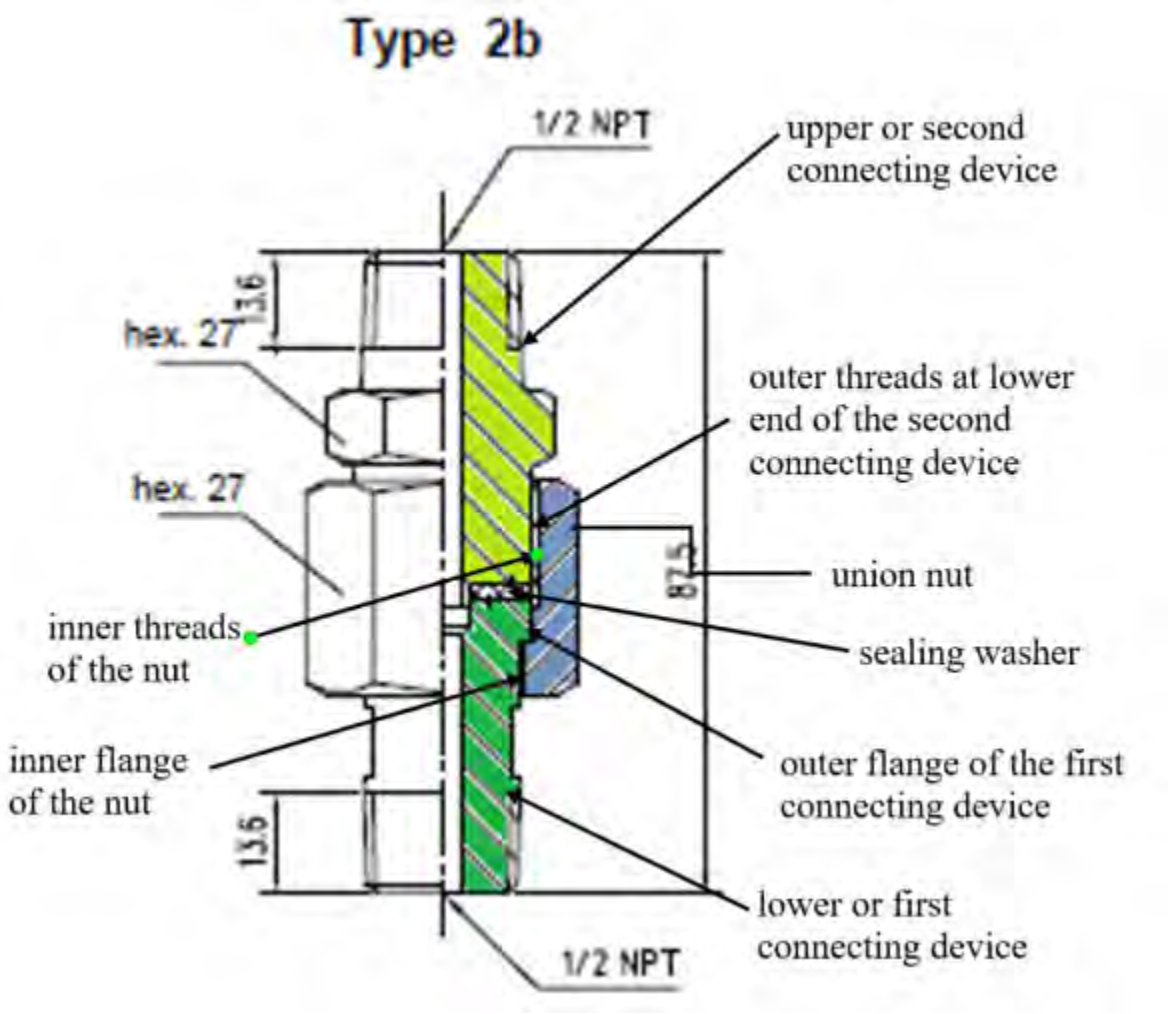
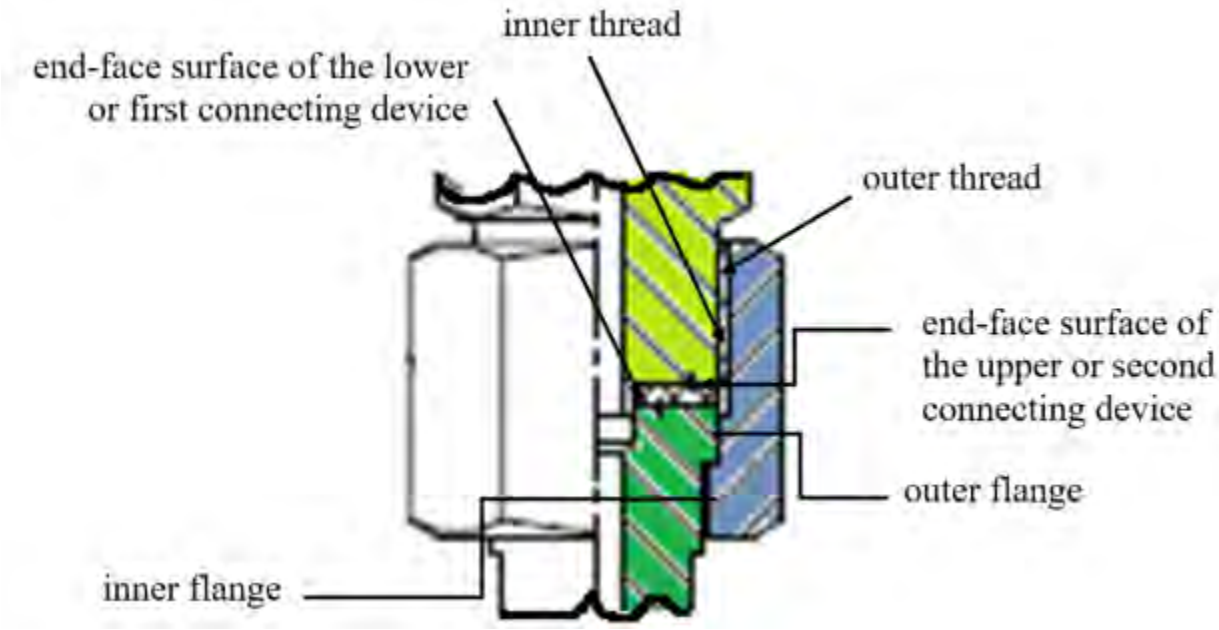


Figure of the Schneider adaptor from the 2008 Instrumentation Products Catalog (annotated with text and color)

[213]. As seen above, the nut (**blue**) of the Schneider adaptor has an inner surface with inner or female threads and an inner flange at an end of the nut and points inwardly. The inner flange of the nut (**blue**) of the Schneider adaptor is

designed to engage an outer or outwardly pointing flange at an end or edge region of the first connecting device (**green**) in a manner such that, when assembled, the outer flange sits behind the inwardly pointing flange. The inner flange of the nut (**blue**) extends around the inner circumference of the nut's inner surface and thus is provided in an encompassing manner. And the outer flange extends around the outer circumference of the first connecting device (**green**) and thus is provided in an encompassing manner.

[214]. Also, the inner or female threads of the nut (**blue**) of the Schneider adaptor are designed to engage corresponding outer or male threads on the second connecting device (**lime**), as seen in the annotated partial view below of the Schneider adaptor.

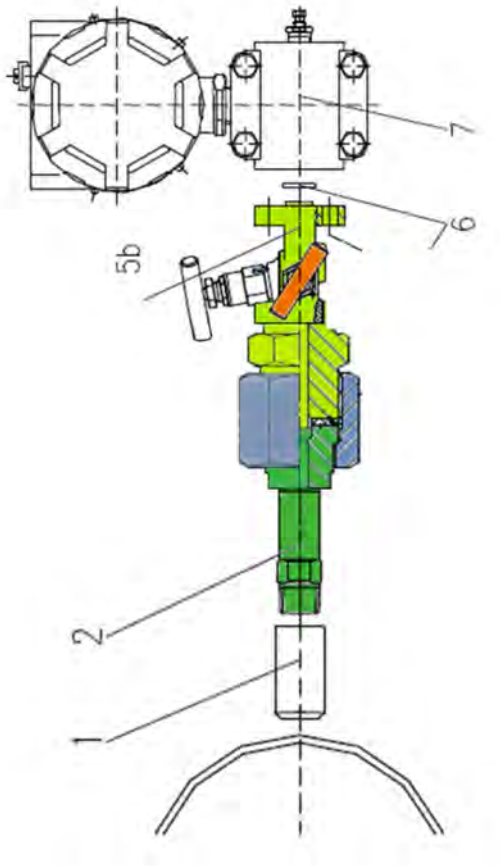


Partial view of the Schneider adaptor (with annotations)

[215]. Also, when the nut (**blue**) of the Schneider adaptor is screwed onto the second connecting device (**lime**), that is the inner and outer threads engage one another, the respective end-face surfaces of the first and second connecting devices are pulled and clamped together via the inner and outer flanges to create a seal, therebetween, that is with "sealing effect", as seen in the view above.

[216]. Although the DPD is shown in the catalog in a horizontal orientation with respect to the process line, a POSITA would have understood that the DPD could have been mounted to the process line in any desired orientation based on the type of fluid in the pipeline, including a vertical orientation, as a matter of choice and without impacting the function of the hook-up. As such, if the DPD was mounted vertically on the process line, then the hex nipple 2 (first connecting device) thereof would be positioned below the valve manifold 5a/5b (second connecting device) with the bolted flange connection being therebetween. As such, the DPD, as modified to replace the bolted flange connection with the Schneider adaptor, would necessarily have the outer flange of the first connecting device (i.e. hex nipple 2) arranged at an upper edge region thereof, the male thread of the second connecting device (i.e. valve manifold 5a/5b) arranged at a lower edge region thereof, and the inner flange arranged at a

lower edge region of the nut, as seen in the figure below showing the DPD with the Schneider adaptor.

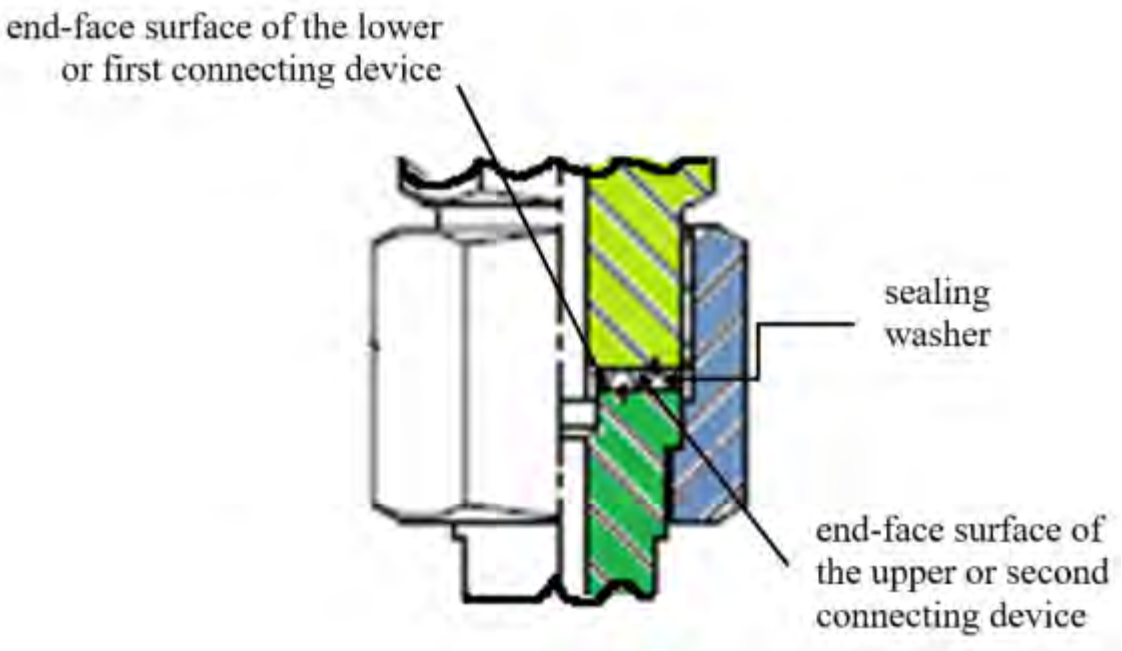


[217]. It would have been obvious to a POSITA to modify DPD to incorporate the union connection of the Schneider adaptor. A POSITA understood that non-rotating connections can have one of two different and basic configurations, i.e. a bolted-flange configuration, as in DPD, or a union

configuration, as in the Schneider adaptor. This is a simple substitution of one non-rotating connection configuration (i.e. DPD) for another (i.e. the Schneider adaptor) that would yield predictable results, i.e. of a non-rotating connection, and maintain the benefits thereof, such as connecting the first and second connecting devices without having to rotate either device. It would have been obvious to a POSITA to try the Schneider adaptor in DPD, because, as stated above, there are a finite number of predictable solutions with a reasonable expectation of success. A POSITA would have understood that a bolted flange and a union are no different in purpose, function, or utility as it relates to connecting pipes or device ends. The non-rotating connection configuration is a mere design choice. Using a union in place of a bolted flange would lead to a predictable result and reasonable expectation of success because the purpose of the threads is simply to mate the first and second connecting devices. Furthermore, unions are simple hardware, and a POSITA would have chosen the union configuration based on economic factors such as cost or accessibility. The union configuration offers the advantage of being more compact and more forgiving for misalignments. Thus, these finite variations in use are based on market forces and the uses are predictable to a POSITA. Finally, there is a teaching, suggestion, or motivation to combine DPD and Schneider, because DPD teaches using a non-rotating connection for connecting process lines to a

valve block, and the Schneider catalog teaches various types of hardware that can be substituted or adapted to tools in this industry for making process line connections.

[218]. The DPD includes a sealing means, that is the seal ring 4, arranged between the flange 3 of the hex nipple 2 (first connecting device) and the corresponding flange of the valve manifold 5a/5b (second connecting device), which are bolted together. Likewise, the Schneider adaptor of the 2012 Accessories Catalog illustrates this common positioning of a sealing washer between end faces of the first and second connecting devices that is the lower (first connecting device) (**green**) and the upper (second connecting device) (**lime**), as seen in the partial view of the Schneider adaptor below. *See* Ex. 1008 at pg. 111.

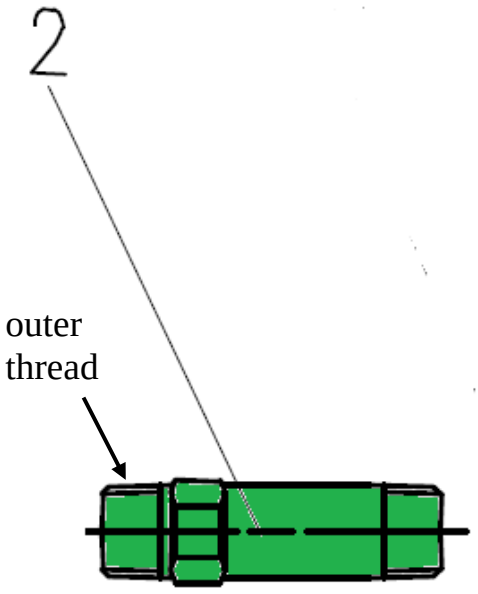


Partial view of the Schneider adaptor of the 2008 (annotated with text and color)

[219]. As such, a POSITA would have recognized that the sealing means provided by the DPD would be maintained if modified to incorporate the connection taught by the Schneider adaptor. Any limitation of claim 1 not met by DPD of the 2008 Hook-ups Catalog is shown in the 2012 Accessories Catalog, particularly with regards to the Schneider adaptor. And the benefits of the Schneider adaptor could be predictably applied to the bolted flange connection of the DPD. A POSITA would also have a reasonable expectation of success in making that modification because it merely involves using a conventional union connection, like the Schneider adaptor, for its intended purpose.

[220]. Moreover, all of the claimed elements were known in the prior art and a POSITA would have combined the elements as claimed by known methods, with no change in their respective functions. It would have been obvious to substitute the union-nut connector for the bolt flange connector to obtain the known benefits of a conventional union connection, such as allowing connection of two components without the need to rotate those components.

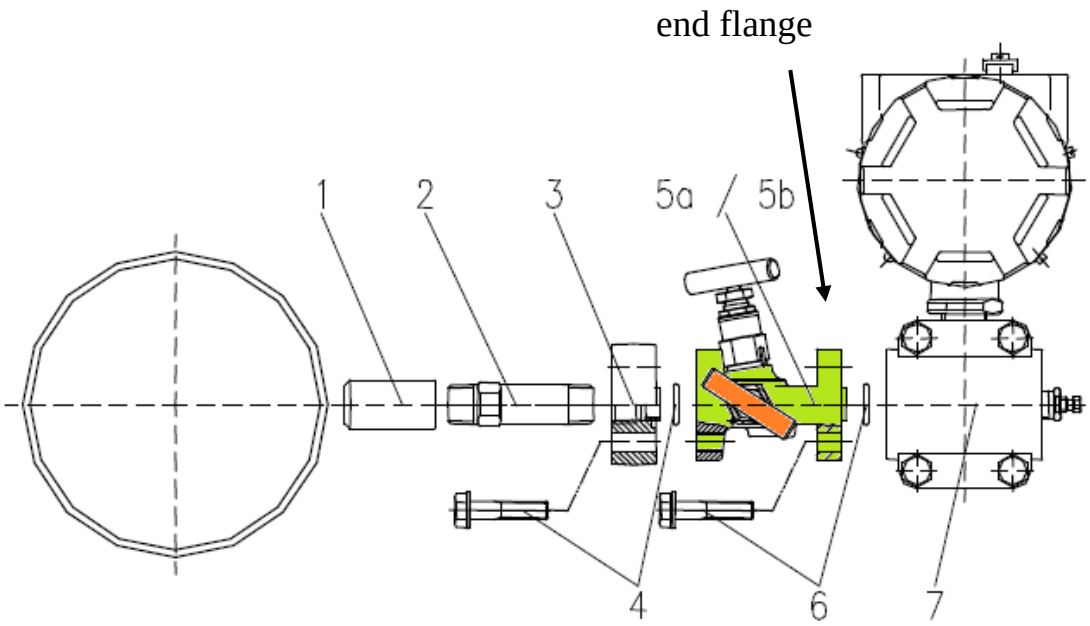
[221]. Regarding claim 2, the hex nipple 2 (first connecting device) (**green**) of the DPD of the 2008 Hook-ups catalog has a thread at its lower end, as seen in the partial exploded view below.



Partial exploded view of DPD (annotated with text and color)

[222]. Regarding claim 3, the outer thread at the lower end of the hex nipple 2 (first connecting device) has a conical shape, as seen in the view above. A POSITA would recognize that the outer thread is an NPT which is commonly used and found in the Schneider catalogs. An NPT is defined as a tapered or conical type of thread.

[223]. Regarding claim 6, the valve manifold 5a/5b (second connecting device) (**lime**) of the DPD has an outwardly pointing outer flange (identified as the "end flange" in the exploded view below) that connects to a measuring instrument, that is instrument 7, via bolts 6.



Exploded view of the DPD (annotated with text and color)

[224]. To the extent that the DPD is considered to require the horizontal orientation shown, which Petitioner does not believe it does, a POSITA would have understood that the DPD could be vertically oriented on the process line and still function in the same way and manner. A POSITA would have understood that the specific orientation of the DPD shown in the catalog is simply a choice of the installer and would have no impact on the function of the hook-up or pressure measurement. A POSITA would understand that the orientation can depend upon the type of fluid in the pipeline. For example, for natural gas, the meter is on the upper side. It would have been obvious to a POSITA to arrange the DPD in any chosen orientation, including a vertical orientation, as shown in the figure above, where the hex nipple 2 is below the valve 5a/5b. In the vertical orientation, the outer flange of the valve manifold 5a/5b is at the upper edge region of the valve manifold 5a/5b, as claimed.

X. CONCLUSION

[225]. I declare that all statements made herein of my knowledge are true, and that all statements made on information and belief are believed to be true, and that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code. I further declare under penalty of perjury under the laws of the United States of America that the

foregoing is true and correct.

Date: 04/25/2024



Dr. John P. Rodgers, Ph.D., P.E.

Appendix A

JOHN P. RODGERS, Ph.D., P.E.

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RIDGEFIELD, CT 06877

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EDUCATION

Massachusetts Institute of Technology
Cambridge, Massachusetts
Department of Aeronautics and Astronautics

-Ph.D. received October 1998.
Major in Structures Technology and Minor in Estimation and Control.
Thesis Title: *Development of an Integral Twist-Actuated Rotor Blade for Individual Blade Control.*

-Master of Science received May 1995.
Thesis Title: *Modeling and Manufacturing of Adaptive Composite Plates Incorporating Piezoelectric Fiber Composite Plies.*

Duke University
Durham, North Carolina
Department of Mechanical Engineering and Material Science

-Bachelor of Science in Engineering received December 1992.
Graduation with Departmental Distinction
Scholarship Recipient, National Academy for the Advancement of Nuclear Power
-Second major in Mathematics.

AREAS OF EXPERTISE

Knowledgeable in a variety of fields related to mechanical, materials, and aerospace, and downhole engineering, including:

- Structural design and analysis
- Actuation and sensing
- Vibration and noise
- Smart materials
- Manufacturing and QC
- Fluid mechanics and dynamics
- Downhole tool design and test
- Forensic engineering
- Electromagnetics
- Aerodynamics and aeroelasticity
- Structural dynamics
- Active control systems
- Polymer-matrix composites
- Crash/shock survival
- Heat transfer
- Testing and characterization of materials, devices, systems
- Machine design
- Intellectual property
- Instrumentation and sensing

EXPERIENCE

Starboard Innovations, LLC, *President, Founder*
Ridgefield, CT
March 2000-present
Engineering consulting company specializing in concept development, new technology research, design, analysis, prototyping, and testing. Recent projects include:

- Development of multiple downhole oilfield tools and integration of new technologies including sensing, autonomous positioning, explosives safety, acoustic telemetry, remote power generation, vibration mitigation; multi-disciplinary FEA, electromagnetic design; support for field testing and operations; qualification testing for thermal, pressure, shock, explosive operations; strength analysis, damage prediction, and troubleshooting of mechanical systems; downhole equipment operation and design including fracturing equipment, perforating equipment, drilling equipment, wellbore plugging devices, valves; slickline, wireline, coiled tubing, tubing-conveyed, casing-conveyed, and drillstring tools; well completions.
- Development of shock simulation software package and shock sensing downhole tool for predicting, measuring, and optimizing perforating gun string and wellbore dynamics. Prediction of tool string failure under operational loading.
- Participation on multiple failure investigation teams that included extensive simulations and tests to demonstrate causation; successful in reducing client liability in negotiations. Rapid redesign of deficient design elements to enable a return to reliable service.
- Analysis of oilfield rig and surface equipment systems operations, including autodrillers, pipe handling tools, coiled-tubing injectors, umbilical handling, desanders, and produced water evaporators.
- Development and implementation of food production engineering systems for major snack food manufacturer.
- Support for large-scale power grid energy storage system design and installation.
- Litigation support and expert witness for plaintiff and defense involving trade secret, product liability, personal injury, contract disputes, and IP.
- Intellectual property development and research, competitive patent analysis.
- Rotorcraft vibration reduction using active material treatments and integrated on-blade actuation technology for Bell Helicopter (Variable Geometry Advanced Rotor Technology program)
- Crashworthy aircraft seat design using shape memory materials and rotorcraft occupant restraint systems for NASA and Air Force

More information at http://www.starboardinnovations.com

Midé Technology Corporation, ***Senior Engineer***
Cambridge, Massachusetts
November 1998-February 2000
Active in technology, product, and business development.
- Co-developer, PowerAct™, a novel piezoceramic actuator/sensor
- Principal Investigator for Air Force-funded research program to develop advanced rotor concepts and team lead for Bell Helicopter Dynamically-Tailored Airframe Structures program

The MIT Active Materials and Structures Laboratory, ***Research Assistant***
Cambridge, Massachusetts
May 1995-October 1998
- Project leader for design, manufacture, and hover testing of a Mach-scale active helicopter rotor blade for individual blade control of vibrations and noise
- Developed manufacturing process for and characterized active fiber composite piezoelectric actuators
- Teamed with Boeing as part of Smart Structures for Rotorcraft Consortium
- Aided in design and led implementation of Mach-scaled rotor test stand facility

The MIT Space Engineering Research Center, ***Research Assistant***
Cambridge, Massachusetts
January 1993-May 1995

- Developed a Rayleigh-Ritz model of a composite plate with embedded, anisotropic active materials and acoustic radiation
- Designed, manufactured, and tested adaptive composite plates with active plies

Duke University Department of Mechanical Engineering, ***Laboratory Assistant***
Durham, North Carolina
May 1992-December 1992

- Fabricated and tested a fiberglass wind-tunnel model for measuring airfoil pressure distribution with LabView data acquisition system virtual instrument shell

NASA Langley Research Center, Configuration Aeroelasticity Branch, ***Intern***
Hampton, Virginia
June 1991-August 1991

- Performed aerothermoelastic analysis of a NASP vertical tail using a finite element model

---

PROFESSIONAL ACTIVITIES

Licensed Professional Engineer (PE) in mechanical engineering in TX, ND, CT

American Society of Mechanical Engineers (ASME), Associate Member, PE License Review Instructor

Guest Lecturer at Texas Christian University, University of North Texas

Society of Petroleum Engineers (SPE), Member

American Institute of Aeronautics and Astronautics (AIAA), Member

---

PUBLICATIONS

Craddock, G.G. Rodgers, J. et al, "Dynamic Response of Side-Mounted Guns and Assessment of the Potential Damage Risk to Sensitive Tools", SPE-195006-MS, presented at SPE Middle East Oil and Gas Show and Conference, March 2019.

Rodgers, J., Glenn, T.S., Serra, M., "Prediction of Gun String Dynamic Failure Risks during Perforating", presented at the North American Perforating Symposium, 2019 NAPS 6.3, Arlington, TX, Aug. 2019.

Anderson, M., Rios, F., Rodgers, J. et al, "The Dynamic Loading Effects of Non-linear Gun Connectors During and After Detonation", presented at the 2018 Latin American Perforating Symposium, Bogota, Columbia, Oct. 2018.

Rodgers, J., Glenn, T.S., Serra, M., Craddock, G.G., "High-Fidelity Finite Element Analysis of Deepwater Gun-Parting Failures", presented at the North American Perforating Symposium, NAPS-46-18, July 2018.

Glenn, T.S., Serra, M., Rodgers, J. et al, "Validation of a Finite Element Simulation of a Downhole Perforating Gun String through Comparison with Data from a New Datalogging Sensor Sub", presented at ASME 2015 Verification and Validation Symposium, May 2015.

Wight et al, "New Shock Sensing Sub Permits Greater Understanding of the Dynamic Response of Perforating Gun Strings", IPS-14-03, presented at the 2014 International Perforating Symposium, May 2014.

Glenn, T.S., Serra, M., Rodgers, J., Wight, J., Zhang, W., Craddock, G.G., Harive, K. "Investigating the Dynamic Three-Dimensional Loading Effects on Perforating Guns Imposed by Shaped Charges – Downhole Evaluation". OTC 24891. Presented at Offshore Technology Conference – Asia, Malaysia, March, 2014.

Craddock, G.G., Zhang, W., Wight, J., Rodgers, J., Glenn, T.S., Serra, M., and Bettenmann, T. "Investigating the Dynamic Three-Dimensional Loading Effects on Perforating Guns Imposed by Shaped Charges". Presented at the International Petroleum Technology Conference, Doha, Qatar, 19–22 January, 2014.

John P. Rodgers, "Energy Harvesting for Powering Remote Sensors and Other Devices", presented at the U. Texas - Arlington Workshop on Piezoelectric Energy Harvesting, Arlington, TX, January 2006.

A. Lengyel and J. Rodgers, "Energy Absorbing Technology for Crashworthy Seats", 61st AHS Annual Forum, Grapevine, TX, June 2005.

M. R. Smith, R. J. Pascal, T. Lee, F. Brad Stamps, M. C. van Schoor, B. P. Masters, C. Blaurock, E. F. Prechtl, J. P. Rodgers, and D. J. Merkley, "Results from the Dynamically Tailored Airframe Structures Program", Proceedings of the AHS 58th Annual Forum, Montreal, June 3-5, 2002.

M. R. Smith, R. J. Pascal, M. C. van Schoor, B. P. Masters, C. Blaurock, E. F. Prechtl, J. P. Rodgers, and D. S. Friedmann, "Dynamically Tailored Airframe Structures Program", Proceedings of the AHS 57th Annual Forum, Washington, DC, May 9-11, 2001.

Douglas B. Weems, Robert C. Derham, Nesbitt Hagood, and John Rodgers, "Structural Modeling of a Rotor Blade Incorporating Active Fiber Composites", Fourth ARO Workshop on Smart Structures, State College, PA, August 16-18, 1999.

J.P. Rodgers and N.W. Hagood, "Hover Testing of a 1/6th Mach-Scale CH-47D Blade with Integral Twist Actuation", Proceedings of the 9th International Conference on Adaptive Structures and Technologies, Cambridge, MA , October 1998.

J.P. Rodgers and N.W. Hagood, "Preliminary Mach-Scale Hover Testing of an Integral Twist-Actuated Rotor Blade", Proceedings of the SPIE Symposium on Smart Materials and Structures, San Diego, CA, March 1998.

J.P. Rodgers and N.W. Hagood, "Design, Manufacture, and Testing of an Integral Twist-Actuated Rotor Blade", proceedings of the 8th International Conference on Adaptive Structures and Technologies, Wakayama, Japan, October 1997.

J.P. Rodgers, N.W. Hagood, and D.B. Weems, "Design and Manufacture of an Integral Twist-Actuated Rotor Blade", AIAA Paper No. 97-1264, Proceedings of the 38th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, Kissimmee, FL, April 1997.

J.P. Rodgers, A.A. Bent, and N.W. Hagood, "Characterization of Interdigitated Electrode Piezoelectric Fiber Composites for High Electrical and Mechanical Loading" SPIE Paper 2717-60, Proceedings of the SPIE Symposium on Smart Materials and Structures, San Diego, CA, February 1996.

J.P. Rodgers and N.W. Hagood, “Modeling and Manufacturing of Adaptive Composite Plates Incorporating Piezoelectric Fiber Composite Plies”, AMSL Report #95-4, Massachusetts Institute of Technology, May 1995.

J.P. Rodgers and N.W. Hagood, “Manufacture of Adaptive Composite Plates Incorporating Piezoelectric Fiber Composite Plies”, Proceedings of the 36th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, New Orleans, LA, April 1995.

A.A. Bent, N.W. Hagood, and J.P. Rodgers, “Anisotropic Actuation with Piezoelectric Fiber Composites”, Journal of Intelligent Material Systems and Structures, Volume 6, No. 3, pp. 338-349, 1995.

J.P. Rodgers, “Applications of Active Actuator Materials for Adaptive Satellite Structures”, MIT Course Handout, December 1994.

J.P. Rodgers, “Aerothermoelastic Analysis of a NASP-Like Vertical Fin”, Proceedings of the 33rd AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, Dallas, TX, April 1992.

US PATENTS

10465498 – Fast test application for shock sensing subassemblies using shock modeling

10337320 – Method and systems for capturing data for physical states associated with perf.

10337299 – Perforating apparatus and method having internal load path

10161723 – Charge case fragmentation control for gun survival

10151152 – Perforating gun connectors

10138718 – Perforation crack designator

9909408 - Protection of electronic devices used with perforating guns

9909384 - Multi-actuating plugging device

9598940 - Perforation gun string energy propagation management system and methods

9447678 - Protection of electronic devices used with perforating guns (8978817*)

9091152 - Perforating gun with internal shock mitigation

9051812 - Through tubing bridge plug and installation method for same (10024132*)

9019798 - Acoustic reception

8985200 - Sensing shock during well perforating

8978817 - Protection of electronic devices used with perforating guns

8978749 - Perforation gun string energy propagation management with tuned mass damper

8893801 - Method and apparatus for pressure-actuated tool connection and disconnection

8881816 - Shock load mitigation in a downhole perforating tool assem.
(8714252*,8714251*)

8714270 - Anchor assembly and method for anchoring a downhole tool

8555959 - Compression assembly and method for actuating downhole packing elements

8490686 - Coupler compliance tuning for mitigating shock produced by well per. (8393393*)

8408286 - Perforating string with longitudinal shock de-coupler (8397800*)

8397814 - Perforating string with bending shock de-coupler

7781939 - Thermal expansion matching for acoustic telemetry system (7557492*)

7595737 - Shear coupled acoustic telemetry system

7363967 - Downhole tool with navigation system

7325605 - Flexible piezoelectric for downhole sensing, actuation and health mon (7234519*)

7322416 - Methods of servicing a well bore using self-activating downhole tool

7246660 - Borehole discontinuities for enhanced power generation

*Denotes additional patents in same family.

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CASE SUMMARY

Start Date	Case	Party	Venue	Case Type	Firm	Outcome	Depo	Court Testify
						TOTALS:	**20**	**10**
2023	WELLMATICS/GR ENERGY V. CANATEX	Canatex	PTAB	IPR	Cabello Hall Zinda		0	0
2022	CANATEX v. WELLMATICS/GR ENERGY	Canatex	S. Distr. TX	Infringe	Cabello Hall Zinda		0	1
2022	IMDEX/AUSTRALIAN MUD CO. v GLOBALTECH	Imdex	PTAB	IPR	Covington		0	0
2022	DYNA ENERGETICS v. HUNTING TITAN, INC.	Dyna	S. Distr. TX	Infringe	Womble Bond Dickinson	No infringe; patent valid	1	1
2021	G&H DIVERSIFIED MFG. v. DYNA ENERGETICS GMBH & CO. KG	Dyna	PTAB	PGR	Womble Bond Dickinson	G&H	1	0
2021	DYNA ENERGETICS GMBH & CO. KG v. SWM, NEXTIER	Dyna	PTAB	PGR	Womble Bond Dickinson		2	0
2021	SCHLUMBERGER V. DYNA ENERGETICS	Dyna	PTAB	PGR	Womble Bond Dickinson	dropped	0	0
2021	DYNA ENERGETICS V. SCHLUMBERGER	Dyna	S. Distr. TX	Infringe	Womble Bond Dickinson	dropped	0	0
2021	KLX V. MAGNESIUM MACHINE	KLX	W. Distr. OK	Contract/ trade secret	Shearman & Sterling		1	0
2021	DYNA ENERGETICS v. BEAR MANUFACTURING	Dyna	N. Distr. TX	Infringe.	Womble Bond Dickinson	dismissed	0	0
2021	DYNA ENERGETICS v. OSO PERFORATING	Dyna	N. Distr. TX	Infringe.	Womble Bond Dickinson	dismissed	1	0
2021	DYNA ENERGETICS v. SWM PERFORATING	Dyna	N. Distr. TX	Infringe.	Womble Bond Dickinson	dismissed	1	0
2021	HUNTING TITAN, INC. v. DYNA ENERGETICS GMBH & CO. KG	Dyna	PTAB	PGR	Womble Bond Dickinson		0	0
2021	NABORS v. H&P/MOTIVE AND COUNTERCLAIM	Nabors	N. Distr. TX	Infringe.	Raley & Bowick	Settled at trial	1	1
2020	HUNTING TITAN, INC. v. DYNA ENERGETICS GMBH & CO. KG	Dyna	PTAB	PGR	Womble Bond Dickinson	Dyna	0	0

2020	Varel v. Taurex	Varel	ITC	ITC	Raley & Bowick	Settled	0	0
2020	Core Laboratories v. Stratum Reservoir	Core	S. Dist. TX	Infringe.	Seiler Mitby		0	0
2020	NCS MULTISTAGE INC., v. TCO PRODUCTS, Inc.	NCS	W. Dist. TX	Infringe.	Blank Rome	jury - NCS	2	1
2020-2022	NCS MULTISTAGE INC. v. Nine Energy Service, Inc.	NCS	W. Dist. TX	Infringe.	Blank Rome	jury - NCS	2	1
2020	HUNTING TITAN, INC. v. DYNA ENERGETICS GMBH & CO. KG	Dyna	PTAB	PGR	Womble Bond Dickinson	Dyna	0	0
2020-2021	IPT GLOBAL, LLC, and INNOVATIVE PRESSURE TESTING, LLC, v. OFFSHORE TECHNICAL COMPLIANCE LLC	IPT	S. Dist. TX	Infringe., IPR	Conley Rose	OTC	1	0
2019-2020	JAMES DAVID BAIRD v. YMCA, YMCA v. ASCO L.P.	ASCO/ Emerson	Iowa, Scott Cty.	Liability	Pearce Durick	Settled	0	0
2019-2021	NATIONAL OILWELL VARCO v. MANOJ GOPALAN and RIME DOWNHOLE TECHNOLOGIES, LLC	NOV	Tarrant Cty. TX	Trade secret	Raley & Bowick	Dropped	1	0
2018-2019	BAKER HUGHES v. INNOVEX DOWNHOLE SOLUTIONS	Innovex	PTAB	IPR	Kirkland & Ellis	--	1	0
2018-2019	NATIONAL OILWELL VARCO v. COIL SOLUTIONS	NOV	Canadian Federal	Infringe.	Belmore Neidrauer	--	0	0
2018-2022	JAMES AINSWORTH v. NOBLE, PRUITT TOOL & SUPPLY	Pruitt	Harris Cty. TX	Liability	Raley & Bowick, Donato Brown	Settled	0	0
2018-2019	SPECIALIZED DESANDERS v. ENERCORP	Enercorp	Canadian Federal	Infringe.	Miller Thomson	Settled	0	0
2018	WEATHERFORD TECHNOLOGY HOLDINGS, LLC, v. TESCO CORPORATION	TESCO/ Nabors	US Eastern Dist. TX	Infringe.	Raley & Bowick	Settled at trial	1	1
2018-2019	HUNTING TITAN, INC. v. DYNA ENERGETICS GMBH	Dyna	PTAB	IPR	Womble Bond Dickinson	Dyna	0	0
2016-2018	NATIONAL OILWELL VARCO, L.P., v. TECHNICAL INDUSTRIES, INC	NOV	PTAB	IPR (4)	Raley & Bowick	NOV (4)	1	0
2016-2020, 2023-2024	SIMMONS v. CUDD PRESSURE CONTROL, INC.; MUREX PETROLEUM; AND SPECIALIZED TECHNICAL THREADING, INC., TILLMAN & ASSOCIATES, LLC;	Cudd	NW Dist. ND	Liability	Pearce Durick, Sutter Law	Trial	1	2
2016-2017	TULLOW OIL VS. VALLOUREC	Vallourec	N/A	Pre-litigation	Clyde & Co.	--	0	0
2015	WPX ENERGY WILLISTON, LLC VS. ARMADA PRESSURE CONTROL, LLC; TERVITA, LLC; SAGE CONSULTING, LLC; AND	Thru-Tubing	Harris Cty. TX	Liability	Brown Sims	Settled	0	0

	THRU-TUBING SOLUTIONS, INC.							
2013-2014	PEAK COMPLETION TECHNOLOGIES, INC. AND SUMMIT DOWNHOLE DYNAMICS, LTD., v. TEAM OIL TOOLS, L.P	Team	Dist. Court Midland, TX	Trade secret	Jackson Walker	Trial	1	1
2007-2009	TOTAL SEPARATION SOLUTIONS, LLC, v. F. ALAN "BUD" FRICK, BUTLER & COOK, INC.	TSS	Harris Cty. TX	Trade secret	Fulkerson Lotz	Trial	1	1

Appendix B
Reserved

Appendix C

Advanced science. Applied technology.

Search

ORIFICE FLOW METER CALIBRATION

Orifice meters measure flow rates using differential pressure created when a fluid passes through an orifice plate. The flow calculations use a form of the Bernoulli equation with an empirical discharge coefficient. Orifice flow meter calibration helps reduce uncertainty in the discharge coefficient from 0.5% to 0.25%.

Orifice meters are normally built to specification from standards such as API 14.3, AGA 3, and ISO 5167. Southwest Research Institute performs flow calibrations to lower uncertainty by matching the Reynolds number to the final application. Improved flow measurement improves accuracy for computing plant efficiency, system balances and end-user consumption.

Orifice Plate Calibration & Flow Meter Services



Flow calibration of an orifice flange fitting and plate over the application Reynolds number

range.

Flow calibrations and tests at SwRI typically require one day for setup and checkout and half a day for testing. Clients can witness tests in person or monitor remotely. Reports can be generated that reference either API 14.3/AGA-3, ASME PTC 19.5, or any other commonly used orifice meter standard.

ISO 5167 Differential Flow Meter Services

In addition to orifice plates and meters, we calibrate and test other ISO 5167 differential flow meters:

- Cone meters
- Averaging pitot meters, anemometers and other velocity flow meters
- Subsonic venturis (ASME MFC-7M and ISO 9300)
- Wedge flow meters

Orifice Flow Meter Troubleshooting & Research

SwRI has been a leader in orifice meter diagnostics for many years as evidenced by the development of the patented square root error indicator (/node/5451216/). Pulsation detection and assessment is just one of the services that we can provide to improve your measurement. SwRI can provide field audits of meter stations that include orifice meters and suggest operational and configuration changes to improve your measurement.

Many improvements to the orifice meter standards were verified by testing at SwRI's Metering Research Facility. Visit Flow Measurement Research Programs (/node/8606/) to learn how SwRI has is helping to advance technology for orifice flow meters and other flow measurement systems.

Flow Measurement & Metering Research

- Flow Measurement Services (/taxonomy/term/508/)
- Flow Measurement Research Programs (/node/8606/)
- Flow Meter Calibration Services (/node/8596/)
- Flow Test Systems & Flow Calibration Capabilities (/node/8608/)
- Metering Research Facility (/node/8607/)
- Coriolis Flow Meter Calibration (/node/239216/)
- Turbine Meter Calibration (/node/982971/)
- Ultrasonic Meter Calibration (/node/2854031/)

CONTACT US (/user/3451/contact?path=/industry/flow-measurement-servic

Or call Adam Hawley at +1 210 522 3427. (tel:+1 210 522 3427)

HOW CAN WE HELP YOU?

ADAM HAWLEY (/CONTENT/CLIENT-SERVICES-CONTACT-FORM?CSID=267791&URL=INDUSTRY/FLOW-MEASUREMENT-SERVICES/ORIFICE-FLOW-METER-CALIBRATION)

+1 210 522 3427 (tel:1 210 522 3427)

FLOW METER CALIBRATION SERVICES (/FLUID-DYNAMICS-FLOW-MEASUREMENT/FLOW-METER-CALIBRATION-SERVICES)

Coriolis Flow Meter Calibration (/industry/flow-measurement-services/coriolis-flow-meter-calibration)

Turbine Meter Calibration (/industry/flow-measurement-services/turbine-meter-calibration)

Ultrasonic Meter Calibration (/industry/flow-measurement-services/ultrasonic-meter-calibration)

Natural Gas Measurement Field Services (/industry/flow-measurement-services/natural-gas-measurement-fi

CONTACT US (/CONTACT-US?URL=/INDUSTRY/FLOW-MEASUREMENT-SERVICES/ORIFICE-FLOW-METER-CALIBRATION)

TRAINING (/EVENTS?URL=/INDUSTRY/FLOW-MEASUREMENT-SERVICES/ORIFICE-FLOW-METER-CALIBRATION)

DIRECTORY (/PROFESSIONAL-TECHNICAL-STAFF-DIRECTORY/START?URL=/INDUSTRY/FLOW-MEASUREMENT-SERVICES/ORIFICE-FLOW-METER-CALIBRATION)

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Appendix D

Parker
Instrumentation

Instrument Tube Fitting Installation Manual

Bulletin 4200-B4
March 2001



Parker
Instrumentation

Instrument Tube Fabrication Manual

This “hands-on-booklet” is an excellent reference tool for the installer of instrumentation tube fittings. It contains a number of important reminders and rules about tube bending which you will find helpful. Keep it handy for reference whenever necessary. This booklet also contains basic information on instrumentation tubing system topics such as tubing selection, tubing preparation, thread identification, port preparation, cleaning, packaging, fitting makeup and remake.

D.F. Bush
Marketing Manager

WARNING

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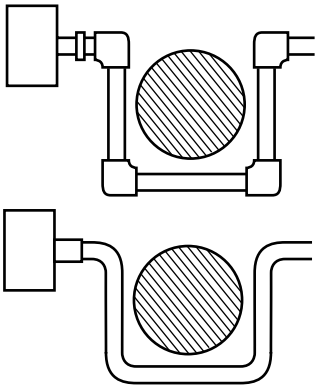
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Tubing vs. Pipe

Standard fluid line systems, whether for simple household use or for the more exacting requirements of industry, were for many years constructed from threaded pipe of assorted materials and were assembled with various standard pipe fitting shapes, unions and nipples. Such systems under high pressures were plagued with leakage problems besides being cumbersome, inefficient and costly to assemble and maintain. Therefore, the use of pipe in these systems has largely been replaced by tubing because of the many advantages it offers.



Old Method - Each connection is threaded - requires numerous fittings - system not flexible or easy to install and service connections not smooth inside - pockets obstruct flow.

Modern Method - Bendable tubing needs fewer fittings - no threading required - system light and compact - easy to install and service - no internal pockets or obstructions to free flow.

Figure 1 Tubing provides simplified, free flow system.

Major Advantages of Tubing vs. Pipe

1. *Bending Quality* - Tubing has strong but relatively thinner walls; is easy to bend. Tube fabrication is simple.
2. *Greater Strength* - Tubing is stronger. No weakened sections from reduction of wall thickness by threading.

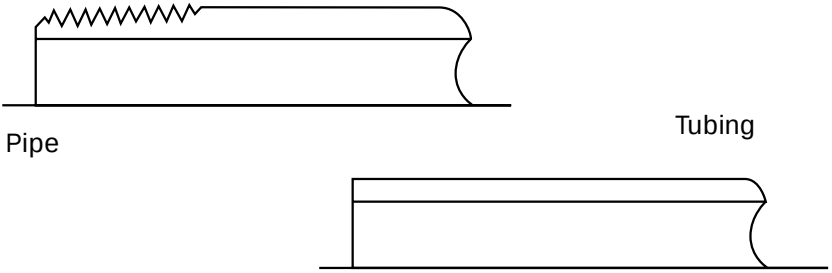


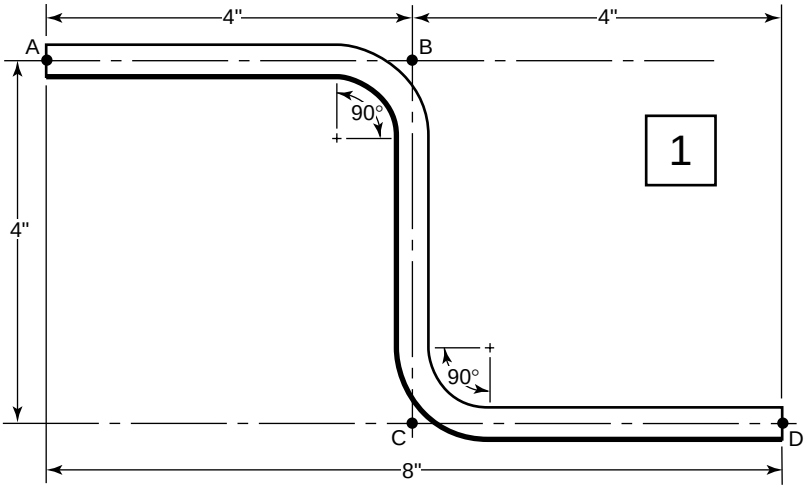
Figure 2 With no threading necessary, tubing does not require extra wall thickness

3. *Less Turbulence* - Smooth bends result in streamlined flow passage and less pressure drop.
4. *Economy of Space and Weight* - With its better bending qualities and a smaller outside diameter, tubing saves space and permits working in close quarters. Tube fittings are smaller and also weigh less.
5. *Flexibility* - Tubing is less rigid, has less tendency to transmit vibration from one connection to another.
6. *Fewer Fittings* - Tubing bends substitute for elbows. Fewer fittings mean fewer joints, fewer leak paths.
7. *Tighter Joints* - Quality tube fittings, correctly assembled, give better assurance of leak-free systems.
8. *Better Appearance* - Tubing permits smoother contours with fewer fittings for a professional look to tubing systems.
9. *Cleaner Fabrication* - No sealing compounds on tube connections. Again no threading; minimum chance of scale, metal chips, foreign particles in system.
10. *Easier Assembly and Disassembly* - Every tube connection serves as a union. Tube connections can be reassembled repeatedly with easy wrench action.
11. *Less Maintenance* - Advantages of tubing and tube fittings add up to dependable, trouble-free installations.

Principles of Tube Line Fabrication

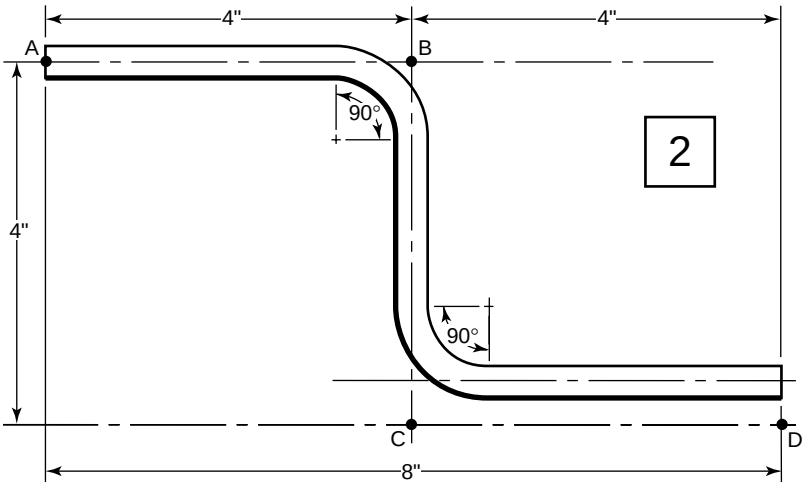
1. Measure Exactly - Bend Accurately

These are the two most important rules which must be observed when fabricating a tube line. Figure 1



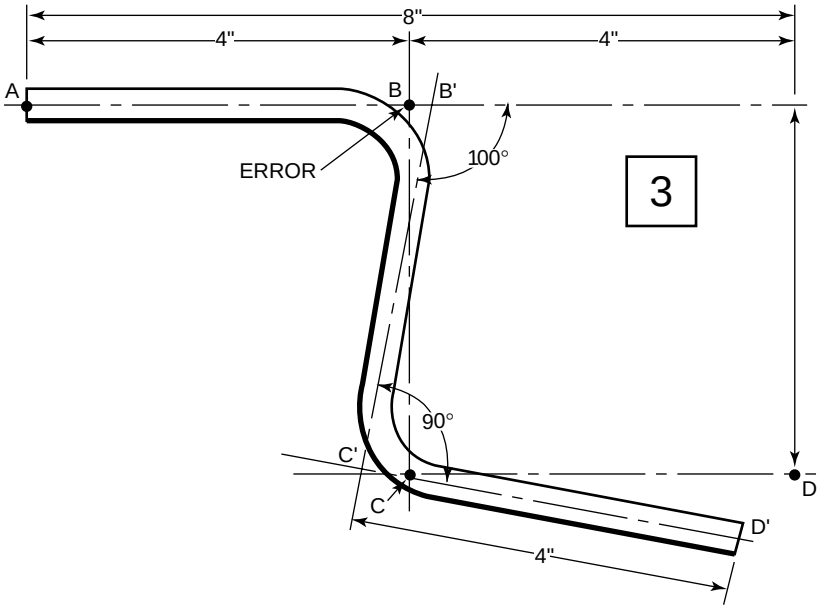
Accurate measurements coupled with exact angles may result in a tube line that will fit at points (A-D).

EXACT MEASUREMENT is required to insure that you obtain the desired distance between bends. If you do not measure exactly, the tube line will not fit. Figure 2



Measuring error on second leg (B-C) results in tube line that can not fit at point (D).

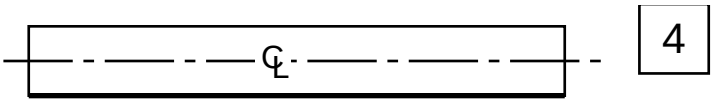
ACCURATE BENDING is necessary to achieve the exact angles required for the tube line. If you do not bend accurately, the tube line will not fit. (Figure 3)



YOU MUST ALWAYS MEASURE EXACTLY AND BEND ACCURATELY

2. Tube Centerline Basis for Measurement

The centerline of the tube is the basis for all tube line measurement. (Figure 4) Always measure from the centerline except from the first bend which is measured from the end of the tube. On most benders, the edge of the radius block is at the centerline of the tube.



3. You Control Accuracy

Remember only you can control the accuracy of your work. Use good, careful workmanship at all times.

Tube Bending Check list

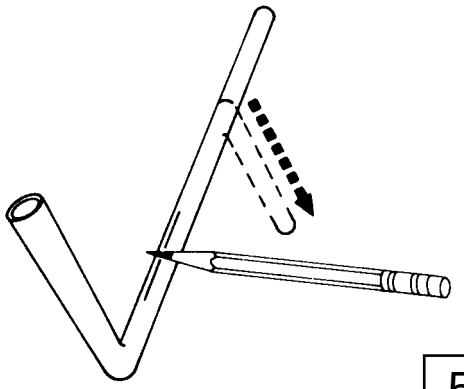
Follow this list to insure good results on each bend.

1. Measure and mark exactly. Insert tube in bender.
2. Always try to bend in the same direction! If you backbend, be sure to compensate for gain or pickup. Remember, gain always occurs to the right side of the tube radius block.
3. Clamp tubing securely in bender.
4. Check to make certain length mark is tangent to desired angle on radius block or in line with the desired degree on the link member.
5. Bend accurately to the desired angle plus springback allowance.
6. Open bender, remove tube.
7. Double check bend angle with triangle.
8. Check measurement length with tape or ruler.

Keep Track of Changes of Plane

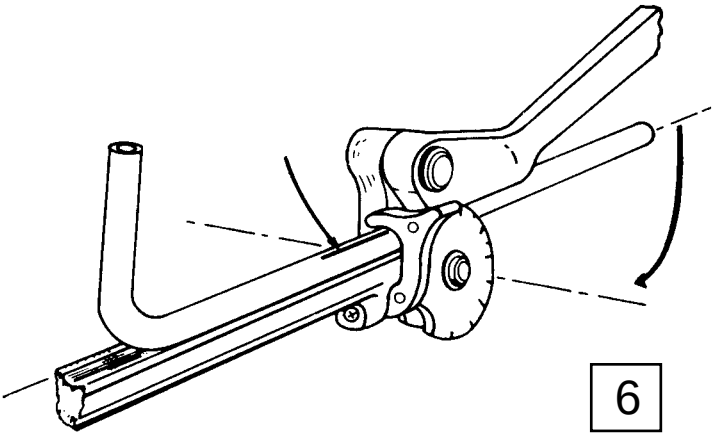
Benders bend in only one direction. Changes in plane are accomplished by rotating the tubing in the bender. To insure that the tubing is correctly placed for the desired change in plane, a reference mark on the tube is very helpful.

Bend Direction Mark



5

One method for keeping track of changes in plane is to use a longitudinal or lengthwise bend direction mark. (Figure 5) Put the mark on the side opposite the direction in which you wish to bend. When you put the tube in the bender, center the mark face up in the groove of the radius block. (Figure 6) This will insure that you bend in the correct direction. It also gives you a reference mark in case you must leave your work unfinished.

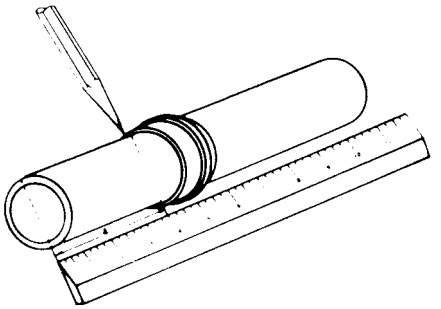


6

Marking the Tube

Whenever you make a mark on tubing, use a sharp pencil. Use a ferrule as a guide to make measurement marks all the way around the tube so that the mark is always visible. (Figure 7) Don't use grease pencils or crayons as these make too wide a line which can easily affect accuracy.

Measure and Mark

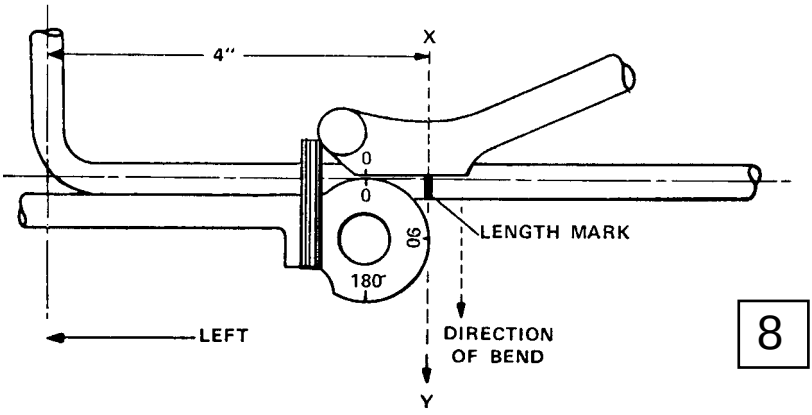


7

Never use a sharp tool to scratch marks onto tubing. Scratches create points where corrosion or stress concentration can ruin or dangerously weaken the tube.

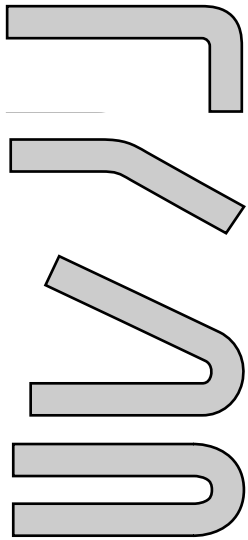
Rules for Positioning Tubing in Bender

A line which is tangent to the desired angle mark on the radius block and which passes through the measurement mark at the centerline of the tube, is used to control the distance between bend centerlines. (Figure 8)



8

Tube Positioning Rules



90˚ ANGLES - TANGENT FLUSH WITH LENGTH MARK (REFER TO DOTTED LINE XY TANGENT TO RADIUS BLOCK @ 90˚ FIG. 8.

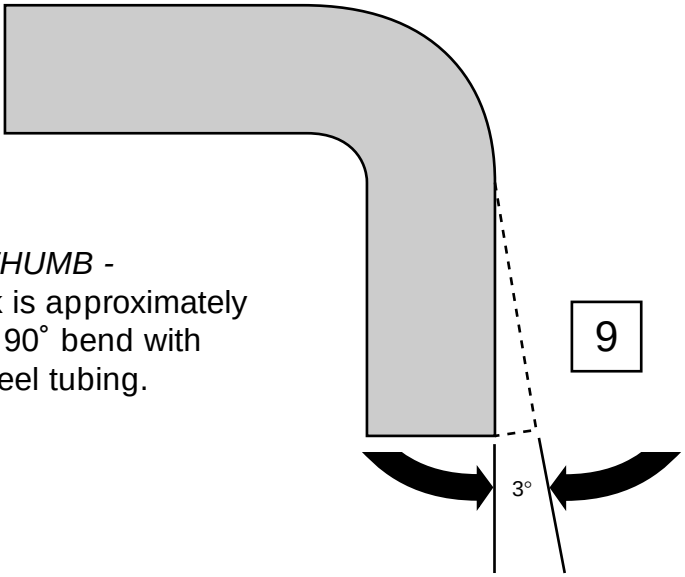
ANGLES LESS THAN 90˚ - TANGENT INTERSECTS LENGTHMARK AT CENTER-LINE.

ANGLES MORE THAN 90˚ - POSITION FOR A 90˚ BEND AND CONTINUE ON TO DESIRED ANGLE, I.E. 135˚, 145˚. (I.E. LENGTH MARK @ 90˚ ON LINK MEMBER)

HORSESHOE OR U-BENDS - MEASURE FIRST LEG, POSITION FOR 90˚, BEND AROUND TO 180˚.

Springback 90˚ Bend

RULE OF THUMB -
Springback is approximately 3˚ for each 90˚ bend with stainless steel tubing.



Compensate for springback:

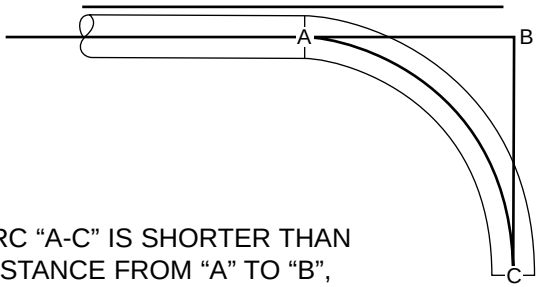
1. Test a piece of the material before you start fabricating a line to see how much it springs back on a 90˚ bend.
2. Overbend by the amount of springback. For example, if the material springs back 3˚ on a 90˚ bend, bend to 93˚ to secure a finished 90˚ bend, or to 46-1/2˚ to obtain finished 45˚ bend. This works especially well with large heavy-wall tubing.
3. Remember, it is always better to underbend slightly. You can always bend a little more if needed, but it's almost impossible to remove or straighten a bend, especially with large, heavy-wall tubing.

REMEMBER - A TUBE BENDER BENDS -
IT CAN NOT UNBEND.

Tube Stretch or Pickup

When bent, tubing seems to stretch or pick up length. This is because it takes a curved shortcut across the inside of the angle. A good “rule of thumb” for most standard tubing materials and radius blocks is that the tubing will stretch approximately one tube diameter for each 90˚ bend.

Triangle A-B-C- with Arc “A-C”



10

THE ARC “A-C” IS SHORTER THAN THE DISTANCE FROM “A” TO “B”, PLUS “B” TO “C”.

Always try to bend in the same direction - away from the original starting end. If you reverse the direction of bending (bending towards instead of away from the original starting end) you will “trap” the stretch. Thus, if you unknowingly make a reverse bend of 90˚, you will trap the gain, in table 11 (approximately one tube O.D.) and increase your length between bends by that amount.

If bend direction for either 45˚ or 90˚ bend must be reversed, subtract the “gain” amount listed in table 11.

While our rule of thumb is approximately correct, the amount of stretch is related to the diameter of the radius block used. This chart (Figure 11) gives the accurate increase in length that occurs with the most commonly used sizes of radius blocks.

As long as you measure and bend with the tube inserted from the left, and measure centerline, “pickup” will not affect your actual center-to-center measurement.

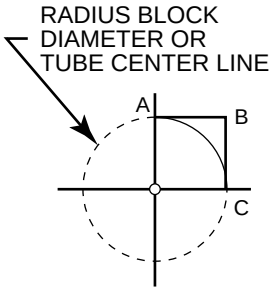
Gain - 90˚ Bend

2R- $\frac{\pi R}{2}$

or

.429 R

π = 3.1416
R= radius bender



Gain - 45˚ Bend

.8284R- $\frac{\pi R}{4}$

or

.043 R

11

Tube	Size	Radius of Bender (in inches)	Gain 90˚	Gain 45˚
1/8	2	3/8	.16	.02
3/16	3	7/16	.19	.02
1/4	4	9/16	.24	.02
5/16	5	11/16	.30	.03
3/8	6	15/16	.40	.04
1/2	8	1-1/2	.64	.06
5/8	10	1-7/8	.80	.08
3/4	12	2-1/4	.97	.10
7/8	14	2-5/8	1.13	.11
1	16	3	1.29	.13
1-1/4	20	3-3/4	1.61	.16
1-1/2	24	4-1/2	1.93	.19
2	32	*8	3.43	.34

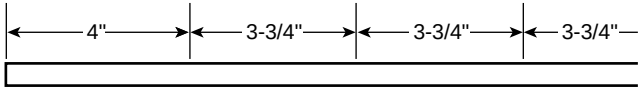
*PER AND 10111 STD

NOTE: Some radius blocks may differ. Consult individual radius block manufacturers for details on other radius diameters.

Pre-Measuring

You may pre-measure a series of bends. Measure the first bend from the end of the tube, the correct length. Compensate for each bend after the first by subtracting the amount of gain from your chart for each 90˚ of bend to allow for stretch (Figure 11). Always custom measure for the last bend.

Example of 1/4” Tubing



12

“Rule of Thumb” Method

Compensate each measurement after the first by subtracting the gain listed in table 11.

Best Way to Measure

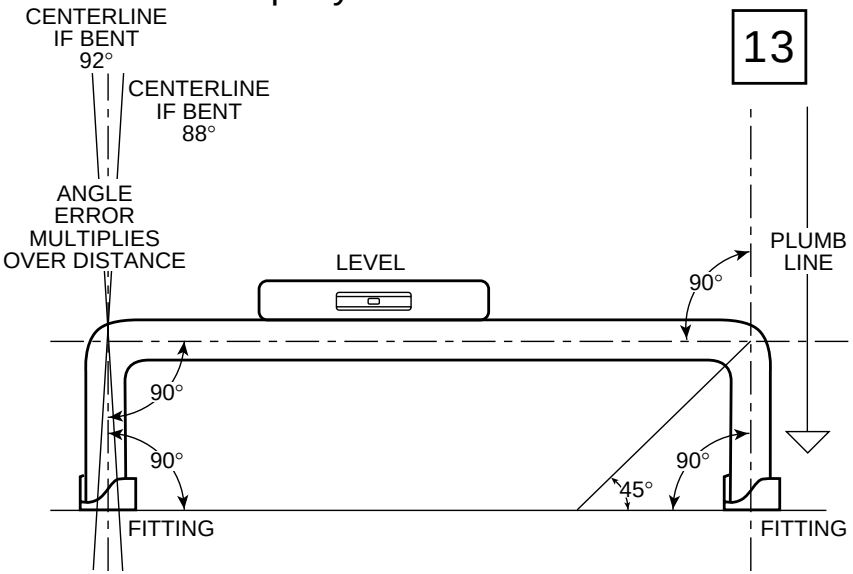
For maximum accuracy, measure and bend exactly for each individual bend in the tubing line. We recommend the practice of *Measure and Bend, Measure and Bend, etc.*

Characteristics of a Well-Made Tubing Circuit

In a well made tubing circuit or line, bends are accurate, measurement exact. The run is plumb, square and level. Tube ends rest firmly in the fittings and entry into the fittings is straight. Straight tube entry is very important to insure that fittings are not under stress and can be assembled without leaks. (Figure 13)

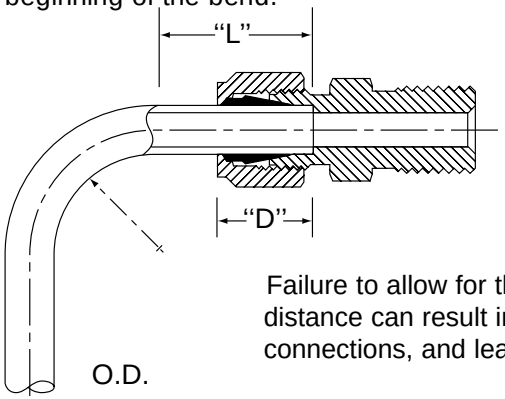
Remember too, that length magnifies bend angles errors. If the leg following the bend is fairly long, an error of 1˚ may result in the tube line missing the desired point completely.

Properly Made Tube Circuit



Recommended Free Tubing Lengths

It is important to consider the length of tubing from the end in the fitting body to the beginning of the bend.



Failure to allow for this proper distance can result in improper connections, and leaks.

TUBE O.D. inches	1/16	1/8	3/16	1/4	5/16	3/8	1/2	5/8	3/4	7/8	1	1-1/4
"L" Free Length of Straight Tubing (inches)	.50	.70	.75	.80	.88	.94	1.19	1.25	1.25	1.31	1.50	1.94
"D" Tube Insertion Depth (inches)	.38	.52	.56	.61	.66	.69	.94	.98	.98	1.05	1.22	1.61

Common Causes of Imperfect Bends

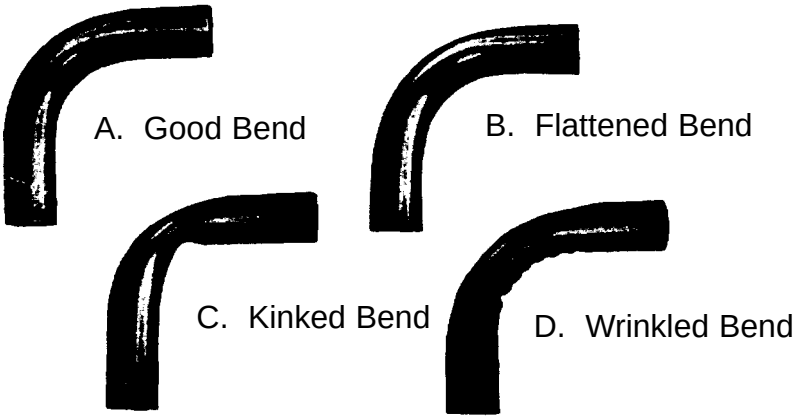
Figure A shows an ideal bend. Bends with little or no flattening are produced when correct equipment and methods are employed; when proper consideration is given to co-relationship of the radius of the bend, material wall thickness and hardness of the tube.

Figure B shows a flattened bend, caused by trying to bend too short a radius, or bending smaller diameter tube in larger radius block.

Figure C shows a kinked and flattened bend, caused by the tube slipping in the bender, or by using non-annealed tubing. Tubes must be firmly clamped by clamp block to prevent slippage during bending process.

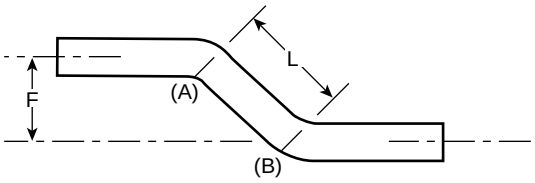
Figure D shows a wrinkled bend, sometimes produced when thin wall tube is bent.

Breakage will sometimes occur when mandrel is too far forward in tube, or when too short a radius is attempts with hard tube.



Offset Bends

To form a tube offset, it is obviously necessary to make two bends. With these Parker hand tube benders, it is easy to make double 45˚ bends. To make an offset bend simply follow the “Offset Bend Allowance” steps below to determine the proper distance between the two 45˚ bends. Here’s the procedure.



STEP 1 First, determine the total amount of offset required (dimension "F" in the diagram).

STEP 2 Next, determine the angle of offset - 30˚ or 45˚. The latter (45˚) is recommended because Parker hand benders are calibrated for 45˚ bending.

STEP 3 Figure the length of the tube required to meet your offset requirements ("L" dimension) in the diagram.

For 30 bends multiply desired offset Fx 2= 30 offset dimension L For 45 bends multiply desired offset Fx 1.414=45 offset dimension L

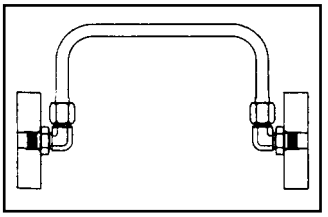
STEP 4 Determine where you want the offset bend of the tube to start; and make a reference mark (A). Now measure off the "L" dimension (determined in Step 3), starting from the reference mark and make a second mark (B). You are now ready to make the bends.

STEP 5 Align mark (A) with reference mark 45˚ on bender shoe handle (measurement end to the left) and proceed with first bend. Then align (B) with 45˚ mark and make second bend in proper direction (measurement end to the left). Follow previous detailed instructions for making 45˚ bends in one plane.

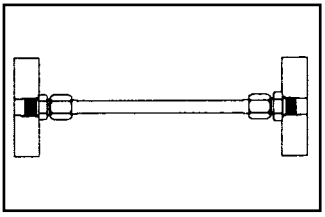
Routing of Bends

Routing of lines is probably the most difficult yet most significant of these system design considerations. Proper routing involves getting a connecting line from one point to another through the most logical path. The most logical path should:

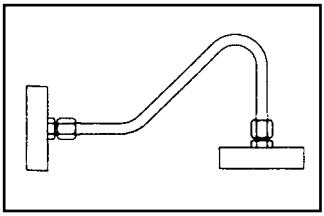
Avoid excessive strain on joints - A strained joint will eventually leak.



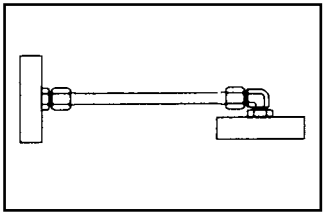
Correct Routing



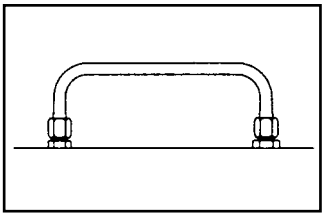
Incorrect Routing



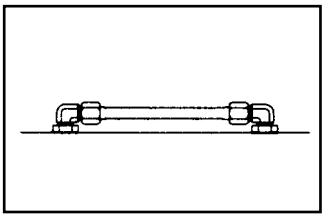
Correct Routing



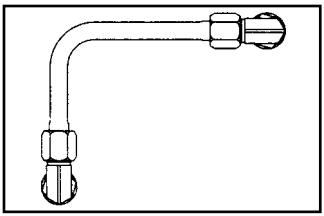
Incorrect Routing



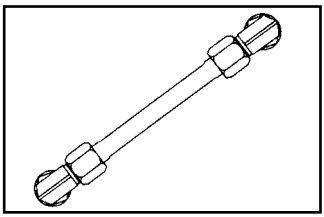
Correct Routing



Incorrect Routing

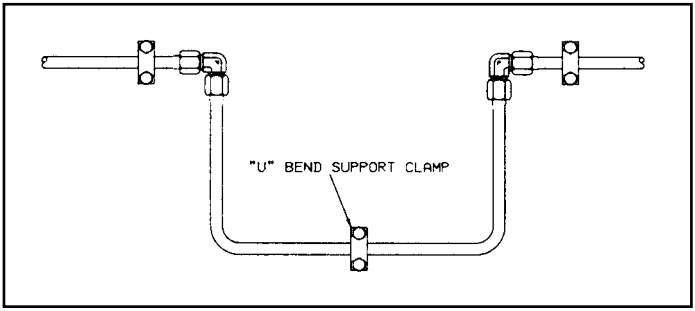


Correct Routing



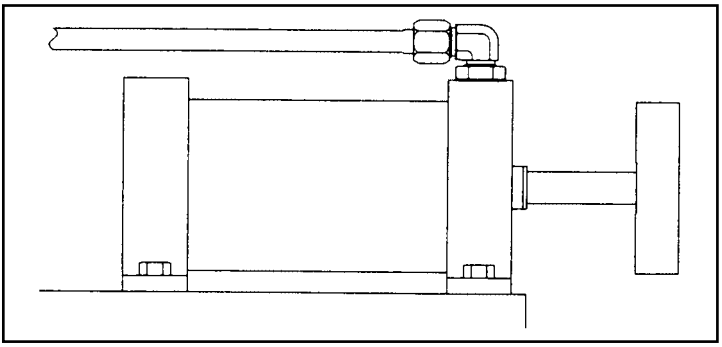
Incorrect Routing

Allow for expansion and contraction - Use a “U” bend in long lines to allow for expansion and contraction.



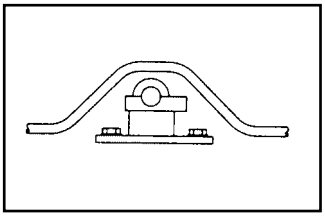
U-Bend Allowing for Expansion and Contraction

Allow for motion under load - Even some apparently rigid systems do move under load.

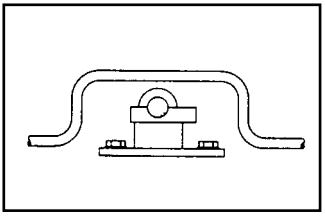


Bent Tube Allowing for Motion Under Load

Get around obstructions without using excessive amount of 90˚ bends. Pressure drop due to one 90˚ bend is greater than that due to two 45˚ bends.

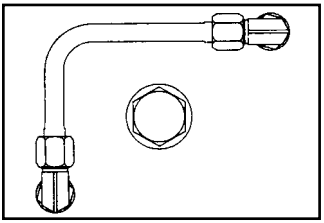


Correct

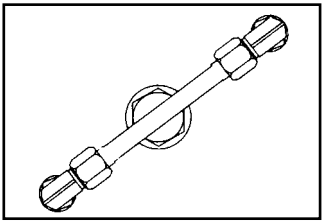


Incorrect

Keep tube lines away from components that require regular maintenance.

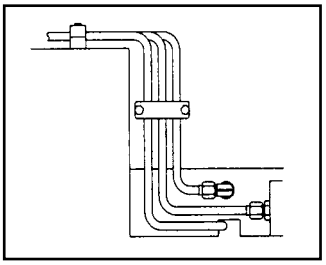


Correct

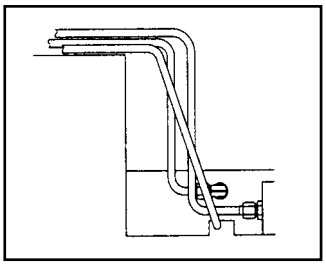


Incorrect

Have a neat appearance and allow for easy trouble shooting, maintenance and repair.



Correct



Incorrect

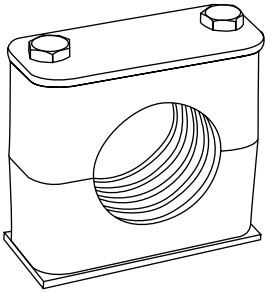
Tube Clamping

Once you've taken the time to make good bends and installed them, it's not enough to just let them lay suspended in mid-air. When tubing is left unsupported, shock and vibration will cause the tubing to shake, and in turn, cause the fitting to loosen and leak or even allow tube to fall through fatigue.

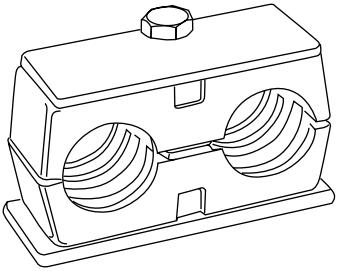
Tube support and clamping is a necessary requirement in the fluid power industry. Tubing can be clamped individually, in sets, and can also be stacked. The most important part of any clamping system is having enough clamps to attain the final result. That being, a well supported, vibration and noise free system.

Also, most manufacturers specify SAE and JIC approved components on their equipment. The best way to meet these specs concerning clamps is to utilize a clamp that employs both an upper and lower unit made of metal and a rubber split bushing which surrounds the tube or pipe and fits on the inside of the clamping units.

Parker Hannifin offers a tube clamp support system by the name of "ParKlamp". ParKlamp can clamp and support tube from 1/4" to 2" and pipe or hose from 1/4" to 1-1/2". It comes standard in steel and uses a rubber grommet around the tube for vibration dampening.



Standard Series -
for outside diameters from 1/4" to 2".
Clamp material: Polypropylene



Twin Series -
for equal or unequal outside diameters from1/4" to 2"
Clamp Material: Polypropylene

Below you will find a chart of recommended spacing between clamps. We suggest you clamp as close to each bend of the tube as possible; and you must clamp each side. This eliminates thrust in all directions.

For more information, write the Parker Hannifin Corporation, 6035 Parkland Ave, Cleveland, Ohio 44124. Catalog #4397 Parker ParKlamp.

TUBE O.D."	EQUIVALENT TUBE (mm)	FOOT SPACING BETWEEN SUPPORTS	SPACING IN METERS (Approx.)
1/4" - 1/2"	6 - 13 mm	3 ft.	.9 m
3/8" - 7/8"	14 - 22 mm	4 ft.	1.2 m
1"	23 - 30 mm	5 ft.	1.5 m
1-1/4" & up	31 & up mm	7 ft.	2.1

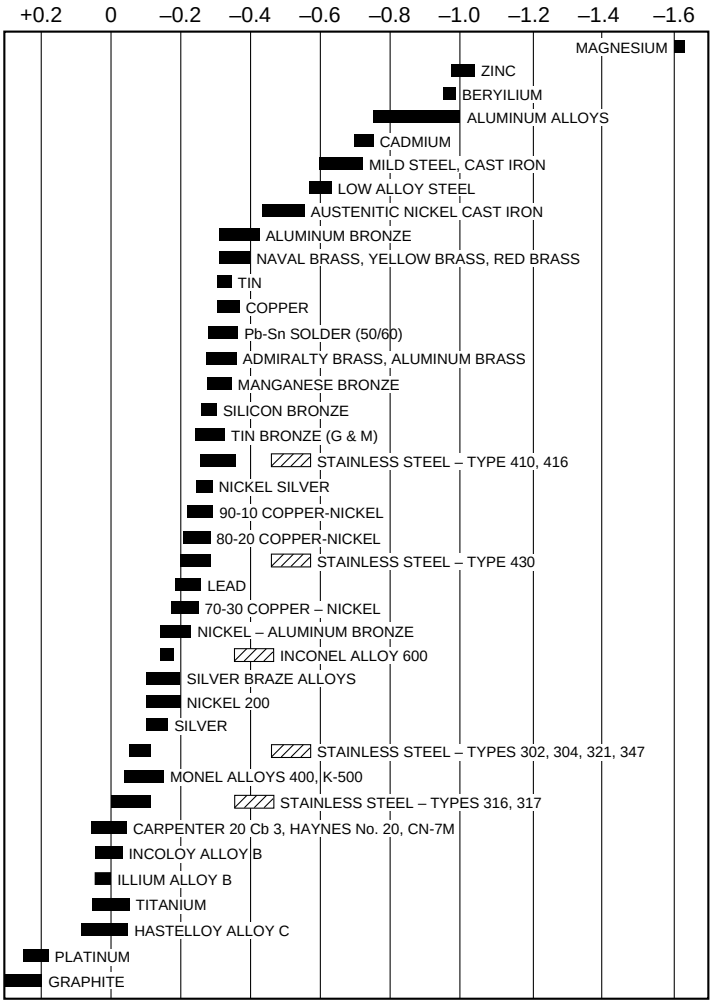
Proper Tubing Selection

1. **Always Match Materials** - I.E., S.S. Tubing should be used only with S.S. Fittings. The only exception to this rule is copper tubing with brass fittings. Mixing materials can cause galvanic corrosion.

   Galvanic Corrosion (Electrochemical)
   All metals have a specific relative electrical potential. When dissimilar metals come in contact in the presence of moisture (electrolyte), a low energy electric flows from the metal having the higher potential to the metal having the lower potential. The result of this galvanic action is the corrosion of the metal with the higher potential (more anodic). (See Galvanic Series Chart on page 19)

PARKER DOES NOT RECOMMEND THE USE OF DISSIMILAR METALS WHEN PUTTING TOGETHER A TUBING/ FITTING CONNECTION SYSTEM.

(Cathodic) **Galvanic Series Chart** (Anodic)



Above represents corrosion potentials of materials in flowing seawater @ temperature in the range 10˚ C - 26˚ C. The hatched symbols indicate potentials exhibited by stainless steels in pits or crevices.

Proper Tube Selection (continued)

2. **Select proper tubing hardness** - Remember Parker Instrumentation Tube Fittings are designed to work within specific hardness ranges. Rb 90 max. for S.S., Rb 80 recommended.
3. **Select proper tubing wall thickness** - Proper wall thickness is necessary to accommodate accepted safety factors relative to desired working pressures. For details on items 2 & 3 note “Instrumentation Tubing Selection Guide” shown on the following pages.
4. **Tubing surface finish** - Always select tubing free of visible drawmarks or surface scratches. If possible, cut off any undesirable sections. These “deep” scratches can cause leaks when attempting to seal low-density gases such as argon, nitrogen, or helium.

Instrument Tubing Selection Guide

Parker’s Instrument Tube Fittings have been designed to work in a wide variety of applications that demand the utmost in product performance.

Although Parker’s Instrument Tube Fittings have been engineered and manufactured to consistently provide this level of reliability, no system’s integrity is complete without considering the critical link, **tubing.**

This guide is intended to assist the designer to properly select and order quality tubing.

Proper tube selection and installation, we believe, are key ingredients in building leak-free, reliable tubing systems.

General Selection Criteria

The most important consideration in the selection of suitable tubing for any application is the compatibility of the tubing material with the media to be contained. Table 1 lists common materials and their associated general application. Table 1 also lists the maximum and minimum operating temperature for the various tubing materials.

In addition, Parker instrumentation fittings should be used only with stainless steel tubing, aluminum fittings with aluminum tubing, etc. The practice of mixing materials is strongly discouraged. The only exception is brass fittings with copper tubing.

Dissimilar materials in contact may be susceptible to galvanic corrosion. Further, different materials have different levels of hardness, and can adversely affect the fittings ability to seal on the tubing.

Table1

Tubing Material	General Application	Recommended Temperature Range
Stainless Steel	High Pressure, High Temperature Generally Corrosive Media	-425˚F to 1,200˚F[1]
Carbon Steel	High Pressure, High Temperature Oil, Air, Some Specialty Chemicals	-65˚F to 800˚F[2]
Cooper	Low Temperature, Low Pressure Water, Oil, Air	-40˚F to 400˚F
Aluminum	Low Temperature, Low Pressure Water, Oil, Air Some Specialty Chemicals	-40˚F to 400˚F
Monel 400™	Recommended for Sour Gas Applications Well Suited for Marine and General Chemical Processing Applications	-400˚F to 800˚F
Alloy C276	Excellent Corrosion Resistance to Both Oxidizing and Reducing Media and Excellent Resistance to Localized Corrosion Attack	-320˚F to 1000˚F
Carpenter 20™	Applications Requiring Resistance to Stress Corrosion Cracking in Extreme Conditions	-400˚F to 800˚F
Alloy 600	Recommended for High Temperature Applications with Generally Corrosive Media	-205˚F to 1200˚F
Titanium	Resistant to Many Natural Environments such as Sea Water, Body Fluids and Salt Solutions	-320˚F to 600˚F

Carpenter 20 is a trademark of Carpenter Technology Corporation.
Monel 400 is a trademark of International Nickel.

1. For operating temperatures above 800 ˚F, consideration should be given to media. 300 Series Stainless Steels are suspectible to carbide precipitation which may lead to intergranular corrosion at elevated temperatures.
2. Consideration should be given to maximum temperature ratings if fittings and/or tubing are coated or plated.

All temperature ratings based on maximum rated temperatures per ASME/ANSI B31-3 Chemical Plant and Petroleum Refinery Piping Code, 1987 Edition.

The information listed in Table 1 is general in scope. For specific applications, please contact Parker's Instrumentation Connectors Division, Product Engineering Department (256) 881-2040.

Gas Service

Special care must be taken when selecting tubing for gas service. In order to achieve a gas-tight seal, ferrules in instrument fittings must seal any surface imperfections. This is accomplished by the ferrules penetrating the surface of the tubing. Penetration can only be achieved if the tubing provides radial resistance and if the tubing material is softer than the ferrules.

Thick walled tubing helps to provide resistance. Tables 2-7 indicate the minimum acceptable wall thickness for various materials in gas service. The ratings in white indicate combinations of diameter and wall thickness which are suitable for gas service.

Acceptable tubing hardness for general application is listed in Table 9. These values are the maximum allowed by the ASTM. For gas service, better results can be obtained by using tubing well below this maximum hardness. For example, a desirable hardness of 80 Rb is suitable for stainless steel. The maximum allowed by ASTM is 90 Rb.

System Pressure

The system operating pressure is another important factor in determining the type, and more importantly, the size of tubing to be used. In general, high pressure installations require strong materials such as steel or stainless steel. Heavy walled softer tubing such as copper may be used if chemical compatibility exists with the media. However, the higher strength of steel or stainless steel permits the use of thinner tubes without reducing the ultimate rating of the system. In any event, tube fitting assemblies should never be pressurized beyond the recommended working pressure.

The following tables (2-7) list by material the maximum suggested working pressure of various tubing sizes. Acceptable tubing diameters and wall thicknesses are those for which a rating is listed. Combinations which do not have a pressure rating are not recommended for use with instrument fittings.

Maximum Allowable Working Pressure Tables

Table 2 **316 or 304 STAINLESS STEEL (Seamless)**

Tube O.D. Size	WALL THICKNESS															
	.010	.012	.014	.016	.020	.028	.035	.049	.065	.083	.095	.109	.120	.134	.156	.188
1/16	5600	6900	8200	9500	12100	16800										
1/8						8600	10900									
3/16						5500	7000	10300								
1/4						4000	5100	7500	10300							
5/16							4100	5900	8100							
3/8							3300	4800	6600							
1/2							2500	3500	4800	6300						
5/8								3000	4000	5200	6100					
3/4								2400	3300	4300	5000	5800				
7/8								2100	2800	3600	4200	4900				
1									2400	3200	3700	4200	4700			
1-1/4										2500	2900	3300	3700	4100	4900	
1-1/2											2400	2700	3000	3400	4000	4500
2												2000	2200	2500	2900	3200

Table 3	316 or 304 STAINLESS STEEL (Welded)																
Tube O.D. Size	WALL THICKNESS .010	.012	.014	.016	.020	.028	.035	.049	.065	.083	.095	.109	.120	.134	.156	.188
1/16	4800	5900	7000	8100	10300	14300										
1/8						7300	9300									
3/16						4700	6000	8700								
1/4						3400	4400	6400	8700							
5/16							3400	5000	6900							
3/8							2800	4100	5600							
1/2							2100	3000	4100	5300						
5/8								2500	3400	4500	5200					
3/4								2100	2800	3700	4200	4900				
7/8								1800	2400	3100	3600	4200				
1									2100	2700	3100	3600	4000			
1-1/4										2100	2400	2800	3100	3500	4200	
1-1/2											2000	2300	2600	2900	3400	4200
2												1700	1900	2100	2500	3000

RATINGS IN GRAY NOT SUITABLE FOR GAS SERVICE

Table 4	CARBON STEEL (Seamless)												
Tube O.D. Size	WALL THICKNESS .028	.035	.049	.065	.083	.095	.109	.120	.134	.148	.165	.180
1/8	8100	10300										
3/16	5200	6700	9700									
1/4	3800	4900	7100	9700								
5/16		3800	5500	7700								
3/8		3100	4500	6200								
1/2		2300	3300	4500	6000							
5/8		1800	2600	3500	4600	5400						
3/4			2200	2900	3800	4400	5100					
7/8			1800	2500	3200	3700	4300					
1			1600	2100	2800	3200	3700	4100				
1-1/4				1700	2200	2500	2900	3200	3700	4100	4600	5100

Table 6	ALUMINUM (Seamless)				
Tube O.D. Size	WALL THICKNESS .035	.049	.065	.083	.095
1/8	8700				
3/16	5600	8100			
1/4	4100	5900			
15/16	3200	4600			
3/8	2600	3800			
1/2	1900	2800	3800		
5/8	1500	2200	2900		
3/4		1800	2400	3200	
7/8		1500	2100	2700	
1		1300	1800	2300	2700

Table 5	COPPER (Seamless)									
Tube O.D. Size	WALL THICKNESS .010	.020	.028	.035	.049	.065	.083	.095	.109	.120
1/16	1700	3800	5400	6000						
1/8			2800	3600						
3/16			1800	2300	3500					
1/4				1700	2600	3500				
5/16				1300	2000	2800				
3/8				1100	1600	2300				
1/2				800	1200	1600	2200			
5/8					900	1300	1700	2000		
3/4					800	1000	1400	1600	1900	
7/8					600	900	1100	1300	1600	
1					600	800	1000	1200	1400	1500

Table 7	MONEL 400 (Seamless)									
Tube O.D. Size	WALL THICKNESS .010	.020	.028	.035	.049	.065	.083	.095	.109	.120
1/16	5900	12600	17000							
1/8			8600	11000						
3/16			5500	7100	10300					
1/4			4000	5100	7500	10300				
5/16				4000	5900	8100				
3/8				3300	4800	6600				
1/2				2300	3300	4500	5900			
5/8					2800	3700	4900	5700		
3/4					2300	3100	4000	4600	5400	
1						2300	2900	3400	3900	4400

Note:

- All working pressures have been calculated using the maximum allowable stress levels in accordance with ASME/ANSI B31.3, Chemical Plant and Petroleum Refinery Piping or ASME/ANSI B31.1 Power Piping.
- All calculations are based on maximum outside diameter and minimum wall thickness.
- All working pressures are at ambient (72˚F) temperature.

Systems Temperature

Operating temperature is another factor in determining the proper tubing material. Copper and aluminum tubing are suitable for low temperature media. Stainless steel and carbon steel tubing are suitable for higher temperature media. Special alloys such as Alloy 600 are recommended for extremely high temperature (see Table 1). Table 8 lists derating factors which should be applied to the working pressures listed in Table 2-7 for elevated temperature (see Table 1). Table 8 lists derating factors which should be applied to the working pressures listed in Tables 2-7 for elevated temperature conditions. Simply locate the correct factor in Table 8 and multiply this by the appropriate value in Tables 2-7 for the elevated temperature working pressure.

Table 8		**Temperature Derating Factors**					
Temperature ˚F	(˚C)	Copper	Aluminum	316 SS	304 SS	Steel	Monel 400
100	(38)	1.00	1.00	1.00	1.00	1.00	1.00
200	(93)	.80	1.00	1.00	1.00	.96	.88
300	(149)	.78	.81	1.00	1.00	.90	.82
400	(204)	.50	.40	.97	.94	.86	.79
500	(260)			.90	.88	.82	.79
600	(316)			.85	.82	.77	.79
700	(371)			.82	.80	.73	.79
800	(427)			.80	.76	.59	.76
900	(486)			.78	.73		
1000	(538)			.77	.69		
1100	(593)			.62	.49		
1200	(649)			.37	.30		

EXAMPLE: 1/2 inch x .049 wall seamless stainless steel tubing has a working pressure of 3500 PSI @ room temperature. If the system were to operate @ 800˚F (425˚C), a factor of 80% (or .80) would apply (see Table 8 above) and the “at temperature” system pressure would be 3500 PSI x .80 = 2800 PS

Tubing Ordering Suggestions

Tubing for use with Parker instrument fittings must be carefully ordered to insure adequate quality for good performance. Each purchase order must specify the material nominal outside diameter, and wall thickness.

Ordering to ASTM specifications insures that the tubing will be dimensionally, physically, and chemically within strict limits. Also, more stringent requirements may be added by the user. All tubing should be ordered free of scratches and suitable for bending.

A purchase order meeting the above criteria would read as follows: 1/2” x .049316 stainless steel, seamless, or welded and redrawn per ASTM A-249. Fully annealed, 80 Rb or less. Must be suitable for bending; surface scratches, and imperfections (incomplete weld seams) are not permissible.

Table 9 lists specific ordering information for each material.

Table 9

Material	Type	ASTM Tubing Spec.	Condition	Max. Recommended Hardness
Stainless Steel	304, 316, 316L	ASTM-A-269, A-249, A-213, A632	Fully Annealed	90 Rb
Copper	K or L	ASTM-B75 B68, B88* (K or L)	Soft Annealed Temper 0	60 Max. Rockwell 15T
Carbon Steel	1010	SAE-J524b, J525b ASTM-A-179	Fully Annealed	72 Rb
Aluminum	Alloy 6061	ASTM B-210	T6 Temper	56 Rb
Monel™	400	ASTM B-165	Fully Annealed	75 Rb
Alloy C-276	C-276	ASTM-B-622, B-626	Fully Annealed	90 Rb
Alloy 600	600	ASTM B-167	Fully Annealed	90 Rb
Carpenter 20™	20CB-3	ASTM B-468	Fully Annealed	90 Rb
Titanium	Commercially Pure Grade 2	ASTM B-338	Fully Annealed	99 Rb 200 Brinell Typical

Note: B88 Copper Tube to be ordered non-engraved

WARNING

FAILURE OR IMPROPER SELECTION OR IMPROPER USE OF THE PRODUCTS AND/OR SYSTEMS DESCRIBED HEREIN OR RELATED ITEMS CAN CAUSE DEATH, PERSONAL INJURY AND PROPERTY DAMAGE.

This document and other information from Parker Hannifin Corporation, its subsidiaries and authorized distributors provide product and/or system options for further investigation by users having technical expertise. It is important that you analyze all aspects of your application and review the information concerning the product or system in the current product catalog. Due to the variety of operating conditions and applications for these products or systems, the user, through its own analysis and testing, is solely responsible for making the final selection of the products and systems and assuring that all performance, safety and warning requirements of the application are met.

The product described herein, including without limitation, product features, specifications, designs, availability and pricing, are subject to change by Parker Hannifin Corporation and its subsidiaries at any time without notice.

ASTM Tubing Specifications Outside Diameter/Wall Thickness

It is important to understand that both of the above can affect the ferrule(s) ability to seal on the tubing. We recommend ordering tubing manufactured to the plus (+) side of the outside diameter tolerance. Wall thickness variations can affect pressure ratings and flow characteristics.

The following tables should explain the allowable variations.

ASTM Dimensional Specifications for Tubing

Table 1 Permissible Variations in Outside Diameter (1)
Table 2 Permissible Variations in Wall Thickness
Table 3 Permissible Variations in Wall Thickness for ASTM B68 and ASTM B75

ASTM Dimensionable Specifications for Tubing

Table 1 Permissible Variations in Outside Diameter (1)

Tube O.D. Inches	A213 A249	A269	A632	A179	B68 B75	B165 B167	B338	B468	B622	B626
1/16	±.004	±.005	+.002	±.004	±.002	+.002	±.004	±.004	N/A	+.004 -.005
1/8			+.003			+.003				
3/16			+.004			+.004				
1/4										
5/16										
3/8										
1/2			N/A			±.005			±.005	
5/8					±.0025	±.0075			±.0075	
3/4										
7/8										
1							±.005	±.006		±.006
1-1/4	±.006			±.006	±.003		±.006			±.008
1-1/2		±.010								
2	±.010			±.010		±.010	±.007	±.010	±.010	±.010

(1) Cold Drawn Tubing

Table 2 Permissible Variations in Wall Thickness

<table>
<tr><th>Tube O.D. Inches</th><th>A213</th><th>A249</th><th>A269</th><th>A632</th><th>A179</th><th>B165
B167</th><th>B338</th><th>B468</th><th>B622</th><th>B626</th></tr>
<tr><td>1/16
1/8
3/16
1/4
5/16
3/8</td><td rowspan="2">+20%</td><td rowspan="2">±10%</td><td rowspan="2">±15%</td><td rowspan="2">±10%</td><td rowspan="2">+20%</td><td rowspan="2">±15%</td><td rowspan="2">±10%</td><td rowspan="2">±15%</td><td rowspan="2">N/A</td><td rowspan="2">±12.5%</td></tr>
<tr><td>1/2
5/8
3/4
7/8
1
1-1/4
1-1/2</td><td rowspan="2">±12.5%</td></tr>
<tr><td>2</td><td>+22%</td><td>+20%</td><td>±10%</td><td>±10%</td><td>±10%</td><td>±10%</td></tr>
</table>

Proper Tubing Preparation

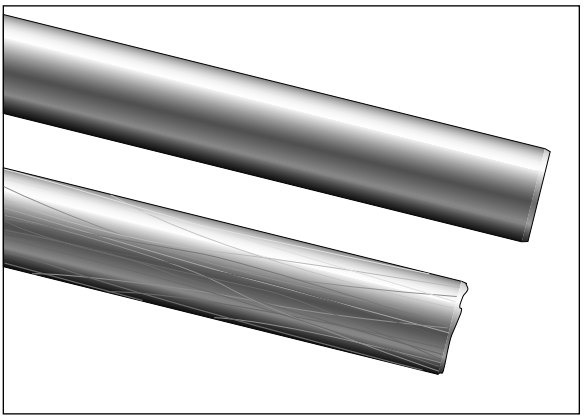
Tube end preparation is essential in assuring leak-free systems. Some important points to consider are:

- Handling Tubing
- Cutting Tube End with either a tube cutter or hacksaw
- Deburring the tube end
- Cleaning the tube end

Handling Tubing

After tubing has been properly selected and ordered, careful handling is important.

From the receiving dock to point of installation, special attention is necessary to prevent scratching and burring the O.D. of the tubing. This is especially important for gas service. Low-density gases such as helium and argon cannot be sealed with damaged tubing.



Make certain not to drag tubing across any surfaces such as truck beds, shelves, or storage racks, the floor and (or) ground of any plant/construction site.This is important for tubing of all materials, particularly for copper and aluminum. Besides scratching, improper handling can create out-of-round tubing. Out-of-round tubing will not fit the I.D. of the ferrule(s) or the body bore properly and will cause leakage.

Cutting the Tube End

To insure a good joint, tube must be cut off square. This can be accomplished with either a tube cutter or hacksaw.

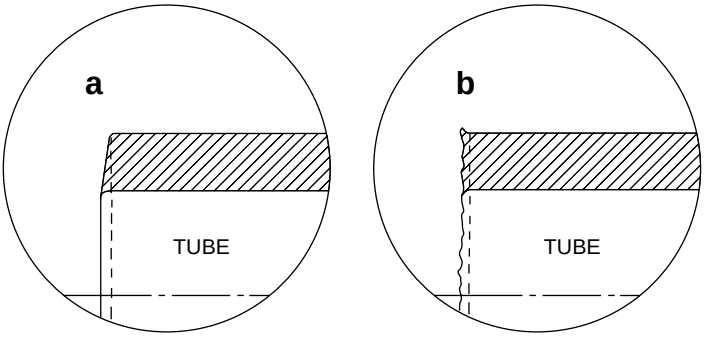
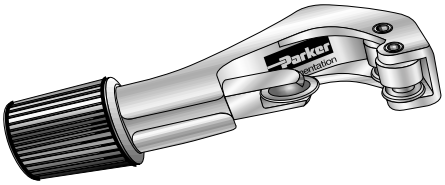
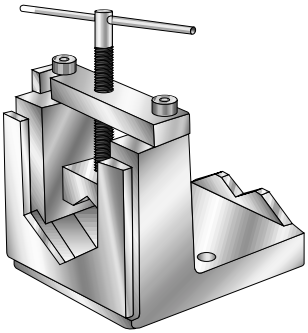


Figure 4 Enlarged section of tube showing differences in tubing cut with a tube cutter (a) and a hacksaw (b).



Tubing Cutters are more commonly utilized on softer tubing such as copper, aluminum or even “soft” steel tubing. If a tube cutter is utilized with stainless steel tubing, remember that a special cutting wheel, designed for use with stainless steel tubing should be employed. The use of dull or improper cutting wheels can work harden the S.S. tubing near the cut area. This CAN adversely affect the fittings sealing ability.

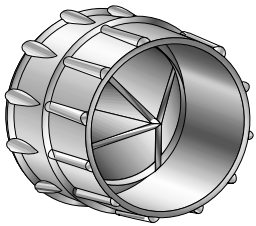
Cutting with a Hacksaw - When using a hacksaw to cut off tubing, it is essential to use a guide to assure square cut-offs. We recommend our Tru-Kut vise Model #710439. (See below) Further, to minimize the residual burrs, a hacksaw blade of 32 teeth per inch minimum is suggested.



Deburring the Tube End

The burrs formed by either the tube cutter or hacksaw must be removed prior to assembly to prevent those burrs from eventually damaging the system. O.D. burrs can prevent tubing from seating properly in a fitting body. I.D. burrs can restrict flow, as well as possibly break loose and damage fine filtration elements.
Note: Do not over deburr the O.D. of tubing.

You may deburr the tubing with your choice of file(s), or utilize Parker's IN-EX De-Burring tool Model #226. This tool can be used to deburr both the I.D. & O.D. of tubing sizes 1/8" thru 1-1/2".



Cleaning the Tube End

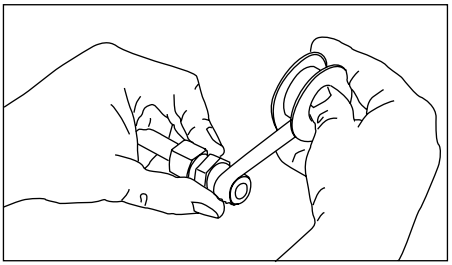
After you deburr the tubing, it is essential to remove burrs from the tubing line. This can be accomplished by:

1. Flushing with solvent or low pressure compressed air.
2. Swab with lint-free cloth.

Again, this should prevent entrapping one of these small burrs down-stream where it might do some system damage.

Port Connections

Before the cleaned and deburred tubing can be inserted into the tube end of the body, care should be taken to insure that the port connection is properly prepared and installed so that it will accept the tubing.



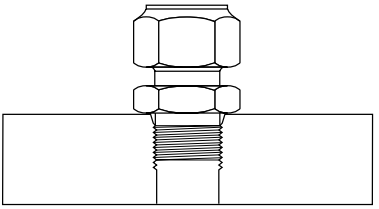
Installation Assembly - fitting to port
Pipe thread port

- Make sure pipe threads are free from nicks, burrs, dirt, etc.
- For use with Teflon® tape. Apply Teflon® tape to threads starting with first thread. 1-1/2 to 2 turns of tape should be applied in the direction of the male pipe spiral.
- Insert fitting into pipe port and turn it in finger tight.
- Tighten with wrench.

NOTE: If thread sealants are being used - follow manufacturers recommended instructions for application.

Installation

Assembly - fitting to port SAE Straight Thread O-ring Fitting (Non adjustable)

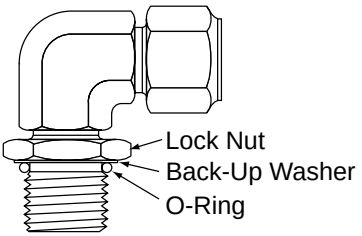


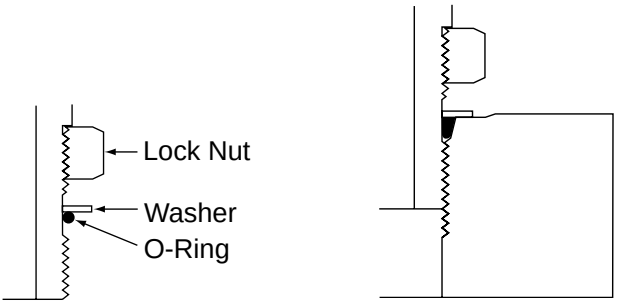
- Make sure both threads and sealing surfaces are free of burrs, nicks & scratches, or any foreign material.
- Lubricate O-ring with system compatible lubricant.
- Tighten to torque level listed in the torque chart on page 32.

Installation

Assembly - fitting to port SAE straight thread O-ring fitting (Adjustable)

- Inspect and correct both mating parts for burrs, nicks, scratches or any foreign particles.
- Lubricate O-ring with system compatible lubricant.



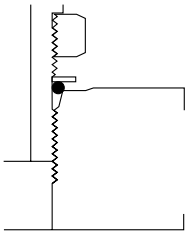


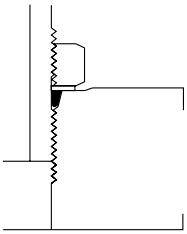
- Back off lock nut as far as possible toward fitting body make sure back-up washer and O-ring are pushed up as far as possible toward upper thread.
- Screw fitting by hand into the port until back-up washer contacts face of the port and continue turning until snug. (Very slight wrenching maybe needed). Back-up washer is now in correct position for assembly.

Installation

Assembly - fitting to port

SAE straight thread O-ring fitting (Adjustable)





- To position the fitting, unscrew by required amount but not more than one full turn.
- To position the fitting, unscrew fitting body by required amount but not more than one full turn.
- Hold fitting in desired position using (2) wrenches and tighten lock nut to torque level listed in the torque chart at bottom of page.
- Hold fitting in desired position and tighten lock nut to torque level listed in the torque chart.

Installation

Assembly - port end

SAE straight thread

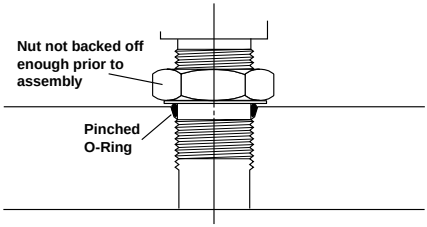
	Straight Port		Adjustable Port	
Size	Torque (in-lbs)	(F.F.F.T.)	Torque (in-lbs)	(F.F.F.T.)
4	245 ± 10	1.0 ± .25	200 ± 10	1.5 ± 25
6	630 ± 25	1.5 ± .25	400 ± 10	1.5 ± 25
8	1150 ± 50	1.5 ± .25	640 ± 10	1.5 ± 25
10	1550 ± 50	1.5 ± .25	1125 ± 50	1.5 ± 25
12	2050 ± 50	1.5 ± .25	1450 ± 50	1.5 ± 25
16	3000 ± 50	1.5 ± .25	2150 ± 50	1.5 ± 25
20	3400 ±100	1.5 ± .25	2800 ±100	2.0 ± 25
24	4500 ±100	1.5 ± .25	3450 ±100	2.0 ± 25

Notes

- Restrain fitting body on adjustables if necessary in installation.
- Values in charts are for assemblies with O-ring lubricated.
- Use upper limits of torque ranges for stainless steel fittings.

Installation

Assembly - fitting to port
SAE straight thread O-ring (adjustable)



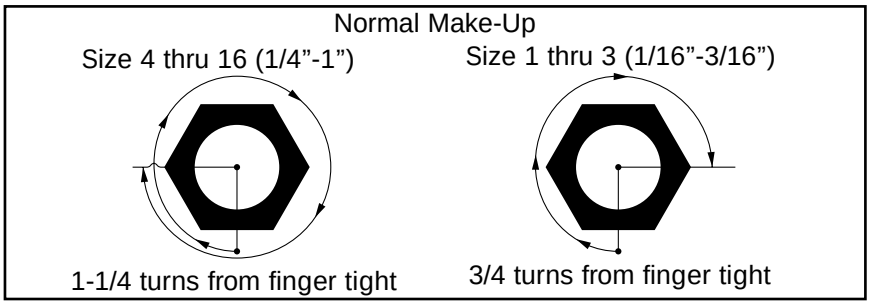
Improper assembly can pinch O-ring causing leaky joint

Nut not backed off enough prior to assembly will pinch the SAE straight thread O-ring.

Proper Tube Fitting Make-Up

Because of considerable variations in tubing wall thickness and surface hardness, Instrument Tube Fittings are not made up by torque. Rather they are assembled by the following simple instructions:

- Once tubing is bottomed out



If you mark the nut before you start, you will know when you have finished; that you have advanced the nut the required number of turns.

- Caps (PNBZ/BLEN) - Wrench tighten 1-1/4 turns from finger tight (Parts with pre-machined ferrules make-up 1/4 T.F.F.T.)
- Tube Plugs (FNZ/BLP) - Wrench tighten 1/4 turn from finger tight
- Port Connector (ZPC/PC) - Wrench tighten 1/4 turn from finger tight

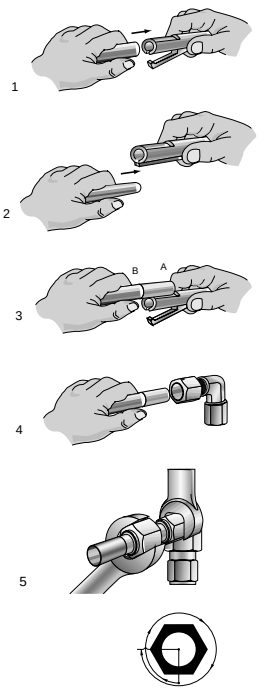
Parker CPI™/A-LOK® Fittings on Plastic Tubing

Parker CPI™ /A-LOK® Instrument Fittings can be successfully used on any of the following plastic tubing: nylon, polyethylene, polypropylene, Teflon®, or vinyl. Normal make-up instructions should be followed, (1-1/4" turns from finger tight) sizes 4 thru 16 (3/4 turn from finger tight for size 3" or below) and a properly-sized insert should be used when required. (Please refer to CPI™ Catalog 4230 or A-LOK® Catalog 4233 for insert details). The use of the insert is dependent upon tubing O.D. Tubing 1/2" O.D. and above requires an insert. Softness of the tubing is another guideline for the use of an insert. Tubing that is soft enough to be easily pinched closed with your fingers will require an insert no matter what the O.D. may be.

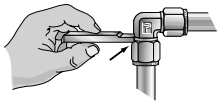
Use of Parker Inspection Gauge and Tube Marker

Gaugeability

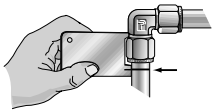
Using the Parker Tube Marker and Inspection Gauges, you can make precise, accurate tubing connections - even though you can't see inside the fitting. Here's how:



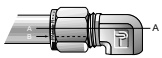
1. Put tube marker completely on to tube.
2. Press marking arm against tube and rotate marker 360˚- to leave a burnish mark around the tube.
3. Check burnish mark position by butting flat (A) on marker against end of tube. Burnish marks is in correct position if it lines up with end of tube marker (B).
4. Now insert the tube into the fitting until tube bottoms inside. (If the fitting is disassembled, note that the small tapered end of the ferrule goes into the fitting body). Tighten nut finger tight.
5. From "finger tight" position, wrench 1-1/4 turns for 1/4" to 1" size fittings. (1/16", 1/8" and 3/16" size tube fittings only wrench 3/4 turn from finger tight position) hold fitting body hex with a second wrench to prevent body from turning as tighten. It is a good idea to mark the nut to help you count the turns.



6. Now select the proper size Inspection Gauge and try to place it as shown, between the nut and the body hex. If gauge DOES NOT FIT AT ANY POINT between them, you have correctly tightened the nut. If you can slip the gauge into the space, the fitting is not properly made up, and you must repeat the assembly procedure.



7. Then place the proper size Inspection Gauge against the fitting, as shown, pressing it against the hex face. Burnish mark on tube should line up within band. If it does, you know the tube insertion depth is correct. If the burnish mark falls outside the band - either above or below it - the tube is incorrectly inserted, and you must repeat the marking and assembly procedures.



8. To get the maximum number of remakes, mark fitting body and nut (A-A) before disassembly. Before retightening, make sure the assembly has been inserted into the fitting until the ferrule(s) seats in the body. Retighten the nut by hand. Rotate the nut with a wrench to the original position as indicated by the previous marks lining up. (A noticeable increase in mechanical resistance will be felt indicating the ferrule(s) is being re-sprung into sealing position). Then snug the nut 1/12 turn (1/2 hex flat) as shown from A to B, past the original position.

Note: The above instructions, if followed correctly and carefully, should provide suitable installation. However, leak tightness may be affected by other installation problems, such as inadvertent scoring of tubing, or by material problems.

Check Your Connections

Tube Marker

Put a burnish mark on the tubing quickly and accurately with this easy to use tube marker (Steps 1 & 2). Also used to check the burnish mark position (Step 3).

Inspection Gauge

This handy gauge does double duty. Use the No-Go portion (on the end) to check the space between the nut and body hex (Step 6). Use the other end to check tube insertion depth (Step 7).

Parker ICD Ferrule Presetting Tool

Ferrule Presetting Components

Part Numbers				Hy-Fer-Set Kit Components	
Threads	Size	Body Die	Nut Die	Item	Part No.
1/4"	4	4 Body Die	Size 4 Nut Die	Kit A Hydraulic Ram (size 4-16)	Hydraulic Ram
3/8"	6	6 Body Die	Size 6 Nut Die	Kit B Hydraulic Ram (size 20-32)	Hy-Fer-Set Body Assembly
1/2"	8	8 Body Die	Size 8 Nut Die	Hydraulic Hand Pump	Enerpac Pump P-392
5/8"	10	10 Body Die	Size 10 Nut Die	Hose Assembly	Hose Assembly w/guards
3/4"	12	12 Body Die	Size 12 Nut Die	Carrying Case	Carrying Case
7/8"	14	14 Body Die	Size 14 Nut Die		
1"	16	16 Body Die	Size 16 Nut Die		Size 16 Body Die Adapter
1-1/4"	20	20 Body Die	Size 20 Nut Die		
1-1/2"	24	24 Body Die	Size 24 Nut Die		
2"	32	32 Body Die	Size 32 Nut Die		

NOTE: To preset 1" with "B" tool, a size 16 body die adapter must be used

ICD Ferrule Presetting Tool Assembly Instructions

Coupler body in hydraulic ram and pump, is a high pressure, screw together coupler. Thread coupler body onto nipple and each end of hose assembly. No tools required.

Presetting CPI™ /A-LOK® Tube Fitting Ferrules Sizes 1/4" Through 1"

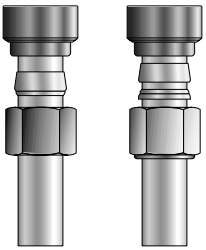


Figure 1

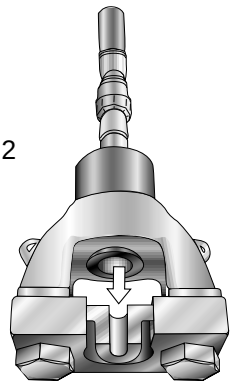


Figure 2

1. Assemble CPI™/A-LOK® nut, CPI™/A-LOK® Ferrule(s) and body die onto tubing as shown in Figure1. Be sure that the tapered end of the Ferrule(s) point toward the body die.
2. Insert "U-shaped" Nut Die into the back-up plate of the Hydraulic Ram as shown in Figure 2.
3. Insert Tube Assembly, Figure 1 into Nut Die as shown in Figure 3.
4. Close the pressure relief valve on the side of the hand pump. Pump the hand pump until the ram reaches a positive stop. At this point an increase in resistance of the handle will be felt and the nut will bottom against the shoulder of the body die Figure 4.

5. Release the hydraulic pressure by opening the relief valve on the side of the pump. The ram will automatically return to the original position.
6. The ferrule(s) are now preset on the tubing. Remove the preset assembly and pull the body die off the end of the tubing. (If the body die does not pull off by hand, clamp on the outside of the body die and move the tubing back & forth while pulling.) **Do not clamp or pull on the preset ferrule(s) as this could damage a sealing surface.**
7. Insert the preset assembly into a fitting body, and make sure the ferrule seats in the fitting. Tighten the nut on the fitting body until finger tight.
8. Tighten the nut with a wrench the additional amount shown in Table 1 for each connection size. **(If an increase in torque is not felt early in wrench make-up the preset assembly was not properly seated.)** If this happens, tighten the nut with a wrench until the torque increase is felt. Then, loosen nut to the finger tight position, tighten the nut the additional amount shown in Table 1.

Figure 3

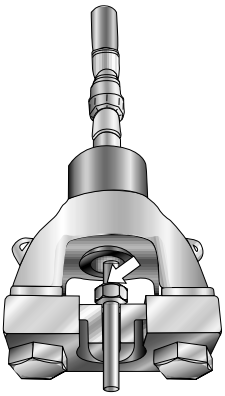


Figure 4

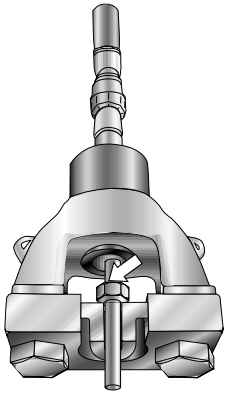


Table 1

Size	4	6	8	10	12	14	16
Turns	1/2	1/2	1/2	1/2	1/2	1/2	1/2

Pre-setting the CPI™ Tube Fitting Ferrules Size 1-1/4", 1-1/2", and 2"

Figure 1

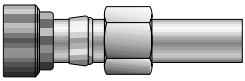


Figure 2

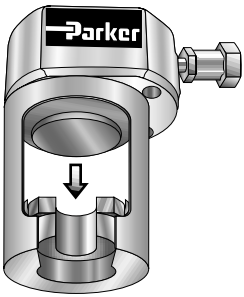
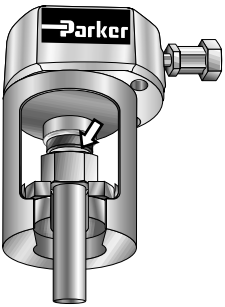


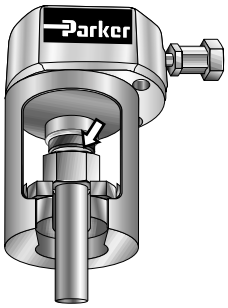
Figure 3



1. Assemble CPI™ nut, CPI™ Ferrule and body die onto tubing as shown in **Figure 1**. Be sure that the tapered end of the ferrule point toward the body die.
2. Insert "U-shaped" Nut die into the Nut Die Adapter of the Hydraulic Ram as shown in **Figure 2**.

   NOTE: For size 32 the nut die adapter is not needed and must be removed before inserting the nut die.
3. Insert Tube Assembly, **Figure 1** into Nut Die as shown in **Figure 3**.
4. Close the pressure relief valve on the side of the hand pump. Pump the hand pump until the ram reaches a positive stop. At this point an increase in resistance of the handle will be felt and the nut will bottom against the shoulder of the body die **Figure 4**.
5. Release the hydraulic pressure by opening the relief valve on the side of the pump. The ram will automatically return to the original position.
6. The ferrule(s) are now preset on the tubing. Remove the preset assembly and pull the body die off the end of the tubing. (If the body die does not pull off by hand, clamp on the outside of the body die and move the tubing back & forth while pulling.) **Do not clamp or pull on the preset ferrule(s) as this could damage a sealing surface.**
7. Insert the preset assembly into a fitting body, and **make sure the ferrule seats in the fitting.** Tighten the nut on the fitting body until finger tight.

Figure 4



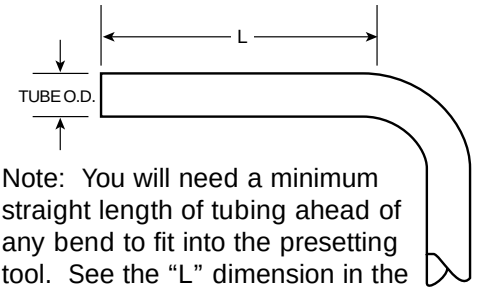
8. Tighten nut with a wrench the additional amount shown in **Table 1** for each connection size. **(If an increase in torque is not felt early in wrench make up the preset assembly was not properly seated.)** If this happens, tighten the nut with a wrench until torque increase is felt. Then, loosen nut to the finger tight position, tighten nut the additional amount shown in **Table 2**.

Table 2

Size	20	24	32
Turns	5/8	5/8	3/4

PLEASE NOTE: Pressure ratings for all Parker Hannifin instrumentation fittings are different because tubing thickness can vary widely. All instrumentation fittings are designed so the tubing is always weaker than the fitting. Thus the pressure rating of the fitting is contingent on the pressure rating of the associated tubing.

Minimum Tubing Lengths

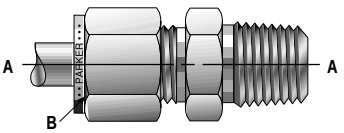


Note: You will need a minimum straight length of tubing ahead of any bend to fit into the presetting tool. See the “L” dimension in the chart for each tube O.D. size.

“L” Chart	
Tube O.D.	“L”
1/4”	2”
3/8”	2-1/8”
1/2”	2-3/8”
5/8”	2-3/8”
3/4”	2-3/8”
7/8”	2-1/2”
1”	2-5/8”
1-1/4”	3”
1-1/2”	3-3/8”
2”	4-1/4”

Proper Tube Fitting Remake Instructions

A disassembled joint can be remade simply by retightening the nut to the position of the original make up. For maximum number of remakes, mark the fitting and nut before disassembly. Before retightening, make sure the assembly has been inserted into the fitting until the ferrule(s) seats in the fitting. Retighten the nut by hand. Rotate the nut with a wrench to the original position as indicated by the previous marks lining up. (A noticeable increase in mechanical resistance will be felt indicating the ferrule is being re-sprung into sealing position.) Then snug the nut 1/12 turn (1/2 hex flat) as shown from A to B, past the original position.



The Parker P32 Rotary Wrench
Size 1-1/4” thru 2”

The patent pending rotary wrench assembles and disassembles large size CPI™ and A-LOK® fittings in place in the field safely and effortlessly. The Rotary Wrench reduces long-term maintenance costs.

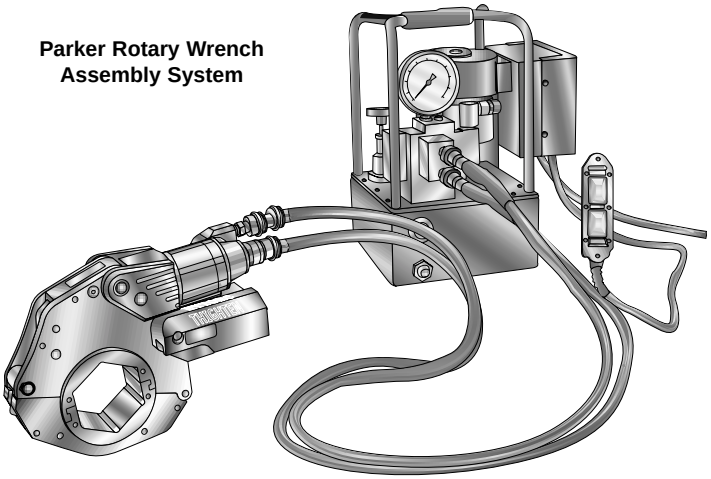
To reach the stage of assembly, follow these steps:

1. Pin reaction pad “F” to rotary wrench.
2. Open outer and inner rotary wrench hinges by loosening (2) cap screws.
3. Select proper split insert (20-24-32) to fit tube nut hex. Place split insert in rotary wrench head. Make certain drive teeth mesh.
4. Re-tighten inner, then outer cap screws to secure rotary wrench head and hex insert.
5. Position rotary wrench’s hex insert on tube fitting nut.
6. Insert properly prepared tubing into tube fitting. Make certain to feel tubing bottom against stop in fitting body. Finger-tighten the nut and ferrule assembly. This eliminates the need for hydraulic pre-setting and hand wrench tightening. No bulky wrenches to create safety hazards.
7. Use the ratcheting action of the PAK-32 Rotary Wrench to find “wrench tight” prior to assembly. By hand, use the rotary wrench to draw the nut and ferrule(s) to their proper position by “wrench” tightening the assembly until a sharp rise in torque is felt.
8. Place hex wrench in “tighten” slot of reaction pad “F”, and secure open end to tube body hex.
9. Mark nut and body hex to indicate starting point
10. Press advance button on remote control and release after each 18° split insert rotation. Repeat sequence until fitting is correctly assembled to 1-1/2 turns.

Note: Correct make-up of 1-1/2 turns should always be verified by relative alignment of marks on nut and body.

For more information, see Catalog 4290-B2 or P32 Video.

Parker Rotary Wrench Assembly System



Note: Customer Power Supply



Parker Rotary Wrench Assembly Kit

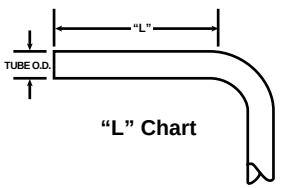
Note: You will need a minimum straight length of tubing ahead of any bend to fit into the pre-setting tool. See the "L" dimension in the chart for each tube O.D. size.

Part Number				Hy-Fer-Set Kit Components
Threads	Size	Body Die	Nut Die	Item
1-1/4"	20	20 Body Die	Size 20 Nut Die	Kit B Hydraulic Ram (size 20-32)
1-1/2"	24	24 Body Die	Size 24 Nut Die	
2"	32	32 Body Die	Size 32 Nut Die	

Tube O.D.	"L"
1-1/4"	3"
1-1/2"	3-3/8"
2"	4-1/4"

Size	20	24	32
Turns	5/8	5/8	3/4

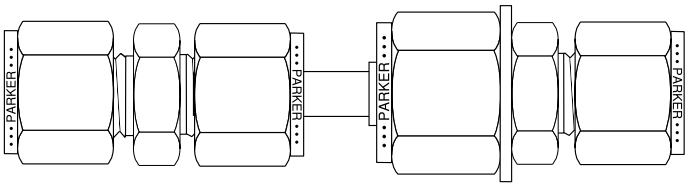
Table 2



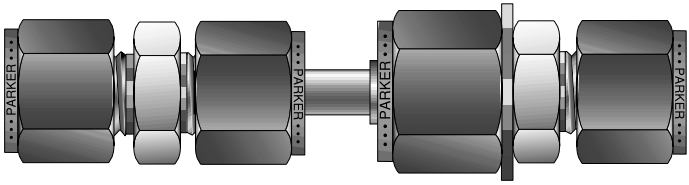
"L" Chart

Dielectric Fittings

Standard Size 8 Fitting Body | Dielectric Assembly | Standard Size 6 Fitting Body

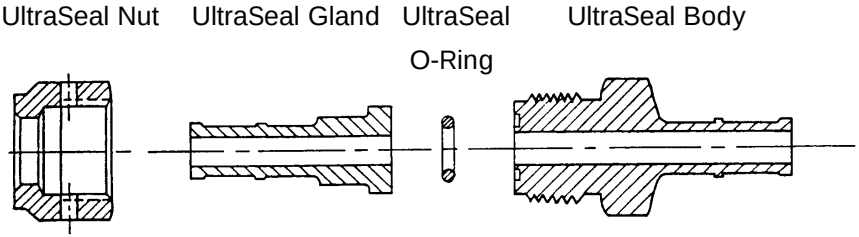


Identification Ring



1. Place Identification Ring over size 8 fitting body.
2. Insert size 8 (dielectric end) into standard fitting body and tighten nut until finger tight. Tighten with wrench until nut contacts identification ring.
3. Insert tube end with pre-set nut and ferrule(s) into fitting body and tighten until finger tight. Tighten with wrench 1/4 turn from finger tight.

Proper High Integrity Couplings Installation

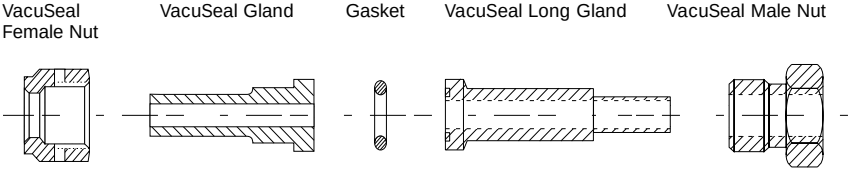


UltraSeal

A positive seal is achieved by advancing the nut no less than 1/4 turn from finger tight position. When a sharp rise in torque is felt, the sealing faces have met and the O-ring seal is compressed into its groove.

UltraSeal is capable of repeated remakes; advance the nut to a finger tight position and wrench until a sharp rise in torque is felt.

VacuSeal



Remove the protector cap from the toroid. Place the gasket into the female nut where applicable. Assemble components and snug finger tight. Holding a backup wrench stationary, tighten the female nut 1/8 turn past finger tight for 316-SS or nickel gaskets. Upon remake a new gasket should be installed each time.

Proper Installation of Weld Fittings

Automatic Buttweld

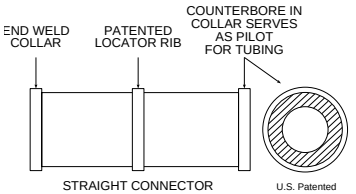


Figure 1 - The Automatic Buttweld fitting has a locator rib positioned a fixed distance from the end weld collar.

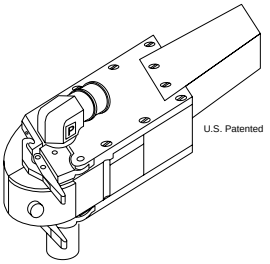


Figure 2 - The orbiting electrode is precisely positioned over the end collar by engaging the locator rib within the weld head.

Note: *The weld head shown is for illustration only.*

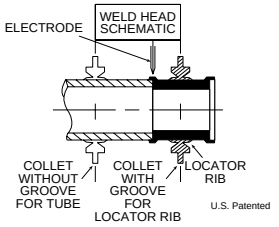


Figure 3 - The orbital welder electrode is shielded within the stationary head and rotates 360˚ to produce uniform, accurate welds.

MiniButtweld Tube Fittings

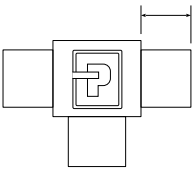


Figure 1 - The Mini-Buttweld tube fitting has a controlled distance from the fitting body shoulder to the end of the tube stub.

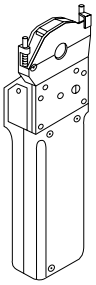


Figure 2 - The orbiting electrode is positioned over the fitting end by batting against the body.

Note: *The weld head shown is for illustration only.*

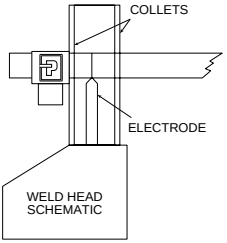


Figure 3 - The orbital welded electrode is shielded within the mini-weld head and rotates 360˚ to produce uniform, accurate, 100% penetration welds.

Purpose

Parker Orbital Tube Weld fittings are designed for applications requiring the reliability of a welded tubing system. They were developed specifically for installation using automatic, orbital TIG (Tungsten/Inert Gas) welding equipment.

Parker Weld fittings offer the easiest, fastest and most reliable way to fabricate welded systems.

Parker MiniButtweld Tube Fittings are available in VIM/VAR stainless steel in tees, 90˚ elbows, reducers and mini glands.

Orbital Tube Weld Fittings are available in AOD/VAR and VIM/VAR stainless steel in straight unions, tees and 90˚ elbows. Orbital Buttweld ends are also available with male pipe and compression tube connections.

For high integrity mechanical connections for positive pressure and vacuum applications in ultra-pure systems, Buttweld fittings may be specified with an UltraSeal or VacuSeal Coupling.

Pressure

Buttweld pressure ratings will be governed by the tubing wall thickness selected for a particular application.

Buttweld working pressures are rated at room temperature based on a 4 to 1 design factor. Pressure ratings are calculated in accordance with ANSI Power Piping Code B31.1.

Interior (I.D.) Surface Finishes

Orbital Tube Weld and MiniButtweld Tube Fittings can be supplied with extremely smooth internal surface finishes to meet requirements of high purity tubing systems. Electropolished internal surfaces can also be provided. Consult your local Parker distributor or factory for more details.

Automatic Buttweld Principles of Operation

Parker's patented Automatic Buttweld tube fittings are designed specifically for installation by means of automatic, orbital TIG (Tungsten/Inert Gas) welding machines. Any one of several makes may be used; their names are available from Parker upon request.

In an orbital welder, the electrode is contained and shielded within the head (see Figure 3 page 49). The head itself does not rotate; rather, the electrode rotates 360˚ within the head.

An orbital-type welder utilizes high-frequency current pulses, producing low-frequency arc pulses. These yield considerable arc penetration into the metal at low current values. As a result, arc-pressure variations are kept low and the resulting agitation of the weld puddle eliminates porosity and refines the grain structure at the weld area.

To Operate a TIG Welding Machine

1. Place the Automatic Buttweld fitting into the weld head, placing the locator rib in the corresponding locator groove. For MiniButtweld, place the fitting into the mini-weld head and position the fitting body shoulder against the tube clamp assembly.
2. Bottom the tubing (square cut, deburred) in the fitting end collar and close the second collet, which locks the tubing to the weld head. Engage the second collet.
3. Close the weld head. Press the “Start” button.

Depending on the size and wall-thickness of the tubing, the welding machine parameters can be programmed to make one or more 360° passes. Once programmed, the machine will repeat the operation precisely, within very close tolerances and in areas too tight for manual welding.

Automatic Centering of Electrode

Each Automatic Buttweld fitting has an external locator rib (patented) situated a fixed distance from the end welding collar (see Figure 1 page 49). When the welder-head clamping collet is applied, the rib fits snugly within a corresponding annular groove in the collet.

As the electrode orbits, the collet follows the rib, maintaining precise positioning of the electrode, over the end collar (see Figure 3 page 49). Thus, electrode and welding positioning are always accurately aligned.

End Weld Collar

On the O.D. of each Automatic Buttweld fitting end, there is an end collar. During welding, the electrode tip is positioned directly over this end collar. As the electrode orbits, a uniform bead on the buttseam is achieved.

Like the locator rib, the end collar is an exclusive Parker feature.

Piloted Mating of Tube to Fitting

The end collar of the Automatic Buttweld fitting is counter bored. This serves as a pilot for the tube end, guiding it accurately into the fitting end.

Like the locator rib, the end collar is an exclusive Parker feature.

Compensation for Tube-Thickness Variations

The outside diameter of the end collar is designed to compensate for normal variations in the nominal O.D. of instrumentation tubing.

In addition, each fitting is machined for the specific wall thickness being specified.

These two features allow for the fitting bore and tube I.D. to be carefully matched. Thus, an ABW connection will allow for full flow, with no protrusions extending into the flow path. This will reduce a major cause of turbulence.

Socket Weld Fittings

General

The weld used in joining a tube to a socket weld tube fitting is like any other type of “tee” weld. The root (i.e., the point of intersection of the outside of the tube and annular end area of the fitting) must be included in the weld zone.

Careful welding procedures are normally followed to assure that this root area is included in the weld. If penetration is not achieved, the joint will have two built-in stress risers which may greatly reduce the strength of the weld. Upon application of an extreme load, these stress risers could result in cracks which could propagate out through the weld or tube depending upon the direction of the greatest load.

Often to achieve full root penetration in TIG welding of stainless steels, a fusion pass will be made first, followed by a final pass utilizing a filler rod to achieve the desired fillet size.

Assembly

The codes applicable to the welding of socket weld fittings require that the tube be inserted into the socket until bottomed against the stop. The tube is then to be backed out approximately 1/16 of an inch and then welded.

If the tube is not backed out, but welded when against a flat bottom stop, the contraction of the weld fillet and fitting socket can combine to produce a static stress on the weld. During thermal transients, the fitting and the portion of the tube within the fitting may experience a differential rate of heating or cooling, again adding to the stress level in the weld.

Tacking

If the weld joint is to be “tacked” before welding, it is recommended that the “tack” weld build-up be held to a minimum.

Excessive build-up on the “tack” may cause an interrupted final bead and a stress riser or lack of complete fusion.

Backing Gas

Backing gas is an inert gas used to flood the interior of the fittings and tube system during welding. It serves the same purpose internally as the shielding gas used in TIG or MIG welding. By reducing the interior oxygen level to as low as practicable, it also serves to control the combustion of contaminates that could affect weld quality.

When a backing gas is not used and nearly 100% weld penetration is achieved, blisters will tend to form on the internal tube wall. This will result in scale which may later break loose. Therefore, in 0.050 wall or thinner tube or where the wall thickness is such that the selected weld process may burn through, the use of a backing gas is mandatory.

In most cases the backing gas will be argon or helium connected to the system through a control regulator. Flow rates, while small, should be high enough to purge the system. Welds should be made in downstream sequence from the gas connection.

Note that the entire system should be purged to insure that there are no openings that will allow air to be drawn into the system.

The use of backing gas, while often not mandatory, will give a better weld joint. This is because the effects of contaminate combustion by-products are eliminated and because the welds are made and cooled under a shielded atmosphere, thus eliminating internal scaling or blistering.

Welding Methods
300 Series Stainless Steels

May be welded by the TIG, MIG, or stick arc-weld process.

TIG welding is recommended as being best for welding Weld-lok systems because it allows better operator control of heat penetration and filler material deposition.

Stick arc welding is not recommended in many cases because of the likelihood of excessive burn-through and improper root penetration. In all cases where stick welding is used, it is recommended that backing gas be used.

MIG welding gives the same characteristics as stick electrode welding with faster deposition of the filler material.

As this process runs “hotter” than the stick process, the use of a backing gas is mandatory. It should be noted that in welding the relatively small fitting sizes found in the Weld-lok line, filler deposition rate economies are not a factor and therefore the MIG method is not commonly applied.

C1018 Steel Fittings

May be welded by the TIG, MIG, stick and oxyacetylene methods. As scale formation remains a problem, the use of a backing gas is still recommended.

Carbide Precipitation

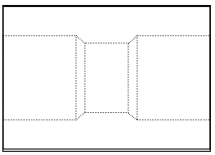
When unstabilized stainless steels are heated to 800˚ - 1500˚ F during welding, the chromium in the steel combines with the carbon to form chrome carbides which tend to form along the grain boundaries of the metal (carbide precipitation). This lowers the dissolved chromium content in these areas and thus lowers their corrosion resistance, making them vulnerable to intergranular corrosion. Carbide precipitation is reduced by holding the carbon content of the material to a very low value. This limits the amount of carbon available to combine with the chromium. The “L” series (extra low carbon) stainless steels are often used for this purpose, but their use reduces system design stress by approximately 15%. Parker Weld-lok fittings are made from a select 316 series with carbon content in the low range of 0.04 to 0.07 percent. This results in a welded fitting with good corrosion resistance and a high strength factor.

All Parker Weld-lok fittings in stainless steel are supplied in the solution-treated condition, capable of passing ASTM-A-262 Tests for Detecting Susceptibility to Intergranular Corrosion.

ARC Polarity

When welding Weld-lok fittings, best results will be obtained by the following arc polarities:

TIG - Direct Current, straight polarity
MIG - Direct Current, reverse polarity
STICK - Polarity dependent on rod used



Parker Weld-lok Union

For further information on Parker’s Welded Fittings refer to Parker’s Welded Fittings Catalog 4280.

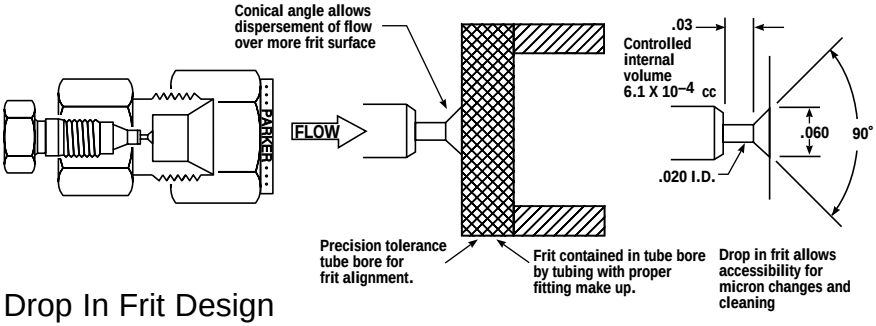
Analytical Tube Fittings

Parker Hannifin's Instrumentation Connectors Division offers a full line of analytical tube fittings. These fittings range from elbows, tees, and male connectors to low dead volume unions and column end fittings. Parker incorporates various features in the column end fittings to effectively address various industry concerns.

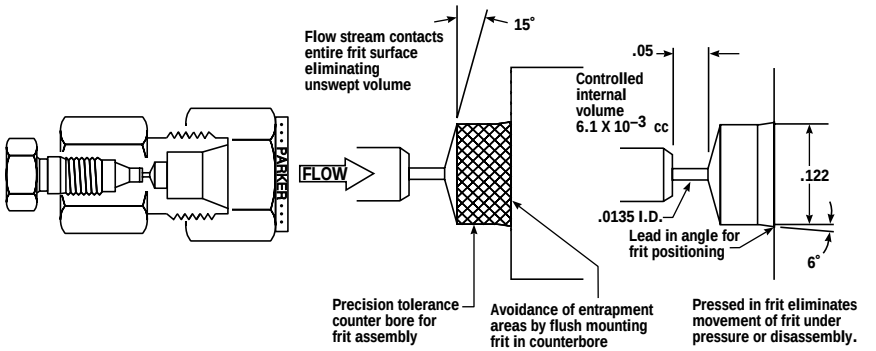
- Peak symmetry for critical analysis
- Internal volume reduction

As the observed media/substance migrates through the HPLC column, a "peak" or "band" is created that denotes the level of concentration.

It is critical to maintain peak symmetry in order to get an accurate reading when processing the observed media/substance. Parker Hannifin, in the development of a line of column-end fittings, has incorporated some key features that help to maintain this "peak symmetry" in HPLC columns.



Drop In Frit Design



Press In Frit Design

Under most circumstances in liquid chromatography (LC), the flow through the tube is laminar, the so-called Poiseulle flow, and in this situation the velocity at all points is parallel to the tube axis.

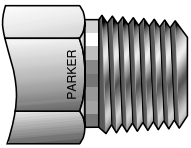
Due to the importance of maintaining smooth laminar flow after injection of the sample into the HPLC column, Parker incorporated a small conical angle on the fitting body internals. This conical angle helps to equally disperse the sample into the column tube. One of the key requirements of an effective column-end fitting is not to delay or disturb the flow of the sample through the instrument (HPLC column).

A second area to address is the minimizing of tube fitting internal “cavities”. A cavity is a short section of the flow path where the flow-channel diameter increases. It can occur where tubes are connected to each other (low dead volume connector) or to injectors, columns (column-end fittings), and detectors. Large cavities can seriously degrade the resolution of any chromatogram, but they can be easily avoided through awareness of the geometric design details of the fittings and connecting parts manufactured by various companies.”

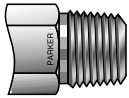
Parker Hannifin has incorporated those critical features in both a low dead volume union connector and the column-end fitting bodies. First, the utilization of inverted 1/16” connections to greatly reduce internal volume or cavities. To eliminate any confusion or occurrence of incorrect effective tube make-up, the port depths (body bore dimensions) are identical by size throughout the entire Parker Hannifin instrumentation line. Second, Parker closely monitors the dimensions of the small through-hole utilized in these low dead volume connectors.

Thread and Tube End Size Chart (U.S.A.)

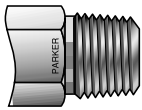
NPT Thread



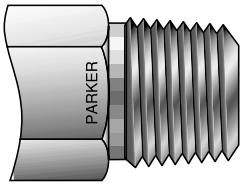
1/4"
(1/4-18)



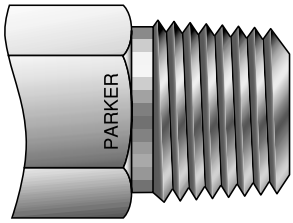
1/16"



1/8"
(1/8-27)

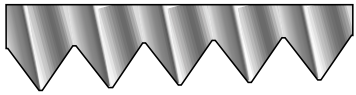


3/8"
(3/8-18)

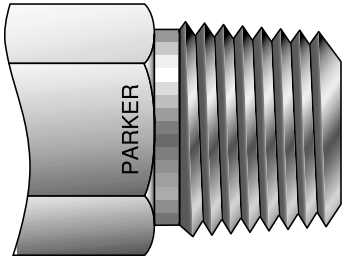


1/2"
(1/2-14)

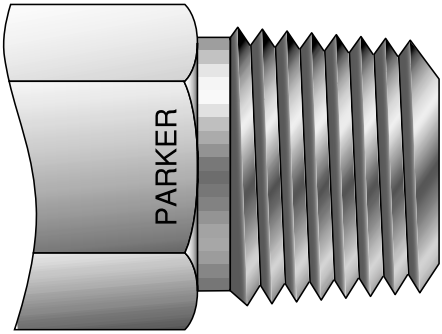
American Standard
Pipe Thread (NPT)



60° thread angle • Pitch measured in inches
• Truncation of root and crest are flat
• Taper angle 1°47'



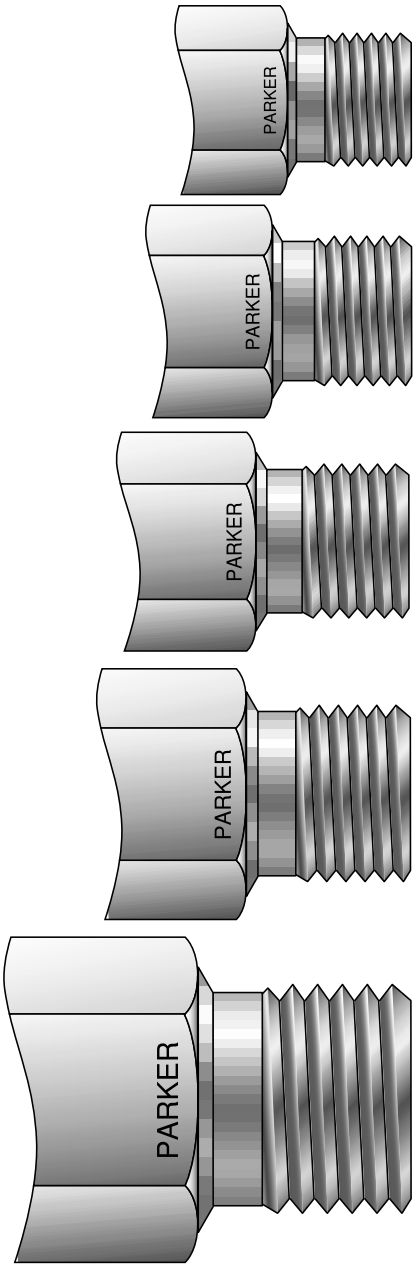
3/4"
(3/4-14)



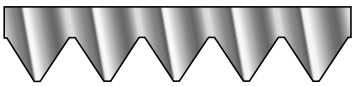
1"
(1"-11 1/2)

Thread and Tube End Size Chart (International)

Straight Thread

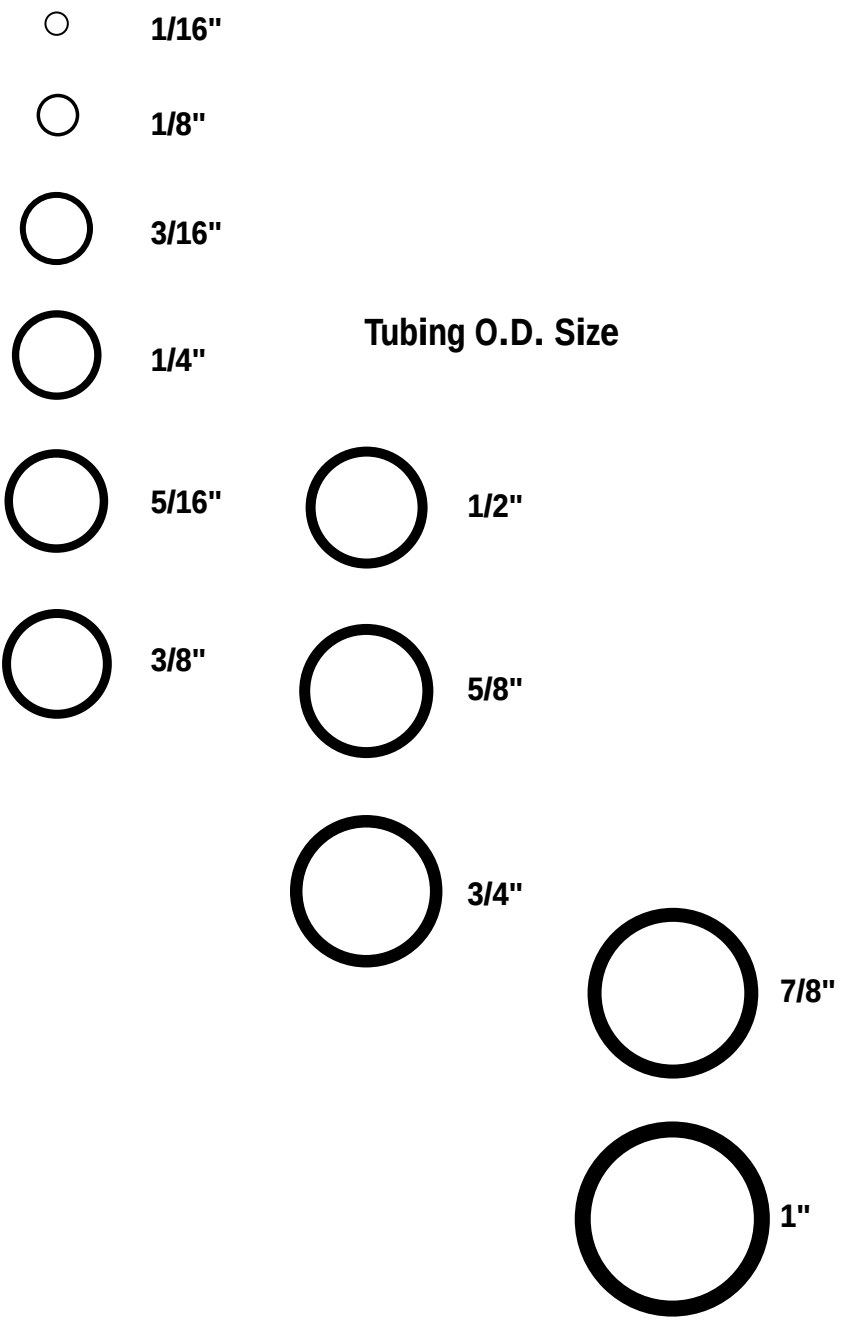


American Standard Unified Thread (Straight)

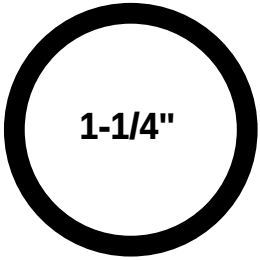


60° thread angle • Pitch measured in inches
• Truncation of root and crest are flat
• Diameter measured in inches

Thread and Tube End Size Chart (U.S.A.)



Pipe and Tube End Size Chart (U.S.A)



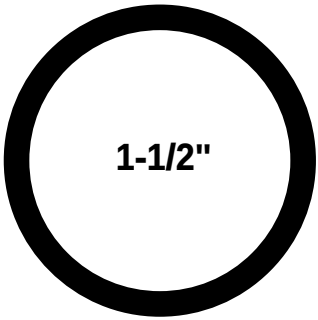
Tubing O.D. Size

1-1/4"



NPT Thread

Pipe and Tube End Size Chart (U.S.A)

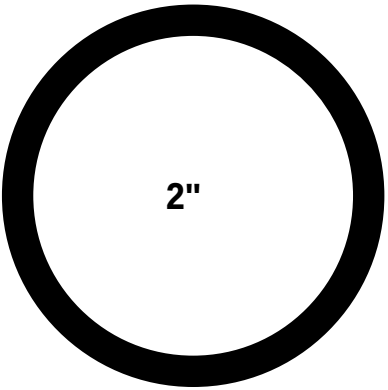


Tubing O.D. Size

1-1/2"

NPT Thread





Tubing O.D. Size

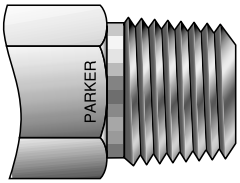
2"

NPT Thread



Thread and Tube End Size Chart (International)

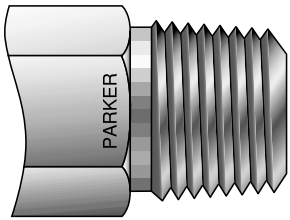
BSPT
Tapered Thread



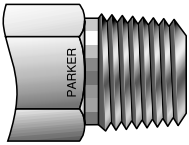
3/8"
(3/8-19)



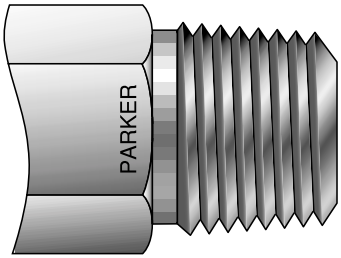
1/8"
(1/8-28)



1/2"
(1/2-14)

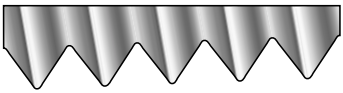


1/4"
(1/4-19)

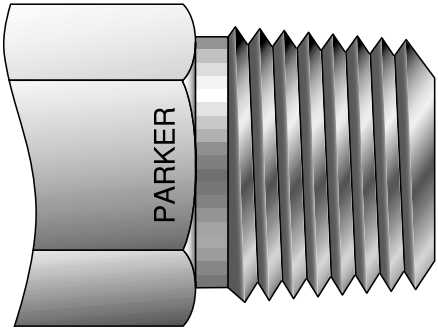


3/4"
(3/4-14)

International Organization
for Standards
(ISO 7/1)



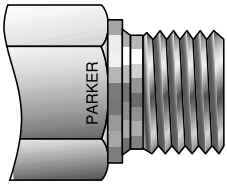
55° thread angle • Pitch measured in inches
• Truncation of root and crest are round
• Taper angle 1°47'



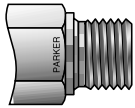
1"
(1"-11)

Thread and Tube End Size Chart (International)

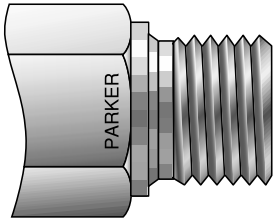
BSPP
Parallel Thread



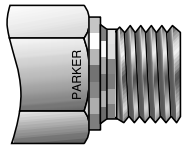
3/8"
(3/8-19)



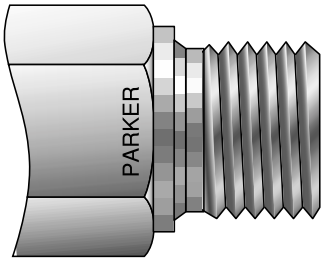
1/8"
(1/8-28)



1/2"
(1/2-14)

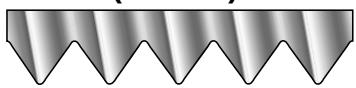


1/4"
(1/4-19)

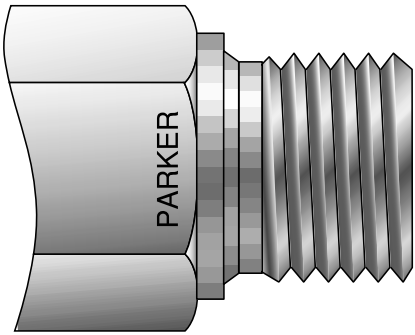


3/4"
(3/4-14)

International Organization for Standards (ISO 228/1)

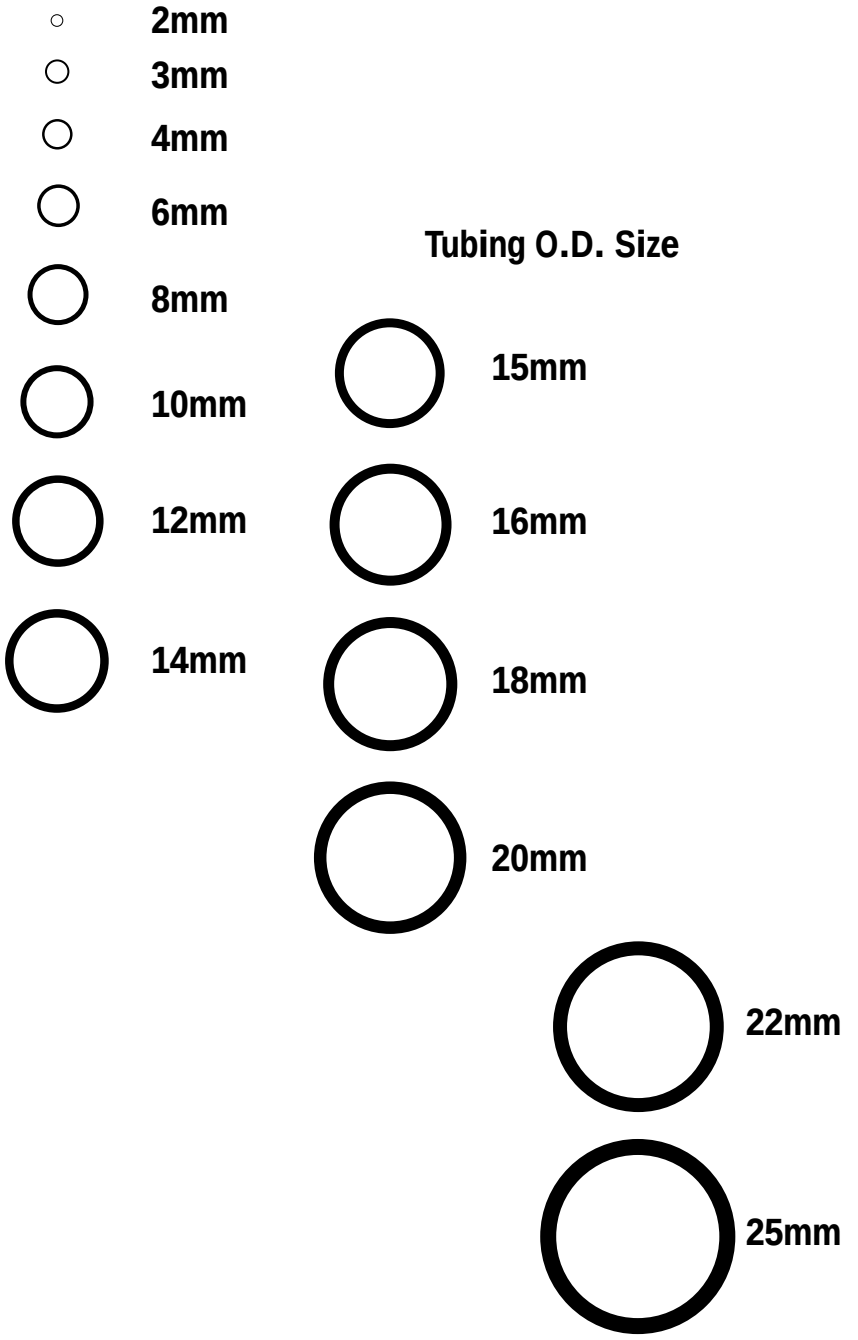


55° thread angle • Pitch measured in inches
• Truncation of root and crest are round
• Diameter measured in inches



1"
(1"-11)

Thread and Tube End Size Chart (International)



Thread Identification

We are frequently asked to explain the differences in various types of threads, as piping specifications and (or) equipment are designed with the following threaded connections:

1. NPT
2. BSPT
3. BSPP
4. Screw Thread
5. S.A.E. Straight Thread
6. Metric Thread

NPT Thread

NPT, National Pipe Thread or pipe taper is the most commonly used pipe thread in the United States and Canada.

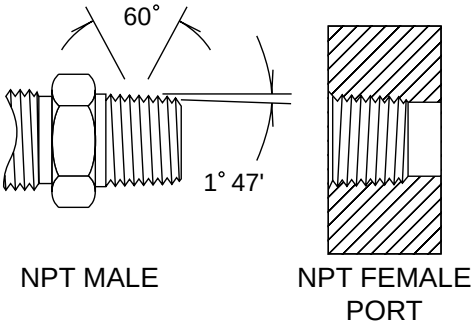


Figure 1 NPT (National Pipe Taper)

Characteristics of NPT

1. Thread Pitch measured in inches.
2. Root & Crest Truncation are flat.
3. 60˚ Thread Angle
4. Taper Angle 1˚ 47’

Parker’s Instrumentation Connectors Division machines this thread on all CPI™, A-LOK® as well as on pipe & pipe adapter fittings where N.P.T. is designated. All male threads are rolled for strength and durability. Parker ICD’s NPT threads meet the standards set forth by ANSI B1.20.1

BSPT - British Standard Taper

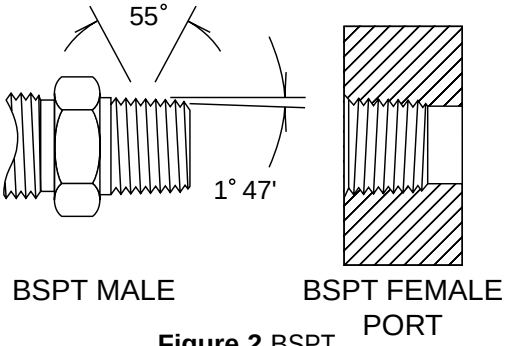


Figure 2 BSPT

Characteristics of BSPT

1. Taper Angle 1˚ 47’
2. 55˚ thread angle
3. Pitch can be measured in millimeters or inches
4. Thread truncation is round

BSPT threads are different from and will not substitute for N.P.T. threads.

The following standards are equivalent to B.S.P.T.

a. ISO 7/1 (International Standards Organization)
b. DIN 2999 (Deutsche Industrial Norme)
c. JIS B0203 (Japanese Industrial Standard)
d. BS 21 British Standard

BSPP - British Standard Parallel Pipe

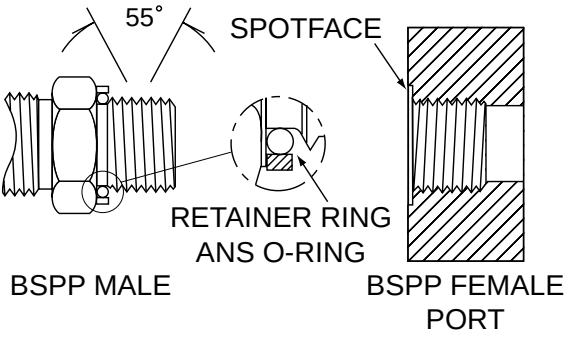


Figure 3 BSPP

Characteristics of BSPP

1. 55° thread angle
2. Thread pitch measured in inches
3. Thread diameter measured in inches
4. Root/Crest Truncation round

A parallel thread form uses the threads for holding power only and seals by means of an O-ring and retainer ring.

The following standards are equivalent to B.S.P.P.

a. ISO 228/1 (International Standards Organization)
b. DIN 3852 Part 2 & Parallel threads (Deutsche Industrial Norme)
c. JIS B0202 (Japanese Industrial Standard)
d. BS 2779 (British Standard)

Unified Screw Threads

These are very common threads utilized on valves and fitting stems, nut and fitting end threads. They are straight, **NOT** tapered threads used for holding power.

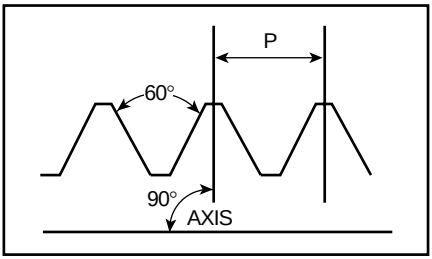


Figure 4

Screw threads are denoted by the following:

For instance:	**5/16**	-	**20**
	Thread Diameter		Number of Threads per inch

In general - screw threads can be further classified into various types of pitch' (UNF) Unified Fine Pitch - (UNC) Unified Coarse - (UN) Unified Constant.

These classifications are determined by the relationship of threads per inch to outer diameter.

Note: For further information on thread pitch, please refer to ISO standards handbook or H-28 handbook.

SAE Straight Thread Port

SAE straight thread O-ring fittings are commonly used for sealing hydraulic ports found in a variety of equipment. Since the O-ring seal is replaceable, this design offers unlimited re-usability

Tube O.D.	Thread Size UNF-2B	D Min. Dia.	J Min. Full Thd. Depth	K +.015 -.000	O Min. Dia.	P Min. Tap Drill Depth	S Max	U +.005 -.000 Dia.	Y Dia.	Z +1 -1
1/8	5/16-24	0.062	.390	.074	.438	.468	.062	.358	.672	12
3/16	3/8-24	0.125	.390	.074	.500	.468	.062	.421	.750	12
1/4	7/16-20	0.172	.454	.093	.563	.547	.062	.487	.828	12
5/16	1/2-20	0.234	.454	.093	.625	.547	.062	.550	.906	12
3/8	9/16-18	0.297	.500	.097	.688	.609	.062	.616	.969	12
1/2	3/4-16	0.391	.562	.100	.875	.688	.094	.811	1.188	15
5/8	7/8-14	0.484	.656	.100	1.000	.781	.094	.942	1.344	15
3/4	1-1/16-12	0.609	.750	.130	1.250	.906	.094	1.148	1.625	15
7/8	1-3/16-12	0.719	.750	.130	1.375	.906	.094	1.273	1.765	15
1	1-5/16-12	0.844	.750	.130	1.500	.906	.125	1.398	1.910	15
1-1/4	1-5/8-12	1.078	.750	.132	1.875	.906	.125	1.713	2.270	15
1-1/2	1-7/8-12	1.312	.750	.132	2.125	.906	.125	1.962	2.560	15
2	2-1/2-12	1.781	.750	.132	2.750	.906	.125	2.587	3.480	15

Figure 5 SAE Straight Thread O-ring Port Dimensions

NOTE: Tap drill lengths “P” given here require bottoming taps. Increase “P” as required for standard taps.

NOTE: Diameter “U” shall be concentric with thread pitch diameter within .005 FIM. It should be free from longitudinal and spiral tool marks.

Metric Threads (ISO 262)

The following sections were prepared with the intention of explaining that NONE of them should be confused with a metric thread.

Please remember that a metric thread, be it parallel or tapered is designated as metric by the distance in millimeters from thread crest to crest. In the case of the parallel thread Figure 6 the O.D. is also expressed in millimeters.

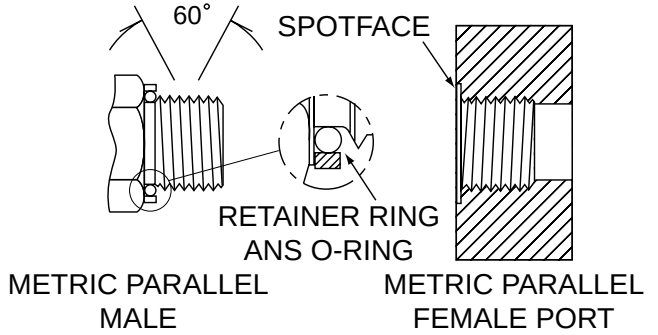


Figure 6

To assist you in determining the various types of threads, Parker has available the International Thread I.D. Kit/Bulletin 4303-B1. It includes calipers, international and screw thread pitch gauges.

Heat Code Traceability

Parker Hannifin’s Instrumentation Divisions offer the following stainless steel high quality fittings and document Heat Code Traceability (HCT).

- CPI™ Tube Fittings
- A-LOK® Tube Fittings
- Instrumentation Pipe Fittings
- Orbital Tube Weld Fittings
- MiniButtweld Fittings
- VacuSeal Couplings
- UltraSeal Couplings
- Needle Valves
- Ball Valves
- Check Valves
- Filters

HCT refers to the fact that a particular part can be traced back to the original mill heat of metal from which it was made. Beginning with the original melt, a package of documents is created which completely describes the metal in physical and chemical terms. The end result is that a number which is permanently stamped to the part, refers back to the document package.

The HCT number is stamped on the material (bar stock or forging) prior to manufacturing. The concept is useful because it provides a method for complete material accountability for the manufacturer and end customer.

For instance, interpretations of applicable specifications governing the use of materials in nuclear power plants lean toward the idea that HCT materials are not mandatory on 3/4" and smaller pipe (1" and smaller O.D. tubing) lines. However, heat code traceability for larger material sizes is mandatory and many designers insist that the protection offered by heat code traceability may be made part of small line installations as well, especially what is known as Class 1 or critical applications. Only Parker tube fittings offer the nuclear designer the capability to specify heat code traceability for his pressure retaining fitting bodies.

The material used in Parker Hannifin instrumentation fitting components is 316 or 316L (welded products) stainless steel as specified and referenced in Section III of the ASME Boiler and Pressure Vessel code.

The American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel code, Section III, latest issue, entitles Rules for Construction of Nuclear Power Plant Components, is the principal document covering this type of fitting in the nuclear field. ANSI Standard B 31.1.0, Power Piping, and ANSI Standard B 31.7, Nuclear Power Piping are also important documents in the field.

In addition to the documentation of chemical and physical properties, great care is taken throughout the manufacture of Parker's tube fittings to ensure that potential stress corrosion will not be a problem in normal usage of the parts. Manufacturing processes avoid exposure of the parts to mercury or halogens, and control of thermal treatment avoids the condition known as continuous grain boundary carbide precipitation.

The entire product line of stainless steel instrumentation fittings is manufactured to meet or exceed all applicable specifications to assure the designer that he is working with a quality product. This also assures the engineer, the contractor, and the customer that they are working with a high quality product that is in full compliance with all applicable specifications.

These specifications ensure high quality instrumentation fittings for use in fossil fuel power plants, chemical refineries, general instrumentation and processing plants. Requirements are now emerging in the semiconductor and pharmaceutical industries.

Not only are the materials continuously monitored, but Parker adheres to a formal, documented Quality Assurance Program that controls manufacture, marking, testing and examination procedures, cleaning and packaging.

Although not all customer orders require the high degree of quality assurance imposed by Parker, it is the policy of the company to manufacture products to meet all existing specifications, as well as anticipated future requirements in the area of Heat Code Traceability.

HCT offers these advantages:

- Raw materials for manufacture must meet code requirements. This can be verified through documentation so that the customer is certain that what is ordered is received.
- HCT provides a record of chemical analysis with the raw material. Thus, in areas requiring welding, the correct welding technique is applied.

HCT relieves the user of Parker instrumentation tube fittings of any doubts. It acts as an assurance for today and for tomorrow.

Parker Suparcase® - Ferrule Hardening

Instrumentation tube fittings were on the market for only a short time when manufacturers realized that a pure compression 316 stainless steel fitting, single or double ferrule, while working well with fluids would not effectively seal gases. Nor would stainless steel compression ferrules hold to the working pressure of the many tube wall thicknesses being specified. Also, compression ferrules would not effectively seal gases on stainless steel tubing with surface imperfections. It became evident that it would be necessary to harden the surface of the ferrule to improve service performance. All fitting manufacturers began to harden the leading edge of the ferrules to solve this problem.

Parker's Instrumentation Connectors Division was not alone in recognizing the application problems associated with pure compression stainless steel fittings. But, as often happens with engineering trade-offs, chemical hardening, while a solution to the problem at hand, affected and changed the chemistry of the 316 stainless material.

Chemical hardening of the ferrule reduced its resistance to corrosion.

The race was on to find a new way to maintain the benefits of chemical hardening without changing the base chemistry of the 316 stainless material. Parker has taken the lead in the development of the chemical hardening process ideal for ferrules designed to grip and seal stainless steel tubing. The process, a technological breakthrough, is called *Suparcase*®.

Parker Suparcase® is a proprietary chemical process for the treatment of ASTM 316 stainless steel ferrules that imparts a unique set of physical characteristics that greatly enhances the corrosion resistance and hardness of ASTM 316 stainless steel. The *Parker Suparcase*® ferrules offer several important advantages over untreated ASTM 316 stainless steel.

The first important advantage lies in performance in corrosive environments. When compared to untreated ASTM 316 stainless steel, *Suparcase*® offers at least equivalent or better performance in the following corrosive environments:

50% sulfuric acid solution at 25˚ C
50% nitric acid solution at 25˚ C
30% acetic acid solution at 25˚ C
5% sodium hypochlorite at 25˚ C
Type II simulated black liquor at 25˚ C
(TAPPI TIS 0402-09)

Standard stress corrosion cracking tests have been performed on Suparcased ASTM 316 stainless steel, and untreated ASTM 316 stainless steel. The tests were conducted on U-bend specimens and on standard tensile specimens in chloride, hydroxide, and sulfide solutions. These tests have shown that the *Suparcase*® is at least equivalent or better in performance in resistance to stress corrosion cracking as compared to untreated ASTM 316 stainless steel.

Also, the *Suparcase*® ferrule has a surface hardness exceeding that of untreated ASTM 316 stainless steel enabling the Suparcase® ferrule to grip and seal ASTM 316 stainless steel tubing.

Over the past several years, ICD has made dramatic product quality improvements. Improvements have been made in forging quality, body seats and tube bore surfaces, pipe threads, nut quality, I.D. surface finishes, overall improved tolerances and now Suparcase®, the ultimate product advantage.

The *Parker Suparcase*® ferrule is a new breakthrough as a result of technology transfer from extensive research into super-corrosion resistant austenitic stainless steel by Parker's Research and Development Group. The *Suparcase*® ferrule has been developed to greatly enhance the corrosion resistance and hardness at ASTM type 316 stainless steel. Due to the *Suparcase*® ferrule's unique set of physical characteristics, it's ideal for instrumentation fitting ferrules which must seal and grip on commercial stainless steel tubing.

The *Parker Suparcase*® ferrule has the following features, advantages and benefits to the user:

1. Superior or equal to ASTM type 316 stainless steel in a broad range of corrosive applications.
2. Not affected by the standard working temperatures of ASTM type 316 stainless steel.
3. Superior resistance to pitting compared to ASTM 316.
4. Superior to ASTM 316 in stress corrosion tests.
5. A high surface hardness that prevents galling and increases remakes.
6. Proven in field applications throughout the world.

Typical Sample of Corrosion Resistance

Corrosion Environment	Suparcase® Ferrule compared to Untreated ASTM 316
Acetic Acid	Superior
Boiling Nitric Acid	Equivalent
Hydrochloric Acid	Equivalent
ASTM Salt Spray Test #B117	Equivalent
Sulfuric Acid	Superior
SO2 Atmosphere	Equivalent
34% $MgCL^2$ Stress Corrosion Test	Superior

ASTM Salt Spray
Test #B117



The photos above show the lack of corrosion damage demonstrated by Parker Suparcase ferrule(s) (left photo) versus a competitor's ferrule (right photo) hardened by a traditional process when exposed to salt spray for only 72 hours.

Elevated Temperature Test

The upper temperature limit for the use of ASTM 316 stainless steel in tube fittings is established by the potential formation of carbide precipitates. The *Suparcase*® ferrules are fully functional at these temperatures.

Stress Corrosion

Stress corrosion tests confirming the superiority of the Suparcase® ferrule have been carried out in 34% Magnesium Chloride solution under pure bending conditions with constant load. The Tensile stress in the specimens is 29,000 lbs/ in^2 that is about 80% of the 02% yield stress.

The first tests were carried out with ground specimens of ASTM 316 at a temperature of 158 degrees F. The results are shown in the following table.

Time to rupture in hours of ground ASTM 316 specimen is shown below.

Temperature of 158 Degrees F

Untreated ASTM 316	Suparcase® Ferrule
Failure at 262 hrs.	No failure at 3,000+ hrs.
Failure at 339 hrs.	No failure at 3,000+ hrs.
Failure at 333 hrs.	No failure at 3,000+ hrs.
Failure at 304 hrs.	No failure at 3,000+ hrs.

Ferrule Surface

The treated surface of the Suparcase® ferrule, because of the complete infusion into the surface, creates no dimensional changes. The Suparcase® ferrule integrity is unaffected by initial or repeated remakes.

Parker Suparcase® A-LOK® Back Ferrule



Unaffected by corrosive etching

Parker Suparcase® Applications and Advantages

Parker Suparcase® is available on CPI™ single ferrule and the rear ferrule of A-LOK® double ferrule fitting. They are ideal for applications where severe corrosive environments are present.

These include:

Offshore Oil Production

Refinery Instrumentation

Co-generation Operations

Environmental Operations

Black Liquor controls in paper mills

Semiconductor

NOTES



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Appendix E

User's Manual

Model EJA110A, EJA120A and EJA130A Differential Pressure Transmitters

IM 01C21B01-01E

YOKOGAWA
Yokogawa Electric Corporation

IM 01C21B01-01E
11th Edition

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Customer Maintenance Parts List

DPharp EJA Series Transmitter Section ..... CMPL 01C21A01-02E
Model EJA110A, EJA120A and EJA130A
Differential Pressure Transmitter ..... CMPL 01C21B00-01E

REVISION RECORD

1. INTRODUCTION

Thank you for purchasing the DPharp electronic pressure transmitter.

The DPharp Pressure Transmitters are precisely calibrated at the factory before shipment. To ensure correct and efficient use of the instrument, please read this manual thoroughly and fully understand how to operate the instrument before operating it.

■ Regarding This Manual

- This manual should be passed on to the end user.
- The contents of this manual are subject to change without prior notice.
- All rights reserved. No part of this manual may be reproduced in any form without Yokogawa's written permission.
- Yokogawa makes no warranty of any kind with regard to this manual, including, but not limited to, implied warranty of merchantability and fitness for a particular purpose.
- If any question arises or errors are found, or if any information is missing from this manual, please inform the nearest Yokogawa sales office.
- The specifications covered by this manual are limited to those for the standard type under the specified model number break-down and do not cover custom-made instruments.
- Please note that changes in the specifications, construction, or component parts of the instrument may not immediately be reflected in this manual at the time of change, provided that postponement of revisions will not cause difficulty to the user from a functional or performance standpoint.
- Yokogawa assumes no responsibilities for this product except as stated in the warranty.
- If the customer or any third party is harmed by the use of this product, Yokogawa assumes no responsibility for any such harm owing to any defects in the product which were not predictable, or for any indirect damages.

NOTE

For FOUNDATION Fieldbus™, PROFIBUS PA and HART protocol versions, please refer to IM 01C22T02-01E, IM 01C22T03-00E and IM 01C22T01-01E respectively, in addition to this manual.

- The following safety symbol marks are used in this manual:

WARNING

Indicates a potentially hazardous situation which, if not avoided, *could* result in death or serious injury.

CAUTION

Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury. It may also be used to alert against *unsafe practices*.

IMPORTANT

Indicates that operating the hardware or software in this manner may damage it or lead to system failure.

NOTE

Draws attention to information essential for understanding the operation and features.

⎓ Direct current

1.1 For Safe Use of Product

For the protection and safety of the operator and the instrument or the system including the instrument, please be sure to follow the instructions on safety described in this manual when handling this instrument. In case the instrument is handled in contradiction to these instructions, Yokogawa does not guarantee safety. Please give your attention to the followings.

(a) Installation

- The instrument must be installed by an expert engineer or a skilled personnel. The procedures described about INSTALLATION are not permitted for operators.

- In case of high process temperature, care should be taken not to burn yourself because the surface of body and case reaches a high temperature.
- The instrument installed in the process is under pressure. Never loosen the process connector bolts to avoid the dangerous spouting of process fluid.
- During draining condensate from the pressure-detector section, take appropriate care to avoid contact with the skin, eyes or body, or inhalation of vapors, if the accumulated process fluid may be toxic or otherwise harmful.
- When removing the instrument from hazardous processes, avoid contact with the fluid and the interior of the meter.
- All installation shall comply with local installation requirement and local electrical code.

(b) Wiring

- The instrument must be installed by an expert engineer or a skilled personnel. The procedures described about WIRING are not permitted for operators.
- Please confirm that voltages between the power supply and the instrument before connecting the power cables and that the cables are not powered before connecting.

(c) Operation

- Wait 10 min. after power is turned off, before opening the covers.

(d) Maintenance

- Please do not carry out except being written to a maintenance descriptions. When these procedures are needed, please contact nearest YOKOGAWA office.
- Care should be taken to prevent the build up of drift, dust or other material on the display glass and name plate. In case of its maintenance, soft and dry cloth is used.

(e) Explosion Protected Type Instrument

- Users of explosion proof instruments should refer first to section 2.9 (Installation of an Explosion Protected Instrument) of this manual.
- The use of this instrument is restricted to those who have received appropriate training in the device.
- Take care not to create sparks when accessing the instrument or peripheral devices in a hazardous location.

(f) Modification

- Yokogawa will not be liable for malfunctions or damage resulting from any modification made to this instrument by the customer.

1.2 Warranty

- The warranty shall cover the period noted on the quotation presented to the purchaser at the time of purchase. Problems occurred during the warranty period shall basically be repaired free of charge.
- In case of problems, the customer should contact the Yokogawa representative from which the instrument was purchased, or the nearest Yokogawa office.
- If a problem arises with this instrument, please inform us of the nature of the problem and the circumstances under which it developed, including the model specification and serial number. Any diagrams, data and other information you can include in your communication will also be helpful.
- Responsible party for repair cost for the problems shall be determined by Yokogawa based on our investigation.
- The Purchaser shall bear the responsibility for repair costs, even during the warranty period, if the malfunction is due to:

  - Improper and/or inadequate maintenance by the purchaser.
  - Failure or damage due to improper handling, use or storage which is out of design conditions.
  - Use of the product in question in a location not conforming to the standards specified by Yokogawa, or due to improper maintenance of the installation location.
  - Failure or damage due to modification or repair by any party except Yokogawa or an approved representative of Yokogawa.
  - Malfunction or damage from improper relocation of the product in question after delivery.
  - Reason of force majeure such as fires, earthquakes, storms/floods, thunder/lightening, or other natural disasters, or disturbances, riots, warfare, or radioactive contamination.

1.3 ATEX Documentation

This procedure is only applicable to the countries in European Union.

GB

All instruction manuals for ATEX Ex related products are available in English, German and French. Should you require Ex related instructions in your local language, you are to contact your nearest Yokogawa office or representative.

DK

Alle brugervejledninger for produkter relateret til ATEX Ex er tilgængelige på engelsk, tysk og fransk. Skulle De ønske yderligere oplysninger om håndtering af Ex produkter på eget sprog, kan De rette henvendelse herom til den nærmeste Yokogawa afdeling eller forhandler.

I

Tutti i manuali operativi di prodotti ATEX contrassegnati con Ex sono disponibili in inglese, tedesco e francese. Se si desidera ricevere i manuali operativi di prodotti Ex in lingua locale, mettersi in contatto con l'ufficio Yokogawa più vicino o con un rappresentante.

E

Todos los manuales de instrucciones para los productos antiexplosivos de ATEX están disponibles en inglés, alemán y francés. Si desea solicitar las instrucciones de estos artículos antiexplosivos en su idioma local, deberá ponerse en contacto con la oficina o el representante de Yokogawa más cercano.

NL

Alle handleidingen voor producten die te maken hebben met ATEX explosiebeveiliging (Ex) zijn verkrijgbaar in het Engels, Duits en Frans. Neem, indien u aanwijzingen op het gebied van explosiebeveiliging nodig hebt in uw eigen taal, contact op met de dichtstbijzijnde vestiging van Yokogawa of met een vertegenwoordiger.

SF

Kaikkien ATEX Ex -tyyppisten tuotteiden käyttöhjeet ovat saatavilla englannin-, saksan- ja ranskankielisinä. Mikäli tarvitsette Ex -tyyppisten tuotteiden ohjeita omalla paikallisella kielellännne, ottakaa yhteyttä lähimpään Yokogawa-toimistoon tai -edustajaan.

P

Todos os manuais de instruções referentes aos produtos Ex da ATEX estão disponíveis em Inglês, Alemão e Francês. Se necessitar de instruções na sua língua relacionadas com produtos Ex, deverá entrar em contacto com a delegação mais próxima ou com um representante da Yokogawa.

F

Tous les manuels d'instruction des produits ATEX Ex sont disponibles en langue anglaise, allemande et française. Si vous nécessitez des instructions relatives aux produits Ex dans votre langue, veuillez bien contacter votre représentant Yokogawa le plus proche.

D

Alle Betriebsanleitungen für ATEX Ex bezogene Produkte stehen in den Sprachen Englisch, Deutsch und Französisch zur Verfügung. Sollten Sie die Betriebsanleitungen für Ex-Produkte in Ihrer Landessprache benötigen, setzen Sie sich bitte mit Ihrem örtlichen Yokogawa-Vertreter in Verbindung.

S

Alla instruktionsböcker för ATEX Ex (explosionssäkra) produkter är tillgängliga på engelska, tyska och franska. Om Ni behöver instruktioner för dessa explosionssäkra produkter på annat språk, skall Ni kontakta närmaste Yokogawakontor eller representant.

GR

Όλα τα εγχειρίδια λειτουργίας των προϊόντων με ATEX Ex διατίθενται στα Αγγλικά, Γερμανικά και Γαλλικά. Σε περίπτωση που χρειάζεστε οδηγίες σχετικά με Ex στην τοπική γλώσσα παρακαλούμε επικοινωνήστε με το πλησιέστερο γραφείο της Yokogawa ή αντιπρόσωπο της.

SK

Všetky návody na obsluhu pre prístroje s ATEX Ex sú k dispozícii v jazyku anglickom, nemeckom a francúzskom. V prípade potreby návodu pre Ex-prístroje vo Vašom národnom jazyku, skontaktujte prosím miestnu kanceláriu firmy Yokogawa.

CZ

Všechny uživatelské příručky pro výrobky, na něž se vztahuje nevýbušné schválení ATEX Ex, jsou dostupné v angličtině, němčině a francouzštině. Požadujete-li pokyny týkající se výrobků s nevýbušným schválením ve vašem lokálním jazyku, kontaktujte prosím vaši nejbližší reprezentační kancelář Yokogawa.

LT

Visos gaminiø ATEX Ex kategorijos Eksploatavimo instrukcijos teikiami anglø, vokieèiø ir prancûzø kalbomis. Norëdami gauti prietaisø Ex dokumentacijà kitomis kalbomis susisiekite su artimiausiu bendrovës “Yokogawa” biuru arba atstovu.

LV

Visas ATEX Ex kategorijas izstrâdâjumu Lietoðanas instrukcijas tiek piegâdâtas angïu, vâcu un franèu valodâs. Ja vçlaties saòemt Ex ierîèu dokumentâciju citâ valodâ, Jums ir jâsazinâs ar firmas Jokogava (Yokogawa) tuvâko ofisu vai pârstâvi.

EST

Kõik ATEX Ex toodete kasutamisjuhendid on esitatud inglise, saksa ja prantsuse keeles. Ex seadmete muukeelse dokumentatsiooni saamiseks pöörduge lähima Iokagava (Yokogawa) kontori või esindaja poole.

PL

Wszystkie instrukcje obsługi dla urządzeń w wykonaniu przeciwwybuchowym Ex, zgodnych z wymaganiami ATEX, dostępne są w języku angielskim, niemieckim i francuskim. Jeżeli wymagana jest instrukcja obsługi w Państwa lokalnym ję zyku, prosimy o kontakt z najbliższym biurem Yokogawy.

SLO

Vsi predpisi in navodila za ATEX Ex sorodni pridelki so pri roki v angliš èini, nemš èini ter francoš èini. È e so Ex sorodna navodila potrebna v vašem tukejnjem jeziku, kontaktirajte vaš najbliši Yokogawa office ili predstaunika.

H

Az ATEX Ex mûszerek gépkönyveit angol, német és francia nyelven adjuk ki. Amennyiben helyi nyelven kérik az Ex eszközök leírásait, kérjük keressék fel a legközelebbi Yokogawa irodát, vagy képviseletet.

BG

Всички упътвания за продукти от серията ATEX Ex се предлагат на английски, немски и френски език. Ако се нуждаете от упътвания за продукти от серията Ex на родния ви език, се свържете с най-близкия офис или представителство на фирма Yokogawa.

RO

Toate manualele de instructiuni pentru produsele ATEX Ex sunt in limba engleza, germana si franceza. In cazul in care doriti instructiunile in limba locala, trebuie sa contactati cel mai apropiat birou sau reprezentant Yokogawa.

M

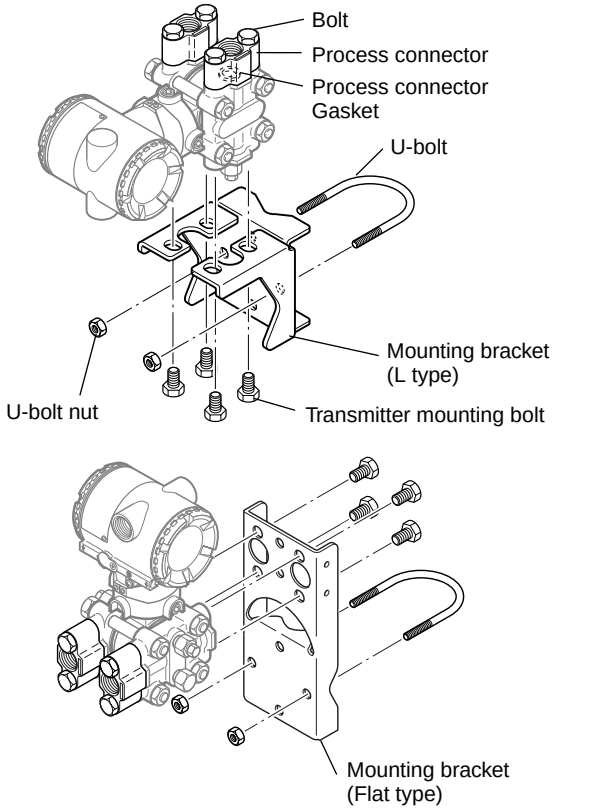
Il-manwali kollha ta’ l-istruzzjonijiet għal prodotti marbuta ma’ ATEX Ex huma disponibbli bl-Ingliż, bil-Ġermaniż u bil-Franċiż. Jekk tkun teħtieġ struzzjonijiet marbuta ma’ Ex fil-lingwa lokali tiegħek, għandek tikkuntattja lill-eqreb rappreżentan jew uffiċċju ta’ Yokogawa.

2. HANDLING CAUTIONS

This chapter describes important cautions regarding how to handle the transmitter. Read carefully before using the transmitter.

The EJA-A Series pressure transmitters are thoroughly tested at the factory before shipment. When the transmitter is delivered, visually check them to make sure that no damage occurred during ship-ment.

Also check that all transmitter mounting hardware shown in Figure 2.1 is included. If the transmitter was ordered without the mounting bracket or without the process connector, the transmitter mounting hardware is not included. After checking the transmitter, repack it in the way it was delivered until installation.

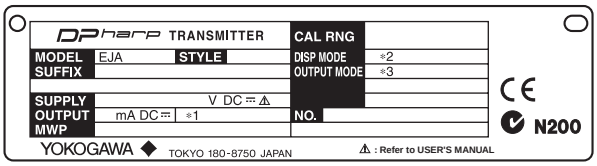


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Figure 2.1 Transmitter Mounting Hardware

2.1 Model and Specifications Check

The model name and specifications are indicated on the name plate attached to the case. If the *reverse* operating mode was ordered (reverse signal), 'REVERSE' will be inscribed in field *[1]; if *square root* display mode was ordered, 'SQRT' is inscribed in field *[2]; if *square root* output mode was ordered, 'SQRT' is inscribed in field *[3].



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Figure 2.2 Name Plate

2.2 Unpacking

When moving the transmitter to the installation site, keep it in its original packaging. Then, unpack the transmitter there to avoid damage on the way.

2.3 Storage

The following precautions must be observed when storing the instrument, especially for a long period.

(a) Select a storage area which meets the following conditions:
- It is not exposed to rain or water.
- It suffers minimum vibration and shock.
- It has an ambient temperature and relative humidity within the following ranges.

Ambient temperature:
–40 to 85°C without integral indicator
–30 to 80°C with integral indicator
Relative humidity:
5% to 100% R.H. (at 40°C)
Preferred temperature and humidity:
approx. 25°C and 65% R.H.

(b) When storing the transmitter, repack it as nearly as possible to the way it was packed when delivered from the factory.

(c) If storing a transmitter that has been used, thoroughly clean the chambers inside the cover flanges, so that no measured fluid remains in it. Also make sure before storing that the pressure-detector and transmitter section are securely mounted.

2.4 Selecting the Installation Location

The transmitter is designed to withstand severe environmental conditions. However, to ensure stable and accurate operation for years, observe the following precautions when selecting an installation location.

(a) Ambient Temperature
Avoid locations subject to wide temperature variations or a significant temperature gradient. If the location is exposed to radiant heat from plant equipments, provide adequate thermal insulation and/or ventilation.

(b) Ambient Atmosphere
Avoid installing the transmitter in a corrosive atmosphere. If the transmitter must be installed in a corrosive atmosphere, there must be adequate ventilation as well as measures to prevent intrusion or stagnation of rain water in conduits.

(c) Shock and Vibration
Select an installation site suffering minimum shock and vibration (although the transmitter is designed to be relatively resistant to shock and vibration).

(d) Installation of Explosion-protected Transmitters
Explosion-protected transmitters can be installed in hazardous areas according to the types of gases for which they are certified. See Subsection 2.9 "Installation of Explosion Protected Type Transmitters."

2.5 Pressure Connection

WARNING

- Instrument installed in the process is under pressure. Never loosen the process connector bolts to avoid the dangerous spouting of process fluid.
- During draining condensate from the pressure-detector section, take appropriate care to avoid contact with the skin, eyes or body, or inhalation of vapors, if the accumulated process fluid may be toxic or otherwise harmful.

The following precautions must be observed in order to safely operate the transmitter under pressure.

(a) Make sure that the four process connector bolts are tightened firmly.
(b) Make sure that there are no leaks in the impulse piping.
(c) Never apply a pressure higher than the specified maximum working pressure.

CAUTION

Maximum working pressure of the model EJA120A differential pressure transmitter is 50 kPa {0.5 kgf/cm^2}.
Should the pressure exceed 50 kPa {0.5 kgf/cm^2}, it is possible to break the sensor. Proceed with caution when applying pressure.

2.6 Waterproofing of Cable Conduit Connections

Apply a non-hardening sealant to the threads to waterproof the transmitter cable conduit connections. (See Figure 6.4.2a, 6.4.2b and 6.4.2c.)

2.7 Restrictions on Use of Radio Transceiver

IMPORTANT

Although the transmitter has been designed to resist high frequency electrical noise, if a radio transceiver is used near the transmitter or its external wiring, the transmitter may be affected by high frequency noise pickup. To test for such effects, bring the transceiver in use slowly from a distance of several meters from the transmitter, and observe the measurement loop for noise effects. Thereafter, always use the transceiver outside the area affected by noise.

2.8 Insulation Resistance and Dielectric Strength Test

Since the transmitter has undergone insulation resistance and dielectric strength tests at the factory before shipment, normally these tests are not required. However, if required, observe the following precautions in the test procedures.

(a) Do not perform such tests more frequently than is absolutely necessary. Even test voltages that do not cause visible damage to the insulation may degrade the insulation and reduce safety margins.
(b) Never apply a voltage exceeding 500 V DC (100 V DC with an internal lightning protector) for the insulation resistance test, nor a voltage exceeding 500 V AC (100 V AC with an internal lightning protector) for the dielectric strength test.

(c) Before conducting these tests, disconnect all signal lines from the transmitter terminals. Perform the tests in the following procedure:

• Insulation Resistance Test

1) Short-circuit the + and – SUPPLY terminals in the terminal box.
2) Turn OFF the insulation tester. Then connect the insulation tester plus (+) lead wire to the shorted SUPPLY terminals and the minus (–) leadwire to the grounding terminal.
3) Turn ON the insulation tester power and measure the insulation resistance. The voltage should be applied short as possible to verify that the insulation resistance is at least 20 MΩ.
4) After completing the test and being very careful not to touch exposed conductors disconnect the insulation tester and connect a 100 kΩ resistor between the grounding terminal and the short-circuiting SUPPLY terminals. Leave this resistor connected at least one second to discharge any static potential. Do not touch the terminals while it is discharging.

• Dielectric Strength Test

1) Short-circuit the + and – SUPPLY terminals in the terminal box.
2) Turn OFF the dielectric strength tester. Then connect the tester between the shorted SUPPLY terminals and the grounding terminal. Be sure to connect the grounding lead of the dielectric strength tester to the ground terminal.
3) Set the current limit on the dielectric strength tester to 10 mA, then turn ON the power and gradually increase the test voltage from '0' to the specified voltage.
4) When the specified voltage is reached, hold it for one minute.
5) After completing this test, slowly decrease the voltage to avoid any voltage surges.

2.9 Installation of Explosion Protected Type

In this section, further requirements and differences and for explosionproof type instrument are described. For explosionproof type instrument, the description in this chapter is prior to other description in this users manual.

For the intrinsically safe equipment and explosionproof equipment, in case the instrument is not restored to its original condition after any repair or modification undertaken by the customer, intrinsically safe construction or explosionproof construction is damaged and may cause dangerous condition. Please contact Yokogawa for any repair or modification required to the instrument.

NOTE

For FOUNDATION Fieldbus and PROFIBUS PA explosion protected type, please refer to IM 01C22T02-01E and IM 01C22T03-00E respectively.

CAUTION

This instrument is tested and certified as intrinsically safe type or explosionproof type. Please note that the construction of the instrument, installation, external wiring, maintenance or repair is strictly restricted, and non-observance or negligence of this restriction would result in dangerous condition.

WARNING

To preserve the safety of explosionproof equipment requires great care during mounting, wiring, and piping. Safety requirements also place restrictions on maintenance and repair activities. Please read the following sections very carefully.

2.9.1 FM Approval

a. FM Intrinsically Safe Type

Caution for FM intrinsically safe type. (Following contents refer "DOC. No. IFM012-A12 P.1 and 2.")

Note 1. Model EJA Series pressure transmitters with optional code /FS1 are applicable for use in hazardous locations.

- Applicable Standard: FM3600, FM3610, FM3611, FM3810, ANSI/NEMA250
- Intrinsically Safe for Class I, Division 1, Groups A, B, C & D. Class II, Division 1, Groups E, F & G and Class III, Division 1 Hazardous Locations.
- Nonincendive for Class I, Division 2, Groups A, B, C & D. Class II, Division 2, Groups E, F & G and Class III, Division 1 Hazardous Locations.
- Outdoor hazardous locations, NEMA 4X.
- Temperature Class: T4
- Ambient temperature: –40 to 60°C

Note 2. Entity Parameters

• Intrinsically Safe Apparatus Parameters
[Groups A, B, C, D, E, F and G]
Vmax = 30 V Ci = 22.5 nF
Imax = 165 mA Li = 730 μH
Pmax = 0.9 W

* Associated Apparatus Parameters
(FM approved barriers)
Voc ≤ 30 V Ca > 22.5 nF
Isc ≤ 165 mA La > 730 μH
Pmax ≤ 0.9W

• Intrinsically Safe Apparatus Parameters
[Groups C, D, E, F and G]
Vmax = 30 V Ci = 22.5 nF
Imax = 225 mA Li = 730 μH
Pmax = 0.9 W

* Associated Apparatus Parameters
(FM approved barriers)
Voc ≤ 30 V Ca > 22.5 nF
Isc ≤ 225 mA La > 730 μH
Pmax ≤ 0.9 W

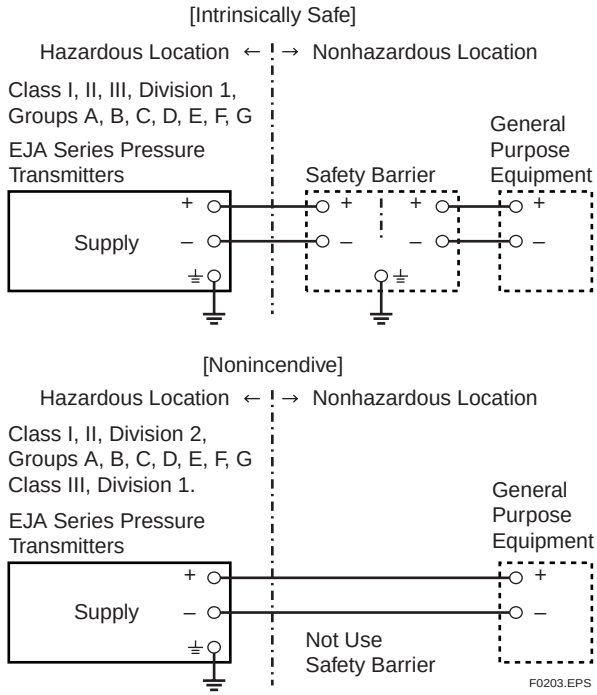
• Entity Installation Requirements
Vmax ≥ Voc or Vt, Imax ≥ Isc or It,
Pmax (IS Apparatus) ≥ Pmax (Barrier)
Ca ≥ Ci + Ccable, La ≥ Li + Lcable

Note 3. Installation

• Barrier must be installed in an enclosure that meets the requirements of ANSI/ISA S82.01.
• Control equipment connected to barrier must not use or generate more than 250 V rms or V dc.
• Installation should be in accordance with ANSI/ISA RP12.6 “Installation of Intrinsically Safe Systems for Hazardous (Classified) Locations” and the National Electric Code (ANSI/NFPA 70).
• The configuration of associated apparatus must be FMRC Approved.
• Dust-tight conduit seal must be used when installed in a Class II, III, Group E, F and G environments.
• Associated apparatus manufacturer’s installation drawing must be followed when installing this apparatus.
• The maximum power delivered from the barrier must not exceed 0.9 W.
• Note a warning label worded “SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY,” and “INSTALL IN ACCORDANCE WITH DOC. No. IFM012-A12 P.1 and 2.”

Note 4. Maintenance and Repair

• The instrument modification or parts replacement by other than authorized representative of Yokogawa Electric Corporation is prohibited and will void Factory Mutual Intrinsically safe and Nonincendive Approval.



b. FM Explosionproof Type

Caution for FM explosionproof type.

Note 1. Model EJA Series differential, gauge, and absolute pressure transmitters with optional code /FF1 are applicable for use in hazardous locations.

• Applicable Standard: FM3600, FM3615, FM3810, ANSI/NEMA250
• Explosionproof for Class I, Division 1, Groups B, C and D.
• Dust-ignitionproof for Class II/III, Division 1, Groups E, F and G.
• Outdoor hazardous locations, NEMA 4X.
• Temperature Class: T6
• Ambient Temperature: –40 to 60°C
• Supply Voltage: 42 V dc max.
• Output signal: 4 to 20 mA

Note 2. Wiring

• All wiring shall comply with National Electrical Code ANSI/NEPA70 and Local Electrical Codes.
• When installed in Division 1, “FACTORY SEALED, CONDUIT SEAL NOT REQUIRED.”

Note 3. Operation

• Keep the “CAUTION” nameplate attached to the transmitter.
CAUTION: OPEN CIRCUIT BEFORE REMOVING COVER. FACTORY SEALED, CONDUIT SEAL NOT REQUIRED. INSTALL IN ACCORDANCE WITH THE INSTRUCTION MANUAL IM 1C22.

• Take care not to generate mechanical sparking when accessing to the instrument and peripheral devices in a hazardous location.

Note 4. Maintenance and Repair

• The instrument modification or parts replacement by other than authorized representative of Yokogawa Electric Corporation is prohibited and will void Factory Mutual Explosionproof Approval.

c. FM Intrinsically Safe Type/FM Explosionproof Type

Model EJA Series pressure transmitters with optional code /FU1 can be selected the type of protection (FM Intrinsically Safe or FM Explosionproof) for use in hazardous locations.

Note 1. For the installation of this transmitter, once a particular type of protection is selected, any other type of protection cannot be used. The installation must be in accordance with the description about the type of protection in this instruction manual.

Note 2. In order to avoid confusion, unnecessary marking is crossed out on the label other than the selected type of protection when the transmitter is installed.

2.9.2 CSA Certification

a. CSA Intrinsically Safe Type

Caution for CSA Intrinsically safe type. (Following contents refer to "DOC No. ICS003-A12 P.1-1 and P.1-2.")

Note 1. Model EJA Series differential, gauge, and absolute pressure transmitters with optional code /CS1 are applicable for use in hazardous locations

Certificate: 1053843

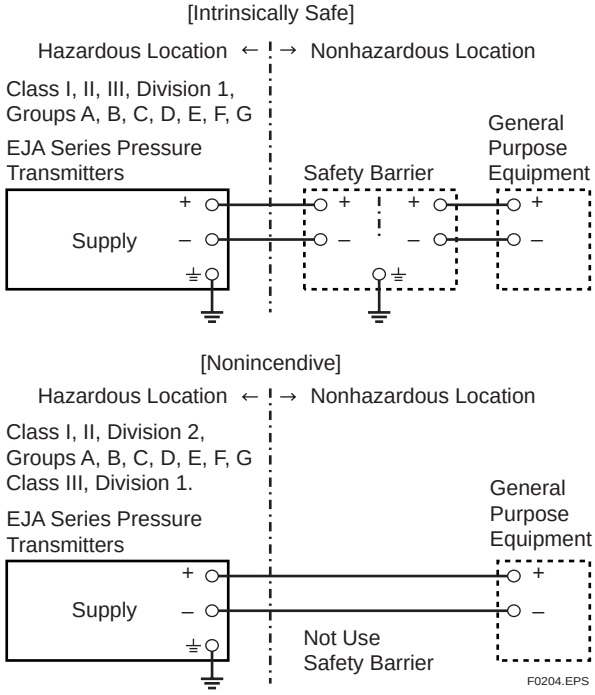
• Applicable Standard: C22.2 No.0, No.0.4, No.25, No.30, No.94, No.142, No.157, No.213
• Intrinsically Safe for Class I, Division 1, Groups A, B, C & D. Class II, Division 1, Groups E, F & G and Class III, Division 1 Hazardous Locations.
• Nonincendive for Class I, Division 2, Groups A, B, C & D, Class II, Division 2, Groups F & G, and Class III, Hazardous Locations. (not use Safety Barrier)
• Encl. "Type 4X"
• Temperature Class: T4
• Ambient temperature: –40 to 60°C
• Process Temperature: 120°C max.

Note 2. Entity Parameters

• Intrinsically safe ratings are as follows:
Maximum Input Voltage (Vmax) = 30 V
Maximum Input Current (Imax) = 165 mA
Maximum Input Power (Pmax) = 0.9 W
Maximum Internal Capacitance (Ci) = 22.5 nF
Maximum Internal Inductance (Li) = 730 μH
* Associated apparatus (CSA certified barriers)
Maximum output voltage (Voc) ≤ 30 V
Maximum output current (Isc) ≤ 165 mA
Maximum output power (Pmax) ≤ 0.9 W

Note 3. Installation

• All wiring shall comply with Canadian Electrical Code Part I and Local Electrical Codes.
• The instrument modification or parts replacement by other than authorized representative of Yokogawa Electric Corporation and Yokogawa Corporation of America is prohibited and will void Canadian Standards Intrinsically safe and nonincendive Certification.



b. CSA Explosionproof Type

Caution for CSA explosionproof type.

Note 1. Model EJA Series differential, gauge, and absolute pressure transmitters with optional code /CF1 are applicable for use in hazardous locations:

Certificate: 1089598

• Applicable Standard: C22.2 No.0, No.0.4, No.25, No.30, No.94, No.142
• Explosionproof for Class I, Division 1, Groups B, C and D.
• Dust-ignitionproof for Class II/III, Division 1, Groups E, F and G.

- Encl "Type 4X"
- Temperature Class: T6, T5, and T4
- Process Temperature: 85°C (T6), 100°C (T5), and 120°C (T4)
- Ambient Temperature: –40 to 80°C
- Supply Voltage: 42 V dc max.
- Output Signal: 4 to 20 mA

Note 2. Wiring

- All wiring shall comply with Canadian Electrical Code Part I and Local Electrical Codes.
- In hazardous location, wiring shall be in conduit as shown in the figure.

  CAUTION: SEAL ALL CONDUITS WITHIN 50 cm OF THE ENCLOSURE.
  UN SCELLEMENT DOIT ÊTRE INSTALLÉ À MOINS DE 50 cm DU BÎTIER.
- When installed in Division 2, "SEALS NOT REQUIRED."

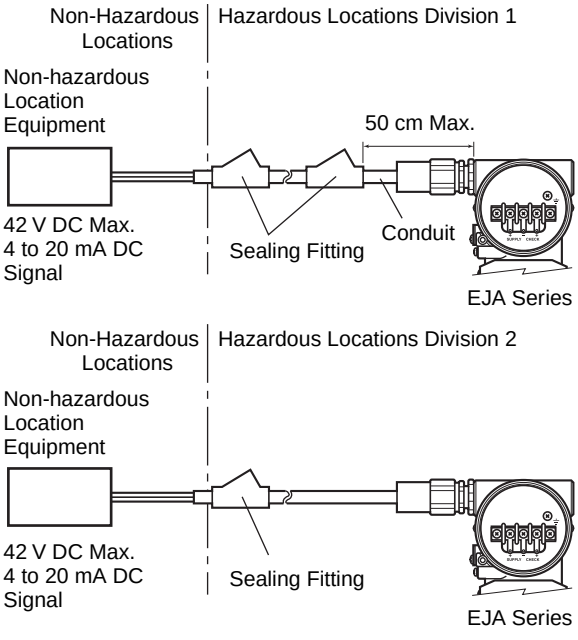
Note 3. Operation

- Keep the "CAUTION" label attached to the transmitter.

  CAUTION: OPEN CIRCUIT BEFORE REMOVING COVER.
  OUVRIR LE CIRCUIT AVANT D´NLEVER LE COUVERCLE.
- Take care not to generate mechanical sparking when accessing to the instrument and peripheral devices in a hazardous location.

Note 4. Maintenance and Repair

- The instrument modification or parts replacement by other than authorized representative of Yokogawa Electric Corporation and Yokogawa Corporation of America is prohibited and will void Canadian Standards Explosionproof Certification.



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c. CSA Intrinsically Safe Type/CSA Explosionproof Type

Model EJA Series pressure transmitters with optional code /CU1 can be selected the type of protection (CSA Intrinsically Safe or CSA Explosionproof) for use in hazardous locations.

Note 1. For the installation of this transmitter, once a particular type of protection is selected, any other type of protection cannot be used. The installation must be in accordance with the description about the type of protection in this instruction manual.

Note 2. In order to avoid confusion, unnecessary marking is crossed out on the label other than the selected type of protection when the transmitter is installed.

2.9.3 IECEx Certification

Model EJA Series differential, gauge, and absolute pressure transmitters with optional code /SU2 can be selected the type of protection (IECEx Intrinsically Safe/type n or flameproof) for use in hazardous locations.

Note 1. For the installation of this transmitter, once a particular type of protection is selected, any other type of protection cannot be used. The installation must be in accordance with the description about the type of protection in this instruction manual.

Note 2. In order to avoid confusion, unnecessary marking is crossed out on the label other than the selected type of protection when the transmitter is installed.

a. IECEx Intrinsically Safe Type / type n

Caution for IECEx Intrinsically safe and type n.

Note 1. Model EJA Series differential, gauge, and absolute pressure transmitters with optional code /SU2 are applicable for use in hazardous locations.

- No. IECEx KEM 06.0007X
- Applicable Standard: IEC 60079-0:2004, IEC 60079-11:1999, IEC 60079-15:2005, IEC 60079-26:2004
- Type of Protection and Marking Code: Ex ia IIC T4, Ex nL IIC T4
- Ambient Temperature :–40 to 60°C
- Max. Process Temp.: 120°C
- Enclosure: IP67

Note 2. Entity Parameters

• Intrinsically safe ratings are as follows:
Maximum Input Voltage (Ui) = 30 V
Maximum Input Current (Ii) = 165 mA
Maximum Input Power (Pi) = 0.9 W
Maximum Internal Capacitance (Ci) = 22.5 nF
Maximum Internal Inductance (Li) = 730 μH

• Type "n" ratings are as follows:
Maximum Input Voltage (Ui) = 30 V
Maximum Internal Capacitance (Ci) = 22.5 nF
Maximum Internal Inductance (Li) = 730 μH

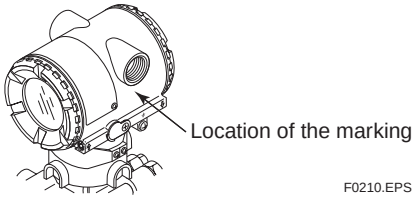
• Installation Requirements
Uo ≤ Ui, Io ≤ Ii, Po ≤ Pi,
Co ≥ Ci + Ccable, Lo ≥ Li + Lcable
Uo, Io, Po, Co, and Lo are parameters of barrier.

Note 3. Installation

• In any safety barreir used output current must be limited by a resistor 'R' such that Io=Uo/R.
• The safety barrier must be IECEx certified.
• Input voltage of the safety barrier must be less than 250 Vrms/Vdc.
• The instrument modification or parts replacement by other than authorized representative of Yokogawa Electric Corporation and will void IECEx Intrinsically safe and type n certification.
• The cable entry devices and blanking elements for type n shall be of a certified type providing a level of ingress protection of at least IP54, suitable for the conditions of use and correctly installed.
• Electrical Connection:
The type of electrical connection is stamped near the electrical connection port according to the following marking.

Screw Size	Marking
ISO M20×1.5 female	⚠ M
ANSI 1/2 NPT female	⚠ A

T0202.EPS



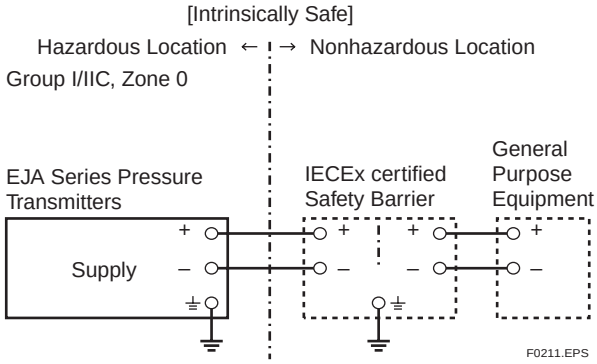
F0210.EPS

Note 4. Operation

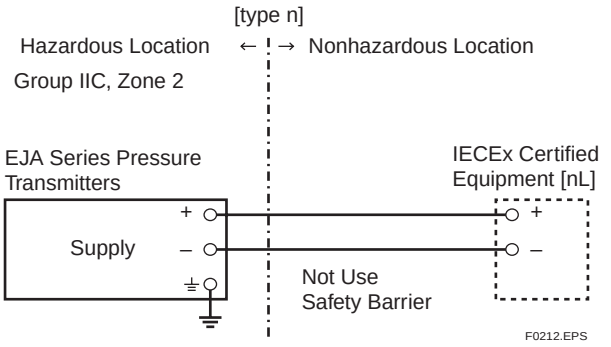
• WARNING:
WHEN AMBIENT TEMPERATURE ≥ 55°C,
USE THE HEAT-RESISTING CABLES ≥ 90°C.

Note 5. Special Conditions for Safe Use

• WARNING:
IN THE CASE WHERE THE ENCLOSURE OF THE PRESSURE TRANSMITTER IS MADE OF ALUMINUM, IF IT IS MOUNTED IN AN AREA WHERE THE USE OF ZONE 0 IS REQUIRED, IT MUST BE INSTALLED SUCH, THAT, EVEN IN THE EVENT OF RARE INCIDENTS, IGNITION SOURCES DUE TO IMPACT AND FRICTION SPARKS ARE EXCLUDED.



F0211.EPS



F0212.EPS

b. IECEx Flameproof Type

Caution for IECEx flameproof type.

Note 1. Model EJA Series differential, gauge, and absolute pressure transmitters with optional code /SU2 are applicable for use in hazardous locations:

• No. IECEx KEM 06.0005
• Applicable Standard: IEC60079-0:2004, IEC60079-1:2003
• Type of Protection and Marking Code:
Ex d IIC T6...T4
• Enclosure: IP67
• Maximum Process Temperature: 120°C (T4), 100°C (T5), 85°C (T6)
• Ambient Temperature: –40 to 75°C (T4), –40 to 80°C (T5), –40 to 75°C (T6)
• Supply Voltage: 42 V dc max.
• Output Signal: 4 to 20 mA dc

Note 2. Wiring

• In hazardous locations, the cable entry devices shall be of a certified flameproof type, suitable for the conditions of use and correctly installed.
• Unused apertures shall be closed with suitable flameproof certified blanking elements. (The plug attached is certificated as the flame proof IP67 as a part of this apparatus.)

• In case of ANSI 1/2 NPT plug, ANSI hexagonal wrench should be applied to screw in.

Note 3. Operation

• WARNING:
AFTER DE-ENERGIZING, DELAY 10 MINUTES BEFORE OPENING.
• WARNING:
WHEN AMBIENT TEMPERATURE ≥ 70°C, USE THE HEAT-RESISTING CABLES ≥ 90°C.
• Take care not to generate mechanical sparking when accessing to the instrument and peripheral devices in a hazardous location.

Note 4. Maintenance and Repair

• The instrument modification or parts replacement by other than authorized representative of Yokogawa Electric Corporation is prohibited and will void IECEx Certification.

2.9.4 CENELEC ATEX (KEMA) Certification

(1) Technical Data

a. CENELEC ATEX (KEMA) Intrinsically Safe Type

Caution for CENELEC ATEX (KEMA) Intrinsically safe type.

Note 1. Model EJA Series differential, gauge, and absolute pressure transmitters with optional code /KS2 for potentially explosive atmospheres:

• No. KEMA 02ATEX1030 X
• Applicable Standard: EN50014:1997, EN50020:1994, EN50284:1999
• Type of Protection and Marking code: EEx ia IIC T4
• Temperature Class: T4
• Enclosure: IP67
• Process Temperature: 120°C max.
• Ambient Temperature: –40 to 60°C

Note 2. Electrical Data

• In type of explosion protection intrinsic safety EEx ia IIC only for connection to a certified intrinsically safe circuit with following maximum values:
Ui = 30 V
Ii = 165 mA
Pi = 0.9 W
Effective internal capacitance; Ci = 22.5 nF
Effective internal inductance; Li = 730 μH

Note 3. Installation

• All wiring shall comply with local installation requirements. (Refer to the installation diagram)

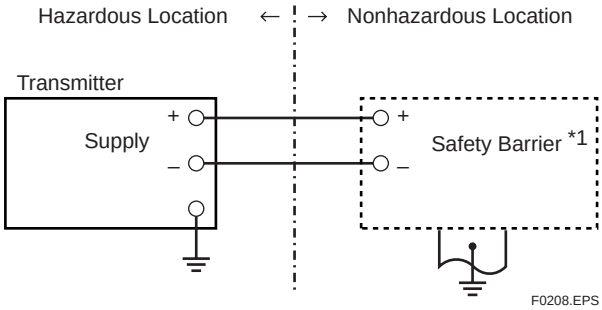
Note 4. Maintenance and Repair

• The instrument modification or parts replacement by other than authorized representative of Yokogawa Electric Corporation is prohibited and will void KEMA Intrinsically safe Certification.

Note 5. Special Conditions for Safe Use

• In the case where the enclosure of the Pressure Transmitter is made of aluminium, if it is mounted in an area where the use of category 1 G apparatus is required, it must be installed such, that, even in the event of rare incidents, ignition sources due to impact and friction sparks are excluded.

[Installation Diagram]



*1: In any safety barriers used the output current must be limited by a resistor "R" such that Imaxout-Uz/R.

b. CENELEC ATEX (KEMA) Flameproof Type

Caution for CENELEC ATEX (KEMA) flameproof type.

Note 1. Model EJA Series differential, gauge, and absolute pressure transmitters with optional code /KF2 for potentially explosive atmospheres:

• No. KEMA 02ATEX2148
• Applicable Standard: EN50014:1997, EN50018:2000
• Type of Protection and Marking Code: EEx d IIC T6···T4
• Temperature Class: T6, T5, and T4
• Enclosure: IP67
• Maximum Process Temperature: 85°C (T6), 100°C (T5), and 120°C (T4)
• Ambient Temperature: T4 and T6; –40 to 75°C, T5; –40 to 80°C

Note 2. Electrical Data

• Supply voltage: 42 V dc max.
• Output signal: 4 to 20 mA

Note 3. Installation

• All wiring shall comply with local installation requirement.
• The cable entry devices shall be of a certified flameproof type, suitable for the conditions of use.

Note 4. Operation

• Keep the “CAUTION” label to the transmitter.
CAUTION: AFTER DE-ENERGIZING, DELAY 10 MINUTES BEFORE OPENING. WHEN THE AMBIENT TEMP.≧70°C, USE HEAT-RESISTING CABLES≧90°C.

• Take care not to generate mechanical sparking when accessing to the instrument and peripheral devices in a hazardous location.

Note 5. Maintenance and Repair

• The instrument modification or parts replacement by other than authorized representative of Yokogawa Electric Corporation is prohibited and will void KEMA Flameproof Certification.

c. CENELEC ATEX (KEMA) Intrinsically Safe Type/CENELEC ATEX (KEMA) Flameproof Type/CENELEC ATEX Type n

Model EJA-A Series pressure transmitters with optional code /KU2 can be selected the type of protection CENELEC ATEX (KEMA) Intrinsically Safe, Flameproof or CENELEC ATEX Type n for use in hazardous locations.

Note 1. For the installation of this transmitter, once a particular type of protection is selected, any other type of protection cannot be used. The installation must be in accordance with the description about the type of protection in this user’s manual.

Note 2. In order to avoid confusion, unnecessary marking is crossed out on the label other than the selected type of protection when the transmitter is installed.

● CENELEC ATEX Type of Protection “n”

⚠ WARNING

When using a power supply not having a non-incendive circuit, please pay attention not to ignite in the surrounding flammable atmosphere. In such a case, we recommend using wiring metal conduit in order to prevent the ignition.

• Applicable Standard: EN60079-15
• Referential Standard: IEC60079-0, IEC60079-11
• Type of Protection and Marking Code:
Ex nL IIC T4
• Temperature Class: T4
• Enclosure: IP67
• Process Temperature: 120°C max.
• Ambient Temperature: –40 to 60°C

Note 1. Electrical Data

Ui = 30 V
Effective internal capacitance; Ci = 22.5 nF
Effective internal inductance; Li = 730 μH

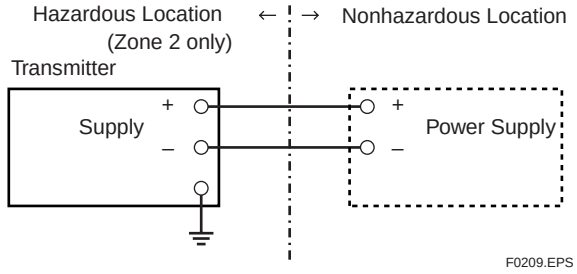
Note 2. Installation

• All wiring shall comply with local installation requirements. (refer to the installation diagram)

Note 3. Maintenance and Repair

• The instrument modification or parts replacement by other than authorized representative of Yokogawa Electric Corporation is prohibited and will void Type of Protection “n”.

[Installation Diagram]



Ratings of the Power Supply as follows;
Maximum Voltage: 30 V

● CENELEC ATEX Type of Protection “Dust”

• Applicable Standard: EN50281-1-1:1997
• Type of Protection and Marking Code: II 1D
• Maximum Surface Temperature:
T65°C (Tamb.: 40°C), T85°C (Tamb.: 60°C), and T105°C (Tamb.: 80°C)

Note 1. Installation instructions

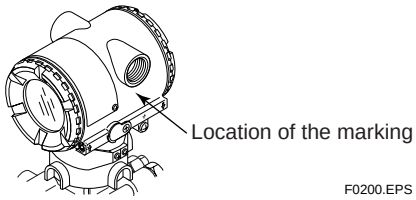
The cable entry devices and blanking elements shall be of a certificated type providing a level of ingress protection of at least IP6x, suitable for the conditions of use and correctly installed.

(2) Electrical Connection

The type of electrical connection is stamped near the electrical connection port according to the following marking.

Screw Size	Marking
ISO M20×1.5 female	⚠ M
ANSI 1/2 NPT female	⚠ A

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(3) Installation

WARNING

- All wiring shall comply with local installation requirement and local electrical code.
- There is no need of the conduit seal for both of Division 1 and Division 2 hazardous locations because this product is sealed at factory.
- In case of ANSI 1/2 NPT plug, ANSI hexagonal wrench should be applied to screw in.

(4) Operation

WARNING

- OPEN CIRCUIT BEFORE REMOVING COVER. INSTALL IN ACCORDANCE WITH THIS USER'S MANUAL
- Take care not to generate mechanical sparking when access to the instrument and peripheral devices in hazardous locations.

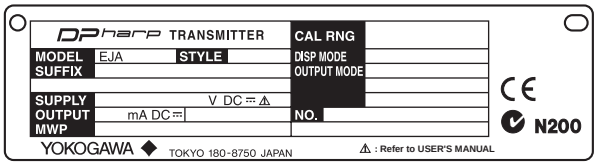
(5) Maintenance and Repair

WARNING

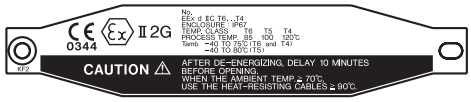
The instrument modification or parts replacement by other than authorized Representative of Yokogawa Electric Corporation is prohibited and will void the certification.

(6) Name Plate

● Name plate



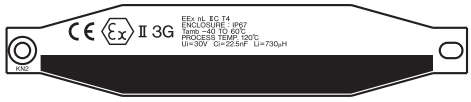
● Tag plate for flameproof type



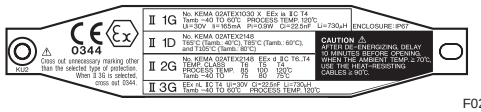
● Tag plate for intrinsically safe type



● Tag plate for type n protection



● Tag plate for flameproof, intrinsically safe type, type n protection, and Dust



F0298.EPS

MODEL: Specified model code.
STYLE: Style code.
SUFFIX: Specified suffix code.
SUPPLY: Supply voltage.
OUTPUT: Output signal.
MWP: Maximum working pressure.
CAL RNG: Specified calibration range.
DISP MODE: Specified display mode.
OUTPUT MODE: Specified output mode.
NO.: Serial number and year of production[*1].
YOKOGAWA ◆ TOKYO 180-8750 JAPAN: The manufacturer name and the address[*2].

*1: The third figure from the last shows the last one figure of the year of production. For example, the production year of the product engraved in "NO." column on the name plate as follows is 2001.

12A819857 132

The year 2001

*2: "180-8750" is a zip code which represents the following address.

2-9-32 Nakacho, Musashino-shi, Tokyo Japan

2.10 EMC Conformity Standards

EN61326-1 Class A, Table 2 (For use in industrial locations)

EN61326-2-3

CAUTION

This instrument is a Class A product, and it is designed for use in the industrial environment. Please use this instrument in the industrial environment only.

NOTE

YOKOGAWA recommends customer to apply the Metal Conduit Wiring or to use the twisted pair Shield Cable for signal wiring to conform the requirement of EMC Regulation, when customer installs the EJA Series Transmitters to the plant.

2.11 PED (Pressure Equipment Directive)

(1) General

- EJA series of pressure transmitters are categorized as pressure accessories under the vessel section of this directive 97/23/EC, which corresponds to Article 3, Paragraph 3 of PED, denoted as Sound Engineering Practice (SEP).
- EJA130A, EJA440A, EJA510A, and EJA530A can be used above 200 bar and therefore considered as a part of a pressure retaining vessel where category lll, Module H applies. These models with option code /PE3 conform to that category.

(2) Technical Data

- Models without /PE3
  Article 3, Paragraph 3 of PED, denoted as Sound Engineering Practice (SEP) .
- Models with /PE3
  Module: H
  Type of Equipment: Pressure Accessory - Vessel
  Type of Fluid: Liquid and Gas
  Group of Fluid: 1 and 2

Model	PS(bar)*1	V(L)	PS-V(bar-L)	Category*2
EJA110A	160	0.01	1.6	Article 3, paragraph 3 (SEP)
EJA120A	0.5	0.01	0.005	Article 3, paragraph 3 (SEP)
EJA130A	420	0.01	4.2	Article 3, paragraph 3 (SEP)
EJA130A With code /PE3	420	0.01	4.2	III
EJA310A	160	0.01	1.6	Article 3, paragraph 3 (SEP)
EJA430A	160	0.01	1.6	Article 3, paragraph 3 (SEP)
EJA440A	500	0.01	50	Article 3, paragraph 3 (SEP)
EJA440A With code /PE3	500	0.01	50	III
EJA510A	500	0.01	50	Article 3, paragraph 3 (SEP)
EJA510A With code /PE3	500	0.01	50	III
EJA530A	500	0.01	50	Article 3, paragraph 3 (SEP)
EJA530A With code /PE3	500	0.01	50	III

*1: PS is maximum allowable pressure for vessel itself.
*2: Referred to Table 1 covered by ANNEX II of EC Directive on Pressure Equipment Directive 97/23/EC

T0299.EPS

(3) Operation

CAUTION

- The temperature and pressure of fluid should be applied under the normal operating condition.
- The ambient temperature should be applied under the normal operating condition.
- Please pay attention to prevent the excessive pressure like water hammer, etc. When water hammer is to be occurred, please take measures to prevent the pressure from exceeding PS by setting the safety valve, etc. at the system and the like.
- When external fire is to be occurred, please take safety measures at the device or system not to influence the transmitters.

2.12 Low Voltage Directive

Applicable standard : EN61010-1

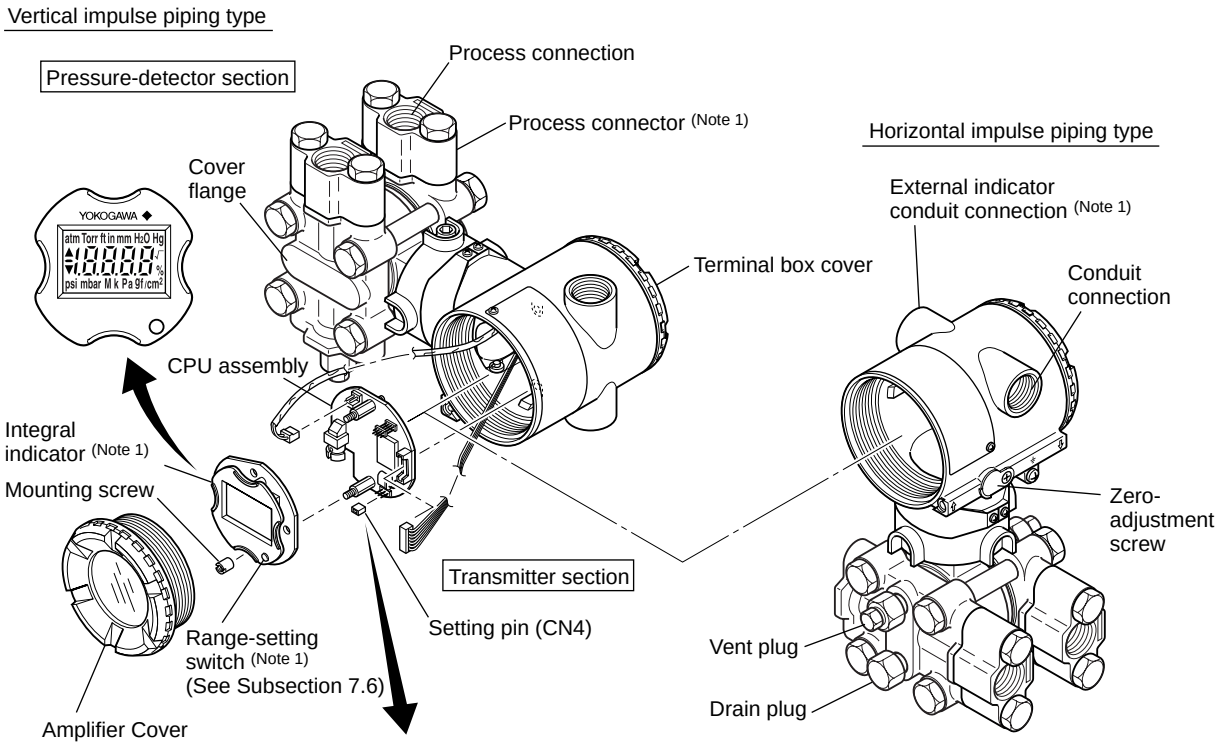
(1) Pollution Degree 2

"Pollution degree" describes the degree to which a soild, liquid, or gas which deteriorates dielectric strength or surface resistivity is adhering. " 2 " applies to normal indoor atmosphere. Normally, only non-conductive pollution occurs. Occasionally, however, temporary conductivity caused by condenstaion must be expected.

(2) Installation Category I

"Overvoltage category(Installation category)" describes a number which defines a transient overvoltage condition. It implies the regulattion for impulse withstand voltage. " I " applies to electrical equipment which is supplied from the circuit when appropriate transient overvoltage control means (interfaces) are provided.

3. COMPONENT NAMES



Setting Pin (CN4) Position (Note 2)	Burn-Out Direction	Output at Burn-Out
H / L	HIGH	110% or higher
H / L	LOW	–5% or lower

F0301.EPS

Note 1: See Subsection 10.2, “Model and Suffix Codes,” for details.
Note 2: Insert the pin (CN4) as shown in the figure above to set the burn-out direction. The pin is set to the H side for delivery (unless option code /C1 is specified in the order).
The setting can be confirmed by calling up parameter D52 using the BRAIN TERMINAL. Refer to Subsection 8.3.3 (11).

Figure 3.1 Component Names

Table 3.1 Display Symbol

Display Symbol	Meaning of Display Symbol
$\sqrt{}$	Display mode is ‘square root’. (Display is not lit when ‘proportional’ mode.)
▲	The output signal being zero-adjusted is increasing.
▼	The output signal being zero-adjusted is decreasing.
%, Pa, kPa, MPa, kgf/cm^2, gf/cm^2, mbar, bar, atm, mmHg, mmH_2O, inH_2O, inHg, ftH_2O, psi, Torr	Select one of these sixteen available engineering units for the display.

T0301.EPS

4. INSTALLATION

4.1 Precautions

Before installing the transmitter, read the cautionary notes in Section 2.4, “Selecting the Installation Location.” For additional information on the ambient conditions allowed at the installation location, refer to Subsection 10.1 “Standard Specifications.”

IMPORTANT

- When welding piping during construction, take care not to allow welding currents to flow through the transmitter.
- Do not step on this instrument after installation.

4.2 Mounting

- The distance between the impulse piping connection ports is usually 54 mm (Figure 4.2.1). By changing the orientation of the process connector, the dimension can be changed 51 mm or 57 mm.
- The transmitter is shipped with the process connection, according to the ordering specifications. To change the orientation of the process connections, refer to Section 4.3.
- The transmitter can be mounted on a nominal 50 mm (2-inch) pipe using the mounting bracket supplied, as shown in Figure 4.2.2 and 4.2.3. The transmitter can be mounted on either a horizontal or a vertical pipe.
- When mounting the bracket on the transmitter, tighten the (four) bolts that hold the transmitter with a torque of approximately 39 N·m {4kgf·m}.

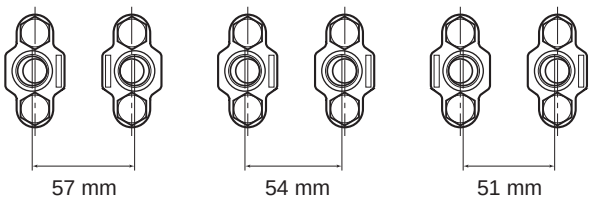
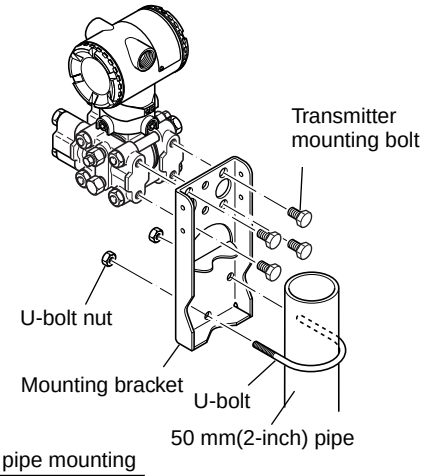


Figure 4.2.1 Process Connector Impulse Piping Connection Distances

Vertical pipe mounting



Horizontal pipe mounting

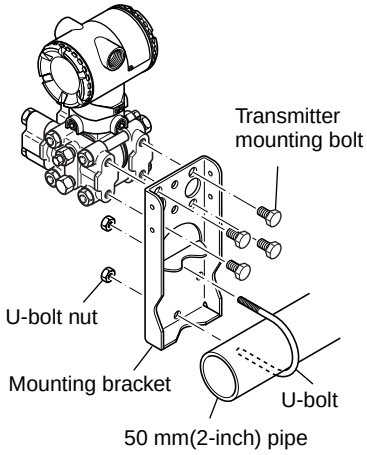
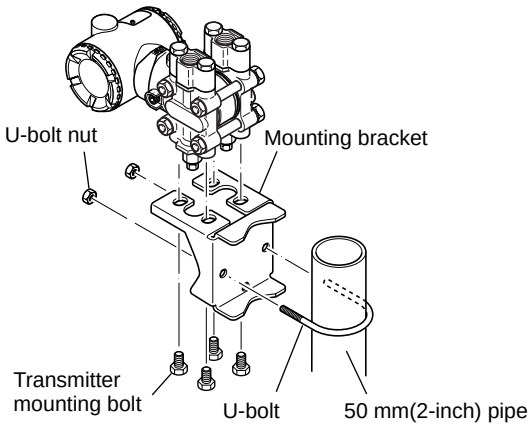
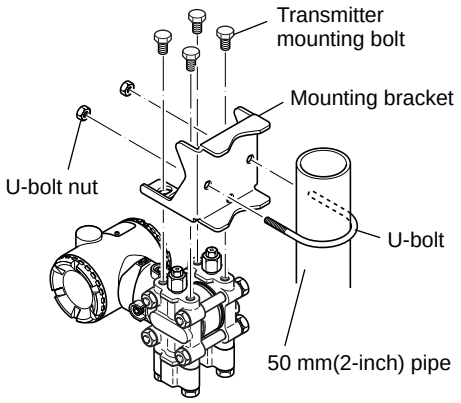


Figure 4.2.2 Transmitter Mounting (Horizontal Impulse Piping Type)

Vertical pipe mounting
(Process connector upside)



Vertical pipe mounting
(Process connector downside)



F0403.EPS

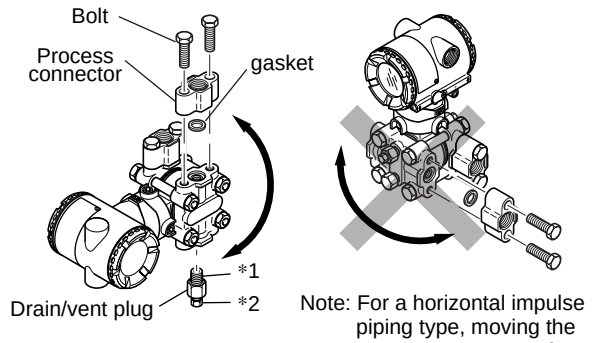
Figure 4.2.3 Transmitter Mounting (Vertical Impulse Piping Type)

4.3 Changing the Process Connection

The transmitter is shipped with the process connection specified at the time of ordering. To make a change such as modifying the drain (vent) plug(s) attached to the upside of the cover flange on shipment to be attached to the downside follow the procedure below.

To begin, use a wrench to slowly and gently unscrew the drain (vent) plug(s). Then, remove and remount them on the opposite side. Wrap sealing tape around the drain (vent) plug threads (*1 in the figure below), and apply a lubricant to the threads of the drain (vent) screw(s) (*2 below) to screw it (them) in. To tighten the drain (vent) plugs, apply a torque of 34 to 39 N·m {3.5 to 4 kgf·m}. Tighten the process connector bolts uniformly to a torque of 39 to 49 N·m {4 to 5 kgf·m}.

Vertical impulse piping type | Horizontal impulse piping type



Note: For a horizontal impulse piping type, moving the process connectors from the front side to the back is not allowed.

F0404.EPS

Figure 4.3 Changing Process Connection

4.4 Swapping the High/Low-pressure Side Connection

4.4.1 Rotating Pressure-detector Section 180°

This procedure can be applied only to a transmitter with a vertical impulse piping type.

The procedure below can be used to turn the pressure-detector assembly 180°. Perform this operation in a maintenance shop with the necessary tools laid out and ready for use, and then install the transmitter in the field after making the change.

1) Use a Allen wrench (JIS B4648, nominal 5 mm) to remove the two Allen screws at the joint between the pressure-detector section and transmitter section.
2) Leaving the transmitter section in position, rotate the pressure-detector section 180°.
3) Tighten the two Allen screws to fix the pressure-detector section and transmitter section together (at a torque of 5 N·m).

IMPORTANT

Do not rotate the pressure-detector section more than 180°.

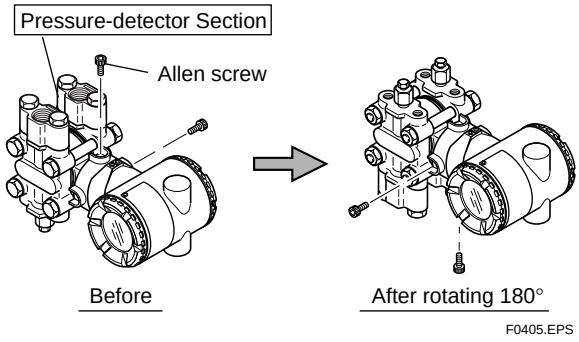


Figure 4.4 Before and After Modification

4.4.2 Using the BRAIN TERMINAL BT200

This method is applicable only to the Model EJA110A-□L, EJA110A-□M, EJA110A-□H, EJA120A-□E, EJA130A-□M and EJA130A-□H.

With a BRAIN TERMINAL, you can change which process connection is used as the high-pressure side without mechanically rotating the pressure-detector section 180 as described in Subsection 4.4.1. To change, call parameter 'D45: H/L SWAP' and select REVERSE (right side: low pressure; left side: high pressure) or select NORMAL to change back to normal (right side: high pressure; left side: low pressure).

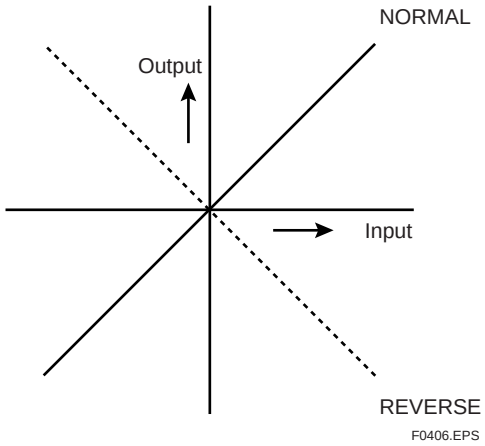


Figure 4.5 Input/Output Relationship

IMPORTANT

Since the H/L label plate on the capsule assembly will remain unchanged even if this function is used, use this function only if you cannot switch the impulse piping. If the 'D45: H/L SWAP' setting is changed, the input/output relationship is reversed as shown in Figure 4.5; be sure this is understood by all. Whenever possible, use the procedure in Subsection 4.4.1.

4.5 Rotating Transmitter Section

The DPharp transmitter section can be rotated in 90° segments.

1) Remove the two Allen screws that fasten the transmitter section and capsule assembly, using the Allen wrench.
2) Rotate the transmitter section slowly in 90° segments.
3) Tighten the two Allen screws to a torque of 5 N·m.

IMPORTANT

Do not rotate the transmitter section more than 180°.

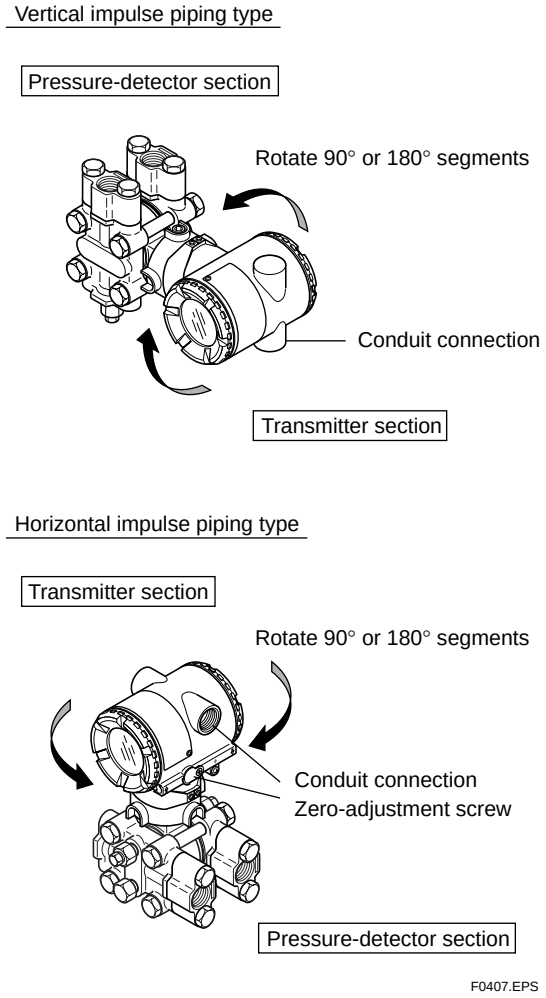


Figure 4.6 Rotating Transmitter Section

4.6 Changing the Direction of Integral Indicator

IMPORTANT

Always turn OFF power, release pressure and remove a transmitter to non-hazardous area before disassembling and reassembling an indicator.

An integral indicator can be installed in the following three directions. Follow the instructions in section 9.4 for removing and attaching the integral indicator.

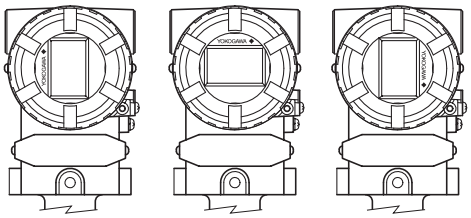


Figure 4.7 Integral Indicator Direction

5. INSTALLING IMPULSE PIPING

5.1 Impulse Piping Installation Precautions

The impulse piping that connects the process outputs to the transmitter must convey the process pressure accurately. If, for example, gas collects in a liquid-filled impulse piping, or the drain of a gas-filled impulse piping becomes plugged, the impulse piping will not convey the pressure accurately. Since this will cause errors in the measurement output, select the proper piping method for the process fluid (gas, liquid, or steam). Pay careful attention to the following points when routing the impulse piping and connecting the impulse piping to the transmitter.

5.1.1 Connecting Impulse Piping to the Transmitter

(1) Check the High and Low Pressure Connections on the Transmitter (Figure 5.1.1a)

Symbols “H” and “L” are shown on a capsule assembly to indicate high and low pressure side. Connect the impulse piping to the “H” side, and the low impulse piping to the “L” side.

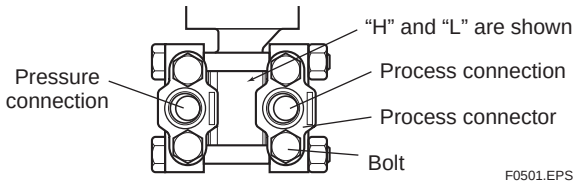


Figure 5.1.1a “H” and “L” Symbols on a Capsule Assembly

(2) Changing the Process Connector Piping Connections (Figure 4.1)

The impulse piping connection distances can be changed between 51 mm, 54 mm and 57 mm by changing the orientation of the process connectors. This is convenient for aligning the impulse piping with the process connectors when connecting the piping.

(3) Tightening the Process Connector Mounting Bolts

After connecting the impulse piping, tighten the process connector mounting bolts uniformly.

(4) Connecting the Transmitter and 3-Valve Manifold

A 3-valve manifold consists of two stop valves to block process pressure and an equalizing valve to equalize the pressures on the high and low pressure sides of the transmitter. Such a manifold makes it easier to disconnect the transmitter from the impulse piping, and is convenient when adjusting the transmitter zero point.

There are two types of 3-valve manifold: the pipe-mounting type and the direct-mounting type; care should be taken with respect to the following points when connecting the manifold to the transmitter.

■ **Pipe-Mounting Type 3-Valve Manifold (Figure 5.1.1b)**

1) Screw nipples into the connection ports on the transmitter side of the 3-valve manifold, and into the impulse piping connecting ports on the process connectors. (To maintain proper sealing, wind sealing tape around the nipple threads.)
2) Mount the 3-valve manifold on the 50 mm (2-inch) pipe by fastening a U-bolt to its mounting bracket. Tighten the U-bolt nuts only lightly at this time.
3) Install the pipe assemblies between the 3-valve manifold and the process connectors and lightly tighten the ball head lock nuts. (The ball-shaped ends of the pipes must be handled carefully, since they will not seal properly if the ball surface is scratched or otherwise damaged.)
4) Now tighten the nuts and bolts securely in the following sequence:
   Process connector bolts → transmitter-end ball head lock nuts → 3-valve manifold ball head lock nuts → 3-valve manifold mounting bracket U-bolt nuts

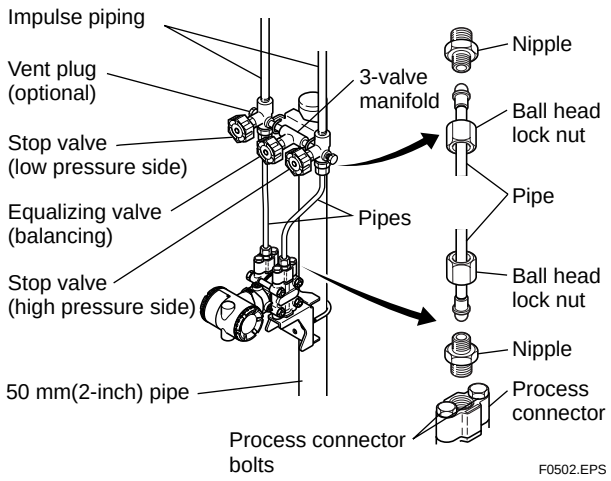


Figure 5.1.1b 3-Valve Manifold (Pipe-Mounting Type)

■ Direct-Mounting Type 3-Valve Manifold (Figure 5.1.1c)

1) Mount the 3-valve manifold on the transmitter. (When mounting, use the two gaskets and the four bolts provided with the 3-valve manifold. Tighten the bolts evenly.)
2) Mount the process connectors and gaskets on the top of the 3-valve manifold (the side on which the impulse piping will be connected).

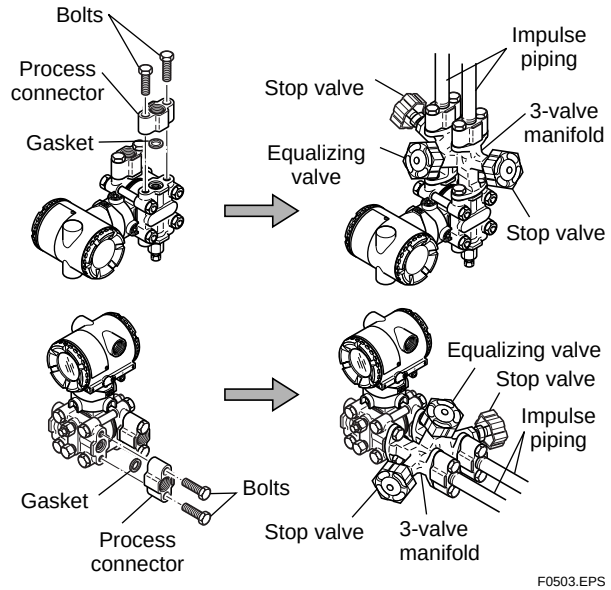


Figure 5.1.1c 3-Valve Manifold (Direct-Mounting Type)

NOTE

After completing the connection of the transmitter and 3-valve manifold, be sure to CLOSE the low pressure and high pressure stop valves, OPEN the equalizing valve, and leave the manifold with the equalizing valve OPEN.
You must do this in order to avoid overloading the transmitter from either the high or the low pressure side when beginning operation.
This instruction must also be strictly followed as part of the startup procedure (Chapter 7).

5.1.2 Routing the Impulse Piping

(1) Process Pressure Tap Angles

If condensate, gas, sediment or other extraneous material in the process piping gets into the impulse piping, pressure measurement errors may result. To prevent such problems, the process pressure taps must be angled as shown in Figure 5.1.2 according to the kind of fluid being measured.

NOTE

- If the process fluid is a gas, the taps must be vertical or within 45° either side of vertical.
- If the process fluid is a liquid, the taps must be horizontal or below horizontal, but not more than 45° below horizontal.
- If the process fluid is steam or other condensing vapor, the taps must be horizontal or above horizontal, but not more than 45° above horizontal.

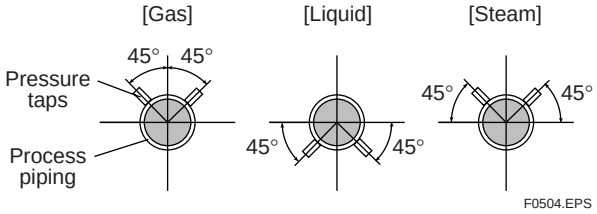


Figure 5.1.2 Process Pressure Tap Angle (For Horizontal Piping)

(2) Position of Process Pressure Taps and Transmitter

If condensate (or gas) accumulates in the impulse piping, it should be removed periodically by opening the drain (or vent) plugs. However, this will generate a transient disturbance in the pressure measurement, and therefore it is necessary to position the taps and route the impulse piping so that any extraneous liquid or gas generated in the leadlines returns naturally to the process piping.

- If the process fluid is a gas, then as a rule the transmitter must be located higher than the process pressure taps.
- If the process fluid is a liquid or steam, then as a rule the transmitter must be located lower than the process pressure taps.

(3) Impulse Piping Slope

The impulse piping must be routed with only an upward or downward slope. Even for horizontal routing, the impulse piping should have a slope of at least 1/10 to prevent condensate (or gases) from accumulating in the pipes.

(4) Temperature Difference Between Impulse Piping

If there is a temperature difference between the high and low impulse piping, the density difference of the fluids in the two lines will cause an error in the measurement pressure. When measuring flow, impulse piping must be routed together so that there is no temperature difference between them.

(5) Condensate Pots for Steam Flow Measurement

If the liquid in the impulse piping repeatedly condenses or vaporizes as a result of changes in the ambient or process temperature, this will cause a difference in the fluid head between the high pressure and low pressure sides. To prevent measurement errors due to these head differences, condensate pots are used when measuring steam flow.

(6) Preventing Wind Speed Effects in Very Low Differential Pressure Measurement

IMPORTANT

When using a differential pressure transmitter to measure very low pressures (draft pressure), the low pressure connection port is left open to atmospheric pressure (the reference pressure). Any wind around the differential pressure transmitter will therefore cause errors in the measurement. To prevent this, it will be necessary either to enclose the transmitter in a box, or to connect a impulse piping to the low pressure side and insert its end into a wind-excluding pot (cylindrical with a base plate).

(7) Preventing Freezing

If there is any risk that the process fluid in the impulse piping or transmitter could freeze, use a steam jacket or heater to maintain the temperature of the fluid.

NOTE

After completing the connections, close the valves on the process pressure taps (*main valves*), the valves at the transmitter (*stop valves*), and the impulse piping drain valves, so that condensate, sediment, dust and other extraneous material cannot enter the impulse piping.

5.2 Impulse Piping Connection Examples

Figure 5.2 shows examples of typical impulse piping connections. Before connecting the transmitter to the process, study the transmitter installation location, the process piping layout, and the characteristics of the process fluid (corrosiveness, toxicity, flammability, etc.), in order to make appropriate changes and additions to the connection configurations.

Note the following points when referring to these piping examples.

- The high pressure connecting port on the transmitter is shown on the right (as viewed from the front).
- The transmitter impulse piping connection is shown for a vertical impulse piping connection configuration in which the direction of connection is either upwards or downwards.
- If the impulse piping is long, bracing or supports should be provided to prevent vibration.
- The impulse piping material used must be compatible with the process pressure, temperature, and other conditions.
- A variety of process pressure tap valves (main valves) are available according to the type of connection (flanged, screwed, welded), construction (globe, gate, or ball valve), temperature and pressure. Select the type of valve most appropriate for the application.

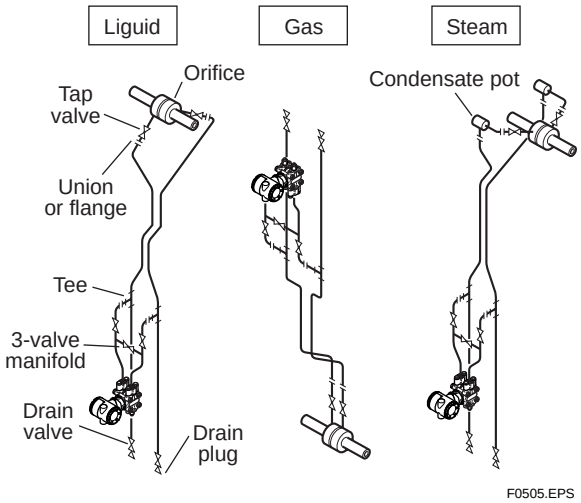


Figure 5.2 Impulse Piping Connection Examples

6. WIRING

6.1 Wiring Precautions

IMPORTANT

- Lay wiring as far as possible from electrical noise sources such as large capacity transformers, motors, and power supplies.
- Remove electrical connection dust cap before wiring.
- All threaded parts must be treated with waterproofing sealant. (A non-hardening silicone group sealant is recommended.)
- To prevent noise pickup, do not pass signal and 0ówer cables through the same ducts.
- Explosion-protected instruments must be wired in accordance with specific requirements (and, in certain countries, legal regulations) in order to preserve the effectiveness of their explosion-protected features.
- The terminal box cover is locked by an Allen head bolt (a shrouding bolt) on CENELEC and IECEx flameproof type transmitters. When the shrouding bolt is driven clockwise by an Allen wrench, it is going in and cover lock is released, and then the cover can be opened by hand. See Subsection 9.4 “Disassembly and Reassembly” for details.

6.2 Selecting the Wiring Materials

(a) Use stranded leadwires or cables which are the same as or better than 600 V grade PVC insulated wire (JIS C3307) or equivalent.
(b) Use shielded wires in areas that are susceptible to electrical noise.
(c) In areas with higher or lower ambient temperatures, use appropriate wires or cables.
(d) In environment where oils, solvents, corrosive gases or liquids may be present, use wires or cables that are resistant to such substances.
(e) It is recommended that crimp-on solderless terminal lugs (for 4 mm screws) with insulating sleeves be used for leadwire ends.

6.3 Connections of External Wiring to Terminal Box

6.3.1 Power Supply Wiring Connection

Connect the power supply wiring to the SUPPLY + and – terminals.

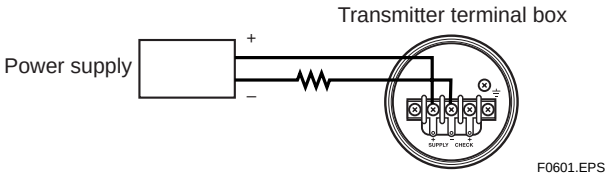


Figure 6.3.1 Power Supply Wiring Connection

6.3.2 External Indicator Connection

Connect wiring for external indicators to the CHECK + and – terminals.

(Note) Use a external indicator whose internal resistance is 10 Ω or less.

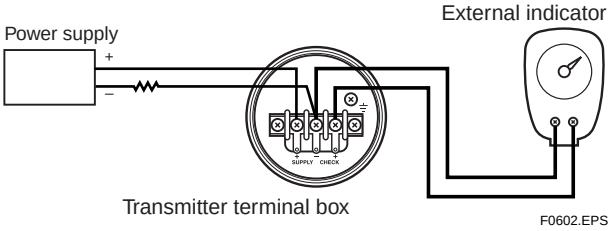


Figure 6.3.2 External Indicator Connection

6.3.3 BRAIN TERMINAL BT200 Connection

Connect the BT200 to the SUPPLY + and – terminals (Use hooks). The communication line requires a reception resistor of 250 to 600 Ω in series.

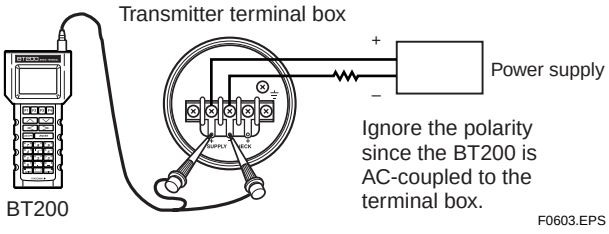


Figure 6.3.3 BT200 Connection

6.3.4 Check Meter Connection

Connect the check meter to the CHECK + and – terminals (use hooks).

• A 4 to 20 mA DC output signal from the CHECK + and – terminals.

(Note) Use a check meter whose internal resistance is 10 Ω or less.

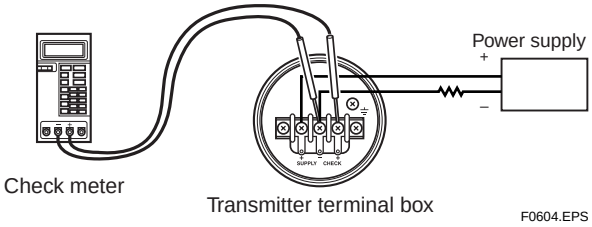


Figure 6.3.4 Check Meter Connection

6.4 Wiring

6.4.1 Loop Configuration

Since the DPharp uses a two-wire transmission system, signal wiring is also used as power wiring.

DC power is required for the transmitter loop. The transmitter and distributor are connected as shown below.

For details of the power supply voltage and load resistance, see Section 6.6; for communications line requirements, see Subsection 8.1.2.

(1) General-use Type and Flameproof Type

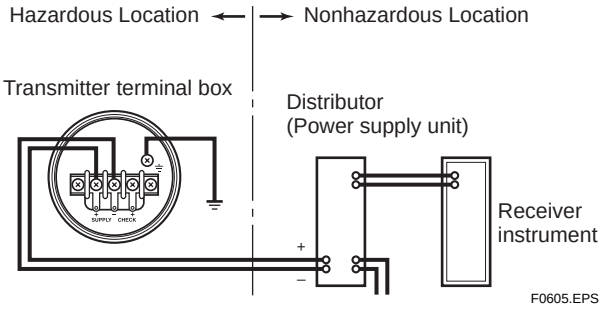


Figure 6.4.1a Connection between Transmitter and Distributor

(2) Intrinsically Safe Type

For intrinsically safe type, a safety barrier must be included in the loop.

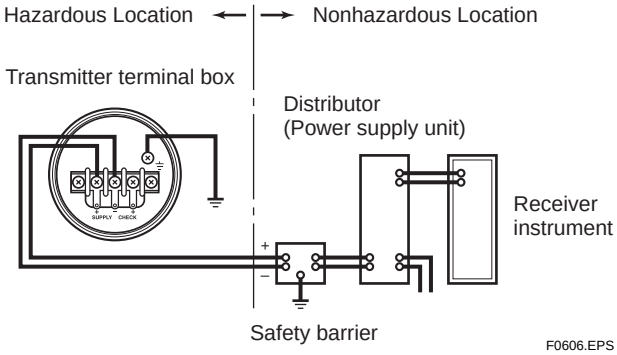


Figure 6.4.1b Connection between Transmitter and Distributor

6.4.2 Wiring Installation

(1) General-use Type and Intrinsically Safe Type

Make cable wiring using metallic conduit or waterproof glands.

• Apply a non-hardening sealant to the terminal box connection port and to the threads on the flexible metal conduit for waterproofing.

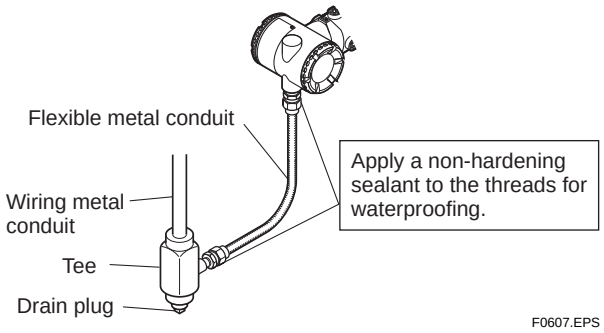


Figure 6.4.2a Typical Wiring Using Flexible Metal Conduit

(2) Flameproof Type

Wire cables through a flameproof packing adapter, or using a flameproof metal conduit.

■ Wiring cable through flameproof packing adapter.

• Apply a nonhardening sealant to the terminal box connection port and to the threads on the flameproof packing adapter for waterproofing.

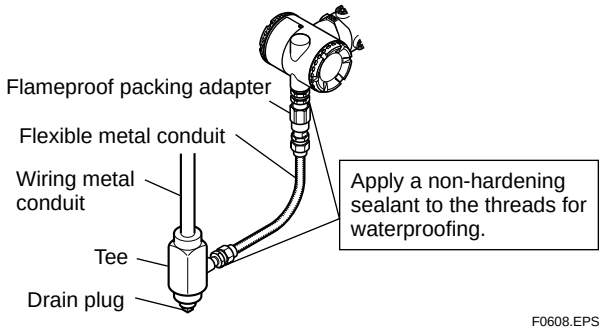


Figure 6.4.2b Typical Cable Wiring Using Flameproof Packing Adapter

■ Flameproof metal conduit wiring

• A seal fitting must be installed near the terminal box connection port for a sealed construction.

• Apply a non-hardening sealant to the threads of the terminal box connection port, flexible metal conduit and seal fitting for waterproofing.

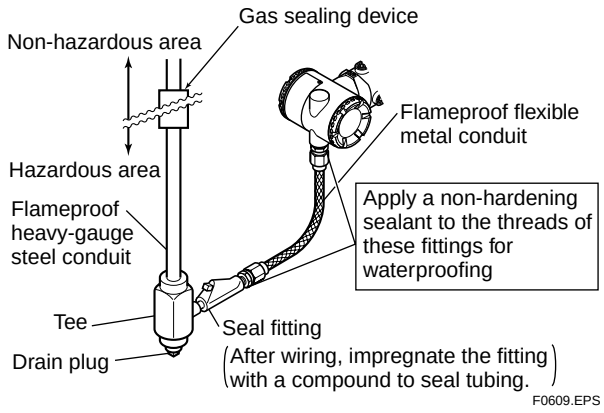


Figure 6.4.2c Typical Wiring Using Flameproof Metal Conduit

6.5 Grounding

Grounding is always required for the proper operation of transmitters. Follow the domestic electrical requirements as regulated in each country. For a transmitter with built-in lightning protector, grounding should satisfy ground resistance of 10Ω or less.

Ground terminals are located on the inside and outside of the terminal box. Either of these terminals may be used.

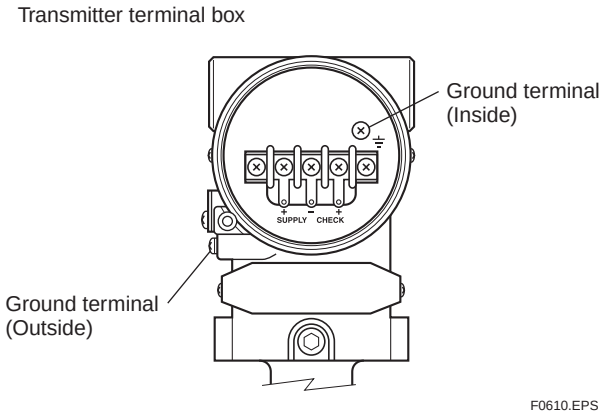


Figure 6.5 Ground Terminals

6.6 Power Supply Voltage and Load Resistance

When configuring the loop, make sure that the external load resistance is within the range in the figure below.

(Note) In case of an intrinsically safe transmitter, external load resistance includes safety barrier resistance.

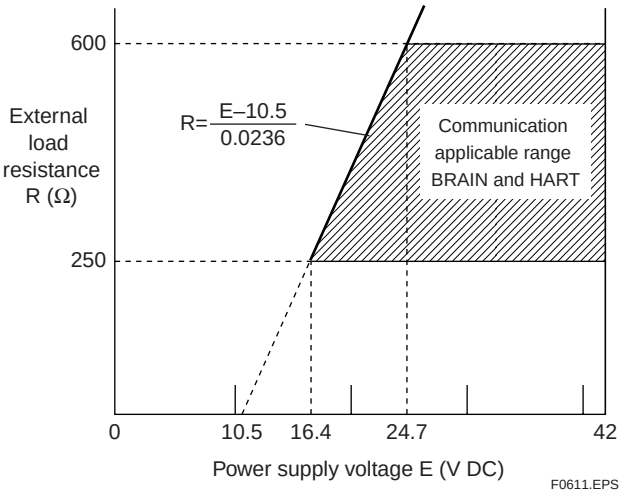


Figure 6.6 Relationship between Power Supply Voltage and External Load Resistance

7. OPERATION

7.1 Preparation for Starting Operation

The Model EJA110A, EJA120A and EJA130A pressure transmitter measures the flow rates and the pressure of liquids, gases, and steam, and also liquid levels. This section describes the operation procedure for the EJA110A as shown in Figure 7.1 (vertical impulse piping type, high-pressure connection: right side) when measuring a liquid flow rate.

NOTE

Check that the process pressure tap valves, drain valves, and 3-valve manifold stop valves on both low pressure and high pressure sides are closed, and that the 3-valve manifold equalizing valve is opened.

(a) Follow the procedures below to introduce process pressure into the impulse piping and transmitter.

1) Open the low pressure and high pressure tap valves to fill the impulse piping with process liquid.
2) Slowly open the high pressure stop valve to fill the transmitter pressure-detector section with process liquid.
3) Close the high pressure stop valve.
4) Gradually open the low pressure stop valve and completely fill the transmitter pressure-detector section with process liquid.
5) Close the low pressure stop valve.
6) Gradually open the high pressure stop valve. At this time, equal pressure is applied to the low and high pressure sides of the transmitter.
7) Check that there are no liquid leaks in the impulse piping, 3-valve manifold, transmitter, or other components.

(b) Venting Gas from the Transmitter Pressure-detector Section

Since the piping in the example of Figure 7.1 is constructed to be self-venting, no venting operation is required. If it is not possible to make the piping self-venting, refer to Subsection 7.5 for instructions. Leave the equalizing valve open even after venting gas.

(c) Turn ON power and connect the BT200.

Open the terminal box cover, and connect the BT200 to the SUPPLY + and – terminals.

(d) Using the BT200, confirm that the transmitter is operating properly. Check parameter values or change the setpoints as necessary. See Chapter 8 for BT200 operation.

If the transmitter is equipped with an integral indicator, its indication can be used to confirm that the transmitter is operating properly.

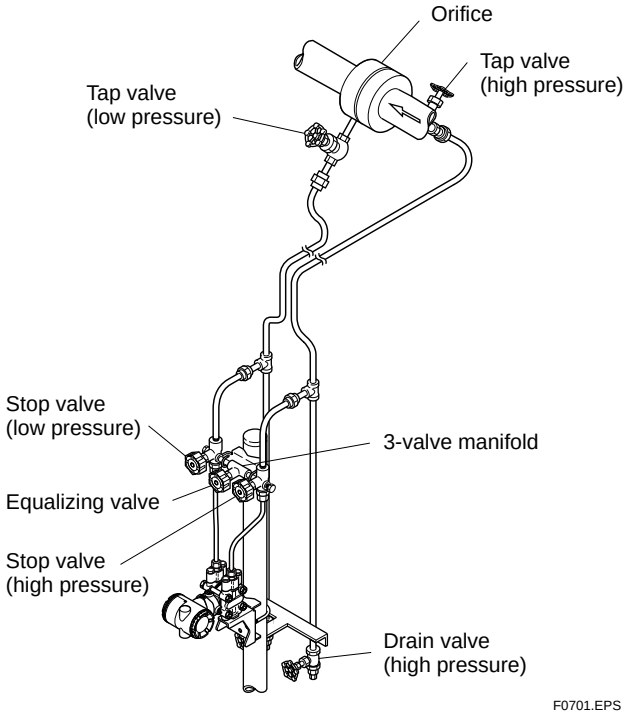
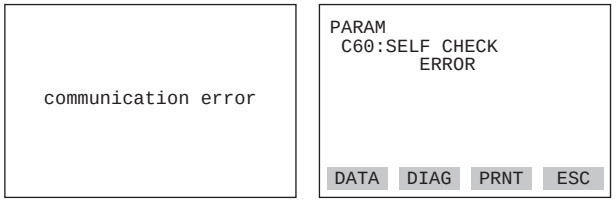


Figure 7.1 Liquid Flow Measurement

■ Confirming that Transmitter is Operating Properly

Using the BT200

- If the wiring system is faulty, 'communication error' appears on the display.
- If the transmitter is faulty, 'SELF CHECK ERROR' appears on the display.



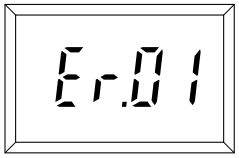
Communication error (Faulty wiring)

Self-diagnostic error (Faulty transmitter)

F0702.EPS

Using the integral indicator

- If the wiring system is faulty, the display stays blank.
- If the transmitter is faulty, an error code will appear on the display according to the nature of the error.



Self-diagnostic error on the integral indicator (Faulty transmitter)

F0703.EPS

NOTE

If any of the error indications above appears on the display of the integral indicator or BT200, refer to Subsection 8.5.2 for corrective action.

■ Verify and Change Transmitter Parameter Setting and Values

The following parameters are the minimum settings required for operation. The transmitter has been shipped with these parameters. To confirm or change the values, see Subsection 8.3.3.

- Measuring range ..... See Subsection 8.3.3 (2)
- Output/integral indicator mode ..... See Subsection 8.3.3 (4)
- Operation mode ..... See Subsection 8.3.3 (9)

7.2 Zero Point Adjustment

Adjust the zero point after operating preparation is completed.

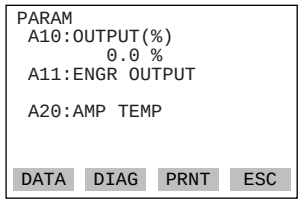
IMPORTANT

Do not turn off the power to the transmitter immediately after a zero adjustment. Powering off within 30 seconds after a zero adjustment will return the adjustment back to the previous settings.

The zero point adjustment can be made in either way: using the zero-adjustment screw of the transmitter or the BT200 operation.

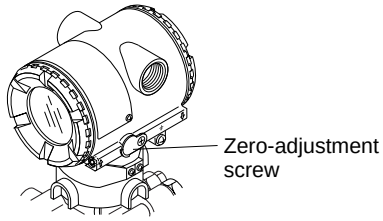
For output signal checking, display the parameter **A10: OUTPUT (%)** in the BT200.

●BT200



Output signal (%) display

●Zero-adjustment Screw



F0704.EPS

■ Using the Transmitter Zero-adjustment Screw

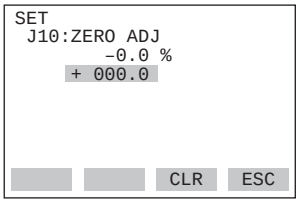
Before adjusting a screw, check that the parameter **J20: EXT ZERO ADJ** displays **ENABLE**. See Subsection 8.3.3 (15) for the setting procedure.

Use a slotted screwdriver to turn the zero-adjustment screw. Turn the screw clockwise to increase the output or counterclockwise to decrease the output. The zero point adjustment can be made with a resolution of 0.01% of the setting range. Since the degree of zero adjustments varies with the screw turning speed, turn the screw slowly for fine adjustment and quickly for coarse adjustment.

■ Using the BT200

Zero point can be adjusted by simple key operation of the BT200.

Select parameter **J10: ZERO ADJ**, and press the ENTER key twice. The zero point will be adjusted automatically to the output signal 0% (4 mA DC). Confirm that the setting value displayed for the parameter is '0.0%' before pressing the ENTER key. See Subsection 8.3.3 (15) for BT200 operating procedures.



A display when parameter J10 is selected.
Press ENTER key twice for 0% output 4 mA DC.

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7.3 Starting Operation

After completing the zero point adjustment, follow the procedure below to start operation.

1) Close the equalizing valve.
2) Gradually open the low pressure stop valve. This places the transmitter in an operational condition.
3) Confirm the operating status. If the output signal exhibits wide fluctuations (hunting) due to periodic variation in the process pressure, use BT200 to dampen the transmitter output signal. Confirm the hunting using a receiving instrument or the integral indicator, and set the optimum damping time constant. See Subsection 8.3.3 (3), "Damping Time Constant Setup."
4) After confirming the operating status, perform the following.

IMPORTANT

- Remove the BT200 from the terminal box, and confirm that none of the terminal screws are loosened.
- Close the terminal box cover and the amplifier cover. Screw each cover in tightly until it will not turn further.
- Two covers are required to be locked on the CENELEC and IECEx Flameproof type transmitters. An Allen head bolts (shrouding bolts) are provided under edge of the each cover for locking. When a shrouding bolts are driven counterclockwise by an Allen wrench, it is coming out and locks up a cover. (See page 9-3) After locking, the covers should be confirmed not to be opened by hand.
- Tighten the zero-adjustment cover mounting screw to fix the cover in position.

7.4 Shutting Down Operation

Shut down the transmitter operation as follows.

1) Turn off the power.
2) Close the low pressure stop valve.
3) Open the equalizing valve.
4) Close the high pressure stop valve.
5) Close the high pressure and low pressure tap valves.

NOTE

- Whenever shutting down the transmitter for a long period, remove any process fluid from the transmitter pressure-detector section.
- The equalizing valve must be left OPEN.

7.5 Venting or Draining Transmitter Pressure-detector Section

Since this transmitter is designed to be self-draining and self-venting with vertical impulse piping connections, neither draining nor venting will be required if the impulse piping is configured appropriately for self-draining or self-venting operation.

If condensate (or gas) collects in the transmitter pressure-detector section, the measured pressure may be in error. If it is not possible to configure the piping for self-draining (or self-venting) operation, you will need to loosen the drain (vent) screw on the transmitter to completely drain (vent) any stagnated liquid (gas).

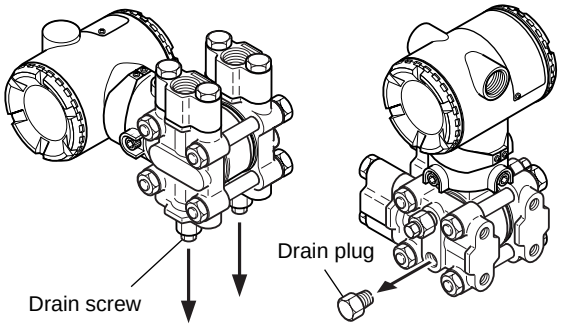
However, since draining condensate or bleeding off gas gives the pressure measurement disturbance, this should not be done when the loop is in operation.

⚠ WARNING

Since the accumulated liquid (or gas) may be toxic or otherwise harmful, take appropriate care to avoid contact with the body, or inhalation of vapors.

7.5.1 Draining Condensate

1) Gradually open the drain screw or drain plug and drain the transmitter pressure-detector section. (See Figure 7.5.1.)
2) When all accumulated liquid is completely removed, close the drain screw or drain plug.
3) Tighten the drain screw to a torque of 10 N·m, and the drain plug to a torque of 34 to 39 N·m.



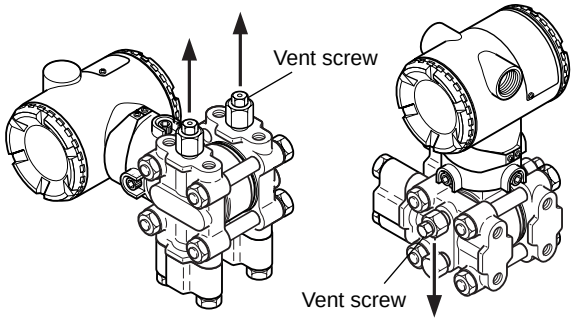
When you loosen the drain screw or drain plug, the accumulated liquid will be expelled in the direction of the arrow.

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Figure 7.5.1 Draining the Transmitter

7.5.2 Venting Gas

1) Gradually open the vent screw to vent gas from the transmitter pressur-detector section. (See Figure 7.5.2.)
2) When the transmitter is completely vented, close the vent screw.
3) Tighen the vent screw to a torque of 10 N·m.



When you loosen the vent screw, the gas escpes in the direction of the arrow.

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Figure 7.5.2 Venting the Transmitter

7.6 Setting the Range Using the Range-setting Switch

With actual pressure being applied to the transmitter, the range-setting switch (push-button) located on the optional integral indicator plate and the external zero-adjustment screw allow users to change (re-range) the low- and high-limit values for the measurement range (LRV and HRV) without using BT200. However, other changes in the display settings (scale range and engineering unit) for the integral indicator requires BT200.

Follow the procedure below to change the LRV and HRV settings.

[Example]

Rerange LRV to 0 and HRV to 3 MPa.

1) Connect the transmitter and apparatus as shown in Figure 9.3.1 and warm up for at least five minutes.
2) Press the range-setting push-button.
   The integral indicator then displays "LSET."
3) Apply a pressure of 0 kPa (atmospheric pressure) to the transmitter. (Note 1)
4) Turn the external zero-adjustment screw in the desired direction. The integral indicator displays the output signal in %. (Note 2)
5) Adjust the output signal to 0% (1 V DC) by rotating the external zero-adjustment screw. Doing so completes the LRV setting.

6) Press the range-setting push-button. The integral indicator then displays “HSET.”
7) Apply a pressure of 3 MPa to the transmitter. (Note 1)
8) Turn the external zero-adjustment screw in the desired direction. The integral indicator displays the output signal in %. (Note 2)
9) Adjust the output signal to 100% (5 V DC) by rotating the external zero-adjustment screw. Doing so completes the HRV setting.
10) Press the range-setting push-button. The transmitter then switches back to the normal operation mode with the measurement range of 0 to 3 MPa.

Note 1: Wait until the pressure inside the pressure-detector section has stabilized before proceeding to the next step.

Note 2: If the pressure applied to the transmitter exceeds the previous LRV (or HRV), the integral indicator may display error number “Er.07” (In this case, the output signal percent and “Er.07” are displayed alternately every two seconds). Although “Er.07” is displayed, you may proceed to the next step. However, should any other error number be displayed, take the appropriate measure in reference to Subsection 8.5.2, “Errors and Countermeasures.”

IMPORTANT

- Do not turn off the power to the transmitter immediately after completion of the change in the LRV and/or HRV setting(s). Note that powering off within thirty seconds after setting will cause a return to the previous settings.
- Changing LRV automatically changes HRV to the following value.

HRV = previous HRV + (new LRV – previous LRV)

- If the range-setting push-button and external zero-adjustment screw are not touched during a range-change operation, the transmitter automatically switches back to the normal operation mode.

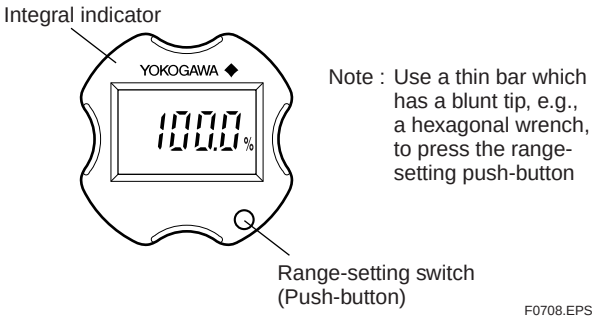


Figure 7.6 Range-setting Switch

8. BRAIN TERMINAL BT200 OPERATION

The DPharp is equipped with BRAIN communications capabilities, so that range changes, Tag No. setup, monitoring of self-diagnostic results, and zero point adjustment can be handled by remote control via BT200 BRAIN TERMINAL or CENTUM CS console. This section describes procedures for setting parameters using the BT200. For details concerning the BT200, see IM 01C00A11-01E, "BT200 User's Manual."

8.1 BT200 Operation Precautions

8.1.1 Connecting the BT200

Connection to the transmitter with the BT200 can be made by either connecting to the BT200 connection hooks in the transmitter terminal box or by connecting to a relaying terminal board.

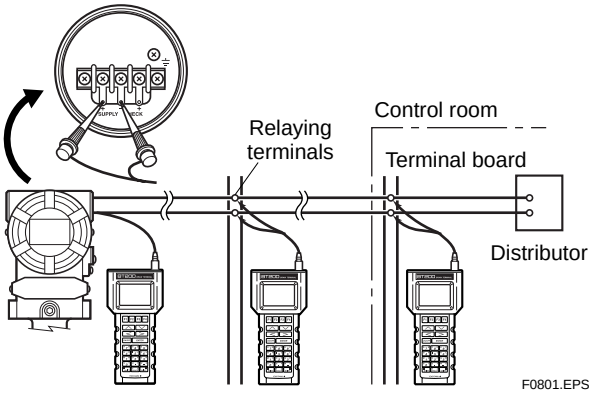


Figure 8.1.1 Connecting the BT200

8.1.2 Conditions of Communication Line

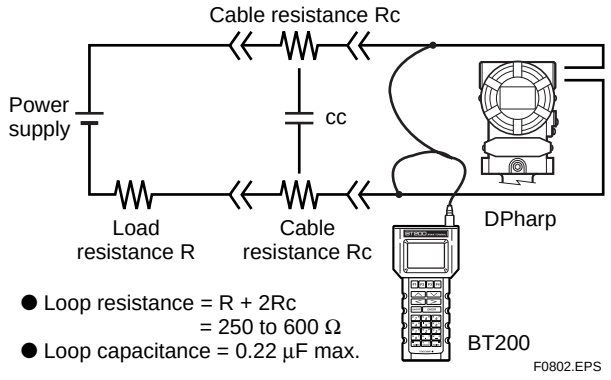


Figure 8.1.2 Conditions of Communication Line

8.2 BT200 Operating Procedures

8.2.1 Key Layout and Screen Display

Figure 8.2.1a shows the arrangement of the operating keys on the BT200 keypad, and Figure 8.2.1b shows the BT200 screen component.

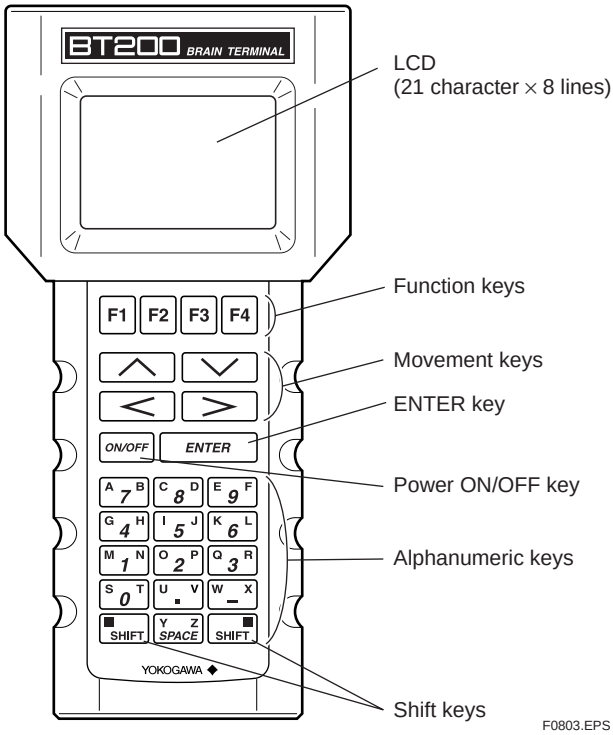


Figure 8.2.1a BT200 Key Layout

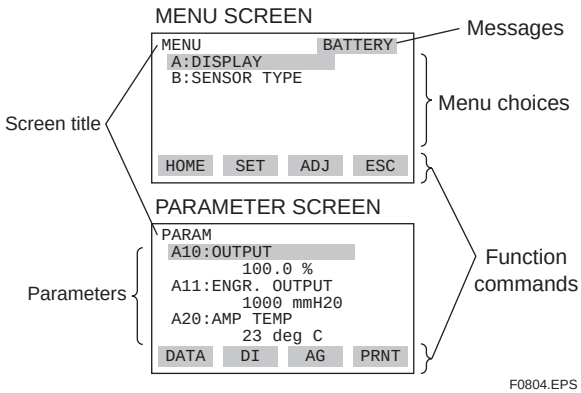
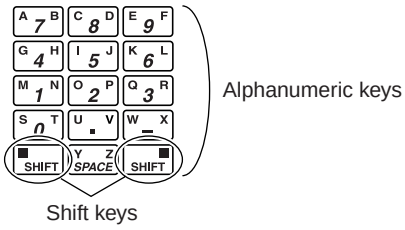


Figure 8.2.1b BT200 Screen Component

8.2.2 Operating Key Functions

(1) Alphanumeric Keys and Shift Keys

You can use the alphanumeric keys in conjunction with the shift keys to enter symbols, as well as alphanumeric keys.



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a. Entering Digits, Symbols, and Spaces

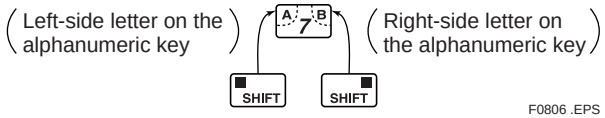
Simply press the alphanumeric keys.

Entry	Key-in Sequence
–4	[–] [4]
0.3	[0] [.] [3]
1 ␣ –9	[1] [SPACE] [–] [9]

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b. Entering Letters (A through Z)

Press an alphanumeric key following a shift key to enter the letter shown on that side which the shift key represents. You must press the shift key before entering each letter.

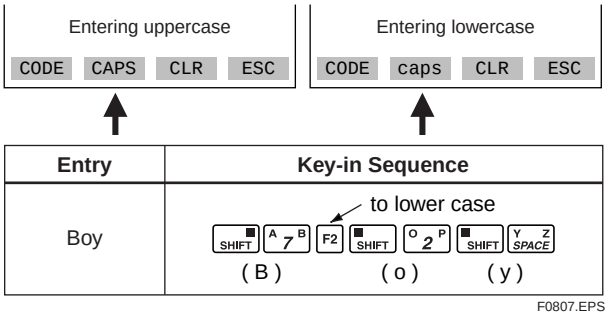


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Entry	Key-in Sequence
W	[SHIFT] [–]
IC	[SHIFT] [5] [SHIFT] [8]
J. B	[SHIFT] [5] [.] [SHIFT] [7]

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Use the function key [F2] CAPS to select between uppercase and lowercase (for letters only). The case toggles between uppercase and lowercase each time you press [F2] CAPS.



Entry	Key-in Sequence
Boy	[SHIFT] [7] [F2] [SHIFT] [2] [SHIFT] [SPACE] (B) (o) (y)

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Use the function key [F1] CODE to enter symbols. The following symbols will appear in sequence, one at a time, at the cursor each time you press [F1] CODE:

/ . – , + *) (' & % $ # " !

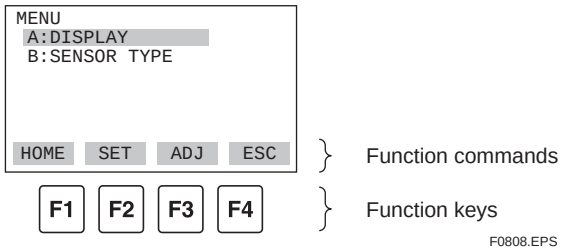
To enter characters next to these symbols, press [>] to move the cursor.

Entry	Key-in Sequence
l/m	symbol command [F2] [SHIFT] [6] [F1] [>] [SHIFT] [1] (l) (/) (m)

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(2) Function Keys

The functions of the function keys depend on the function commands on display.



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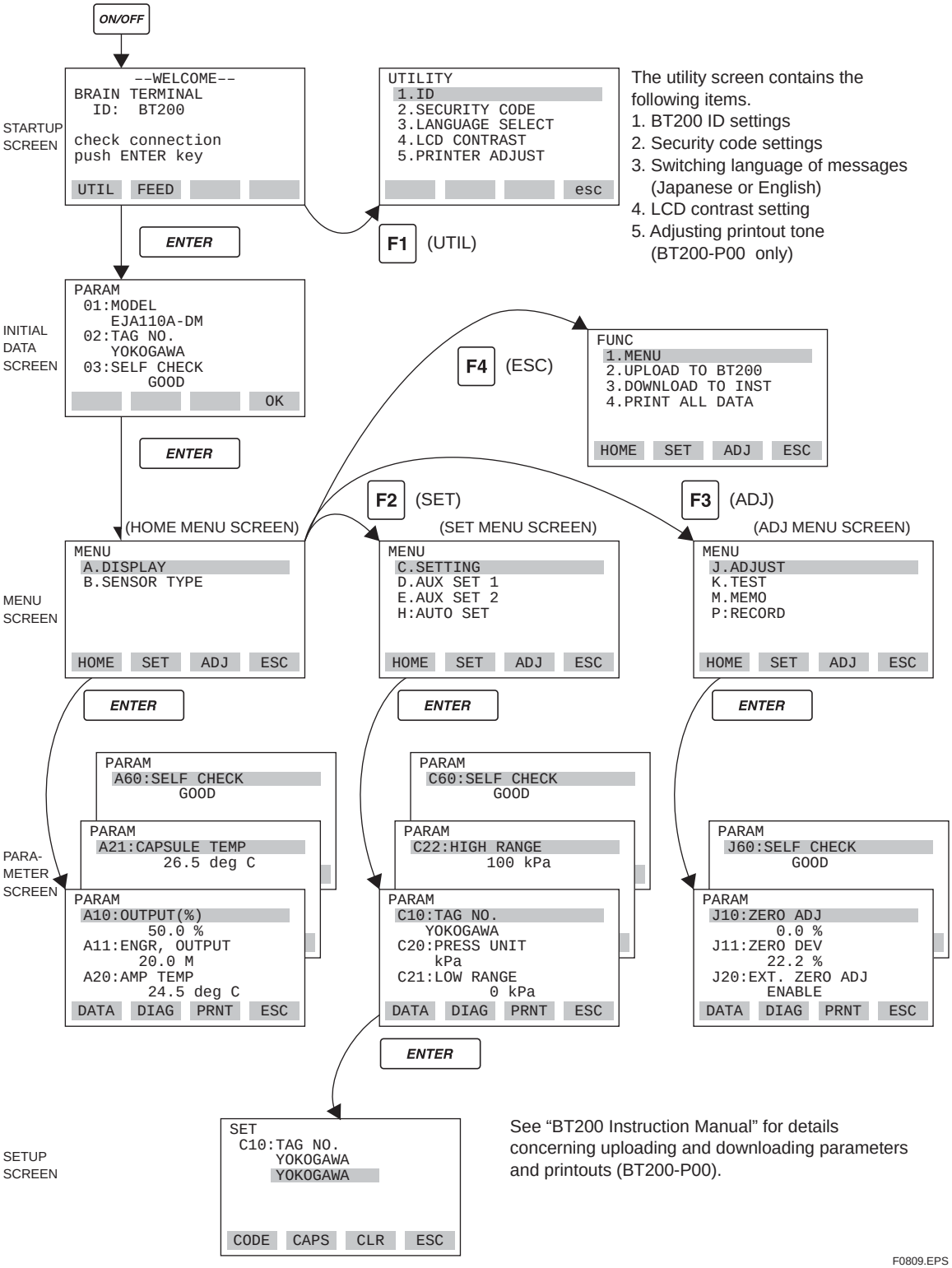
Function Command List

Command	Function
ADJ	Displays the ADJ menu
CAPS/caps	Selects uppercase or lowercase
CODE	Selects symbols
CLR	Erases input data or deletes all data
DATA	Updates parameter data
DEL	Deletes one character
DIAG	Calls the self-check panel
ESC	Returns to the most recent display
HOME	Displays the menu panel
NO	Quits setup and returns to the previous display
OK	Proceeds to the next panel
PARM	Enters the parameter number setup mode
SET	Displays the SET menu
SLOT	Returns to the slot selection panel
UTIL	Calls the utility panel
*COPY	Prints out parameters on display
*FEED	Paper feed
*LIST	Lists all parameters in the menu
*PON/POFF	Automatic printout mode on or off
*PRNT	Changes to the print mode
*GO	Starts printing
*STOP	Cancels printing

* Available on BT200-P00 (with printer).

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8.2.3 Calling Up Menu Addresses Using the Operating Keys



8.3 Setting Parameters Using the BT200

8.3.1 Parameter Summary

Instruments to which applicable:
F: Differential pressure transmitters EJA110A, EJA120A, and EJA130A
P: Pressure transmitters EJA310A, EJA430A, EJA440A, EJA510A, and EJA530A
L: Liquid level transmitters EJA210A and EJA220A

No.	Item	Description	Rewritability	Remarks	Default Value	Applicability		
						F	P	L
01	MODEL	Model+capsule type	–			○	○	○
02	TAG NO.	Tag number	–	16 alphanumerics		○	○	○
03	SELF CHECK	Self-diagnostic result	–	GOOD/ERROR		○	○	○
A	DISPLAY	Measured data display	–	Menu name		○	○	○
A10	OUTPUT (%)	Output (in %)	–	–5 to 110%*3		○	○	○
A11	ENGR. OUTPUT	Output (in engineering units)	–	–19999 to 19999		○	○	○
A20	AMP TEMP	Amplifier temperature	–	Unit specified in D30		○	○	○
A21	CAPSULE TEMP	Capsule temperature	–	Unit specified in D30		○	○	○
A30	STATIC PRESS	Static pressure	–	Unit specified in D31*1		○	–	○
A40	INPUT	Input (indicated as the value after zeroing)	–	–32000 to 32000		○	○	○
A60	SELF CHECK	Self-diagnostic messages	–	GOOD/ERROR, CAP MODULE FAULT, AMP MODULE FAULT, OUT OF RANGE, OUT OF SP RANGE*1, OVER TEMP (CAP), OVER TEMP (AMP), OVER OUTPUT, OVER DISPLAY, ILLEGAL LRV, ILLEGAL HRV, ILLEGAL SPAN, and ZERO ADJ OVER		○	○	○
B	SENSOR TYPE	Sensor type	–	Menu name		○	○	○
B10	MODEL	Model+span	–	16 uppercase alphanumerics		○	○	○
B11	STYLE NO.	Style number	–			○	○	○
B20	LRL	Lower range-limit	–	–32000 to 32000		○	○	○
B21	URL	Upper range-limit	–	–32000 to 32000		○	○	○
B30	MIN SPAN	Minimum span	–	–32000 to 32000		○	○	○
B40	MAX STAT.P.	Maximum static pressure*6	–			○	–	○
B60	SELF CHECK	Self-diagnostic messages	–	Same as A60		○	○	○
C	SETTING	Setting data	–	Menu name		○	○	○
C10	TAG. NO.	Tag number	○	16 alphanumerics	As specified when ordered.	○	○	○
C20	PRESS UNIT	Measurement range units	○	Selected from mmH_2O, mmAq, mmWG, mmHg, Torr, Pa, hPa, kPa, MPa, mbar, bar, gf/cm^2, kgf/cm^2, inH_2O, inHg, ftH_2O, psi, or atm	As specified when ordered.	○	○	○
C21	LOW RANGE	Measurement range, lower range value	○	–32000 to 32000(but within measurement range)	As specified when ordered.	○	○	○
C22	HIGH RANGE	Measurement range, higher range value	○	–32000 to 32000(but within measurement range)	As specified when ordered.	○	○	○
C30	AMP DAMPING	Damping time constant	○	Selected from 0.2*2, 0.5, 1.0, 2.0, 4.0, 8.0, 16.0, 32.0, or 64.0 sec.	2.0 s	○	○	○
C40	OUTPUT MODE	Output mode and integral indicator mode	○	Selected from OUT:LIN; DSP:LIN, OUT:LIN; DSP:SQR, OUT:SQR; DSP:SQR	As specified when ordered. If not specified, OUT: LIN; DSP: LIN.	○	–	–
C60	SELF CHECK	Self-diagnostic messages	–	Same as A60		○	○	○
D	AUX SET 1	Auxiliary setting data 1	–	Menu name		○	○	○
D10	LOW CUT	Low cut	○	0.0 to 20.0%	10.0%	○	○	○
D11	LOW CUT MODE	Low cut mode	○	LINEAR/ZERO	LINEAR	○	○	○
D15	OUT LIMIT(L)	Lower output range-limit	○	–5.0 to 110.0%	–5.0%*1	○	○	○
D16	OUT LIMIT(H)	Upper output range-limit	○	–5.0 to 110.0%	110.0%	○	○	○
D20	DISP SELECT	Display selection	○	NORMAL %/USER SET, USER & %/INP PRES, PRES & %	As specified when ordered.	○	○	○
D21	DISP UNIT	Engineering unit for display	○	8 uppercase alphanumerics		○	○	○
D22	DISP LRV	Engineering range, lower range value	○	–19999 to 19999	As specified when ordered.	○	○	○
D23	DISP HRV	Engineering range, higher range value	○	–19999 to 19999	As specified when ordered.	○	○	○
D30	TEMP UNIT	Temperature setting units	○	deg C/deg F	deg C	○	○	○

*1: Unless otherwise specified by order. When optional code /F1 is specified, substitute the value –5 with –2.5.

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No.	Item	Description	Rewritability	Remarks	Default Value	Applicability		
						F	P	L
D	AUX SET 1	Auxiliary setting data 1	–	Menu name		○	○	○
D31	STAT. P. UNIT	Static pressure setting units	○	Selected from mmH_2O, mmAq, mmWG, mmHg, Torr, Pa, hPa, kPa, MPa, mbar, bar, gf/cm^2, kgf/cm^2, inH_2O, inHg, ftH_2O, psi, or atm	As specified when ordered. If not specified, MPa.	○	–	○
D40	REV OUTPUT	Output reversal	○	NORMAL/REVERSE	If not specified, NORMAL.	○	○	○
D45	H/L SWAP	Impulse piping accessing direction	○	NORMAL/REVERSE*4	NORMAL	○	–	–
D52	BURN OUT	CPU error	–	HIGH/LOW, –5 to 110%*3	HIGH	○	○	○
D53	ERROR OUT	Hardware error	○	HOLD/HIGH/LOW, –5 to 110%*3	HIGH	○	○	○
D60	SELF CHECK	Self-diagnostic messages	–	Same as A60		○	○	○
E	AUX SET 2	Auxiliary setting data 2	–	Menu name		○	○	○
E10	DFS MODE	DFS mode	○	OFF/ON*5	ON	○	○	–
E14	TEMP SELECT	Reference temperature sensor	○	AMP. TEMP/CAP. TEMP*5	CAP. TEMP	○	○	–
E15	TEMP ZERO	Zero shift conpensation setup	○	±10.00*5	0.00	○	○	–
E30	BI DIRE MODE	Bidirectional mode	○	OFF/ON	OFF	○	–	–
E50	AUTO RECOVER	Auto-recover from sensor error	○	OFF/ON	ON	○	○	○
E60	SELF CHECK	Self-diagnostic messages	–	Same as A60		○	○	○
H	AUTO SET	Automatic setup	–	Menu name		○	○	○
H10	AUTO LRV	Automatic measurement range lower range value setup	○	–32000 to 32000	Displays the same data as C21.	○	○	○
H11	AUTO HRV	Automatic measurement range higher range value setup	○	–32000 to 32000	Displays the same data as C22.	○	○	○
H60	SELF CHECK	Self-diagnostic messages	–	Same as A60		○	○	○
J	ADJUST	Adjustment data	–	Menu name		○	○	○
J10	ZERO ADJ	Automatic zero adjustment	○	–5 to 110.0%*3		○	○	○
J11	ZERO DEV.	Manual zero adjustment	○			○	○	○
J15	SPAN ADJ	Manual span adjustment	○	–10.00 to 10.00%	0.00%	○	○	○
J20	EXT. ZERO ADJ	External zero-adjustment screw permission	○	ENABLE/INHIBIT		○	○	○
J30	OUTPUT 4mA	4mA adjustment	○	–10.00 to 10.00%	0.00%	○	○	○
J31	OUTPUT 20mA	20mA adjustment	○	–10.00 to 10.00%	0.00%	○	○	○
J60	SELF CHECK	Self-diagnostic messages	–	Same as A60		○	○	○
K	TEST	Tests	–	Menu name		○	○	○
K10	OUTPUT in %	Test output % setting	○	–5 to 110.0%*3 Displays 'ACTIVE' while executing		○	○	○
K60	SELF CHECK	Self-diagnostic messages	–	Same as A60		○	○	○
M	MEMO	Memo	–	Menu name		○	○	○
M10	MEMO 1	Memo	○	8 uppercase alphanumerics		○	○	○
M20	MEMO 2	Memo	○	8 uppercase alphanumerics		○	○	○
M30	MEMO 3	Memo	○	8 uppercase alphanumerics		○	○	○
M40	MEMO 4	Memo	○	8 uppercase alphanumerics		○	○	○
M50	MEMO 5	Memo	○	8 uppercase alphanumerics		○	○	○
M60	SELF CHECK	Self-diagnostic messages	–	Same as A60		○	○	○
P	RECORD	History of the errors	–			○	○	○
P10	ERROR REC 1	Last error	○	Display the error		○	○	○
P11	ERROR REC 2	One time before	○	Display the error		○	○	○
P12	ERROR REC 3	Two time before	○	Display the error		○	○	○
P13	ERROR REC 4	Three time before	○	Display the error		○	○	○
P60	SELF CHECK	Self-diagnostic messages	–	Same as A60		○	○	○

*1: In case of Model EJA120A, static pressure cannot be measured. The display is always 0 MPa, but this is not a measured value.
*2: When Optional code /F1 is specified, substitute the value with 0.1.
*3: When Optional code /F1 is specified, substitute the value –5 with –2.5.
*4: Not applicable for Model EJA115.
*5: Applicable only for Model EJA118W, EJA118N, EJA118Y, EJA438W, and EJA438N.
*6: See MWP(max. working pressure) on the nameplate. B40 shows an approximate value of maximum pressure for the capsule.

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8.3.2 Parameter Usage and Selection

Before describing the procedure for setting parameters, we present the following table showing how the parameters are used and in what case.

IMPORTANT

If the transmitter is turned off within 30 seconds after parameters have been set, the set data will not be stored and the terminal returns to previous settings.

Table 8.3.1 Parameter Usage and Selection

Setup Item	Description
Tag No. setup ► P.8-7	Sets the Tag No. (using 16 alphanumeric characters).
Calibration range setup ► P.8-7	Sets the calibration range for 4 to 20 mA DC. Sets three data items: range unit, input value at 4 mA DC (LRV), and input value at 20 mA DC (URV). Note: LRV and URV can be specified with range value specifications up to 5 digits (excluding any decimal point) within the range of –32000 to 32000.
Damping time constant setup ► P.8-8	Adjusts the output response speed for 4 to 20 mA DC at amplifier. Can be set from 0.50 to 100.00 s. (from 0.00 to 100.00 s with quick response mode on)
Output and integral indicator display mode setup ► P.8-9	Sets modes for output signal and integral indicator to “Linear mode” (proportional to input differential pressure) or to “Square root mode” (proportional to flow).
Output signal low cut mode setup ► P.8-9	Used mainly to stabilize output near 0% if output signal is the square root mode. Two modes are available: forcing output to 0% for input below a specific value, or changing to proportional output for input below a specific value.
Change the output limits ► P.8-9	Change the range of normal output.
Integral indicator display function ► P.8-10	Available from the following 5 types of integral indicator scale ranges and units: input pressure, % of range, user set scale, input static pressure, % of static pressure range, and alternating among any four of the above. When using the user set scale, 4 types of data should be configurated in advance: user set scale setting, unit (BT200 only), display value at 4 mA DC (LRV), and display value at 20 mA DC (URV). Note: LRV and URV can be specified with range value specifications up to 5 digits (excluding any decimal point) within the range of –32000 to 32000.
Unit setup for displayed temperature ► P.8-11	Sets a unit for temperatures displayed on the BT200.
Unit setup for displayed static pressure ► P.8-11	Sets a unit for static pressure displayed on the BT200.
Operation mode (normal/reverse signal) setup ► P.8-12	Reverses the direction for 4 to 20 mA DC output relative to input. Reverse mode is used for applications in which safety requires that output be driven toward 20 mA if input is lost.
Impulse line connection orientation (higher pressure on right/left side) setup ► P.8-12	Used where installation conditions make it imperative to connect high pressure side impulse line to low pressure side of transmitter. Reversal of orientation should be dealt with by reversing impulse line wherever possible. Use this function only where there is no alternative.
Output status display/setup when a CPU failure ► P.8-12	Displays the status of 4 to 20 mA DC output when a CPU failure. The parameter of the standard unit is fixed to the high limit value.
Output status setup when a hardware error occurs ► P.8-12	Sets the status of the 4 to 20 mA DC output when an abnormal status is detected with the capsule or the amplifier as the result of self-diagnosis. One of the following statuses; last held, high limit, and low limit values, can be selected.
Bi-directional flow measurement ► P.8-13	Used to measure bi-directional flows. Output at zero flow is 12 mA DC, with output range equally divided between forward and reverse flow. Can be used with square root mode.
Range change (while applying actual inputs) ► P.8-13	Range for 4 to 20 mA DC signal is set with actual input applied. Sets 20 mA DC output precisely with respect to user's reference instrument output. Note that DPharp is calibrated with high accuracy before shipment, so span should be set using the normal range setup.
Zero point adjustment ► P.8-14	Adjusts zero point. This can be done either using the external zero-adjustment screw on the transmitteror using the BT200.
Span adjustment ► P.8-15	Adjust the characterization curve. All the transmitters are calibrated at factory and this adjustment is normally not necessary for most cases. Use for specific purposes.
Test output (fixed current output) setup ► P.8-16	Used for loop checks. Output can be set freely from –5% to 110% in 1% steps.
User memo fields ► P.8-16	Allows user to enter up to 5 items of any desired text in up to 8 uppercase alphanumeric characters per item.

T0807.EPS

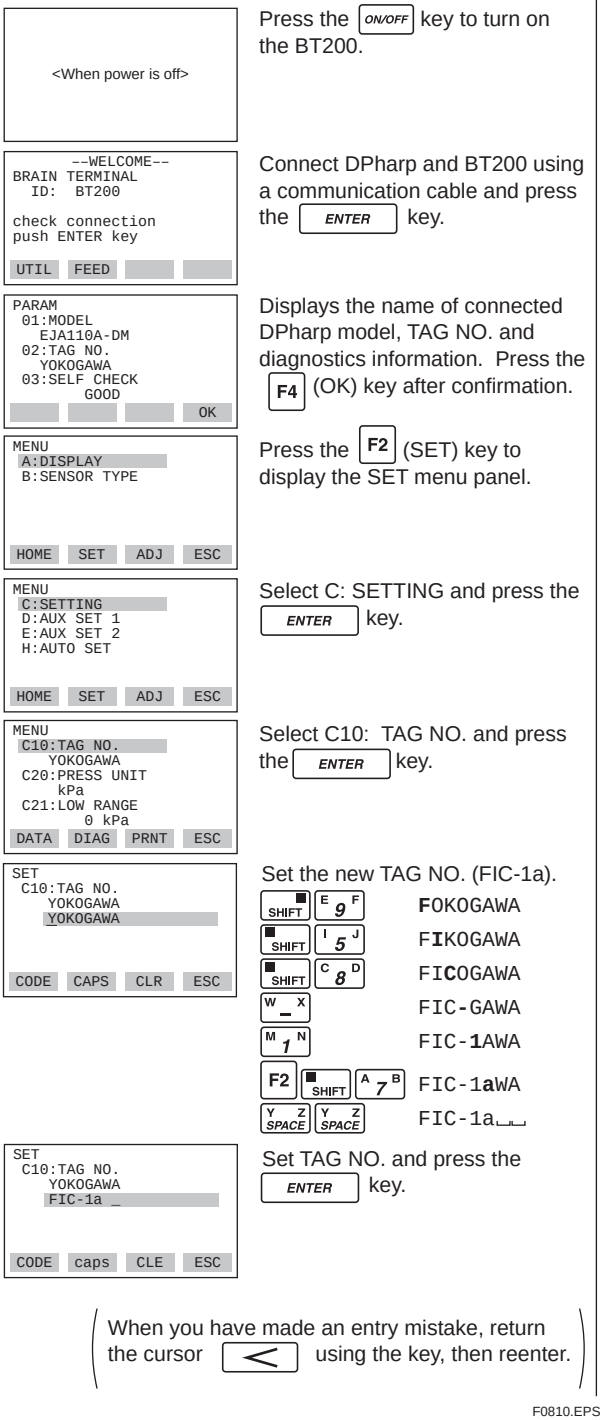
8.3.3 Setting Parameters

Set or change the parameters as necessary. After completing these, do not fail to use the "DIAG" key to confirm that "GOOD" is displayed for the self-diagnostic result at **_60: SELF CHECK**.

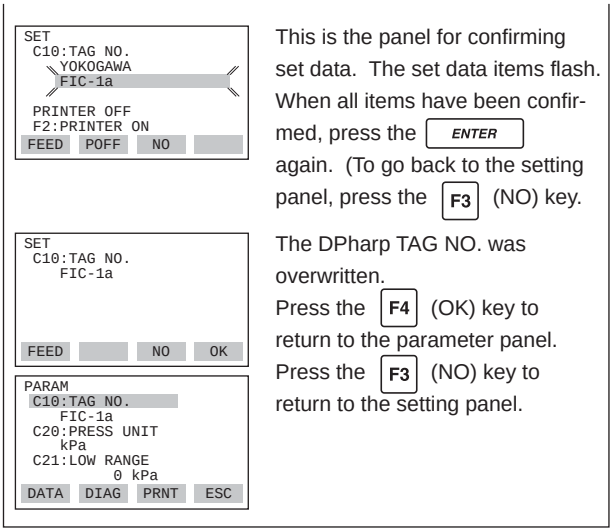
(1) Tag No. Setup (C10: TAG NO)

Use the procedure below to change the Tag No. Up to 16 alphanumeric characters can be entered.

• Example: Set a Tag No. to FIC-1a



F0810.EPS



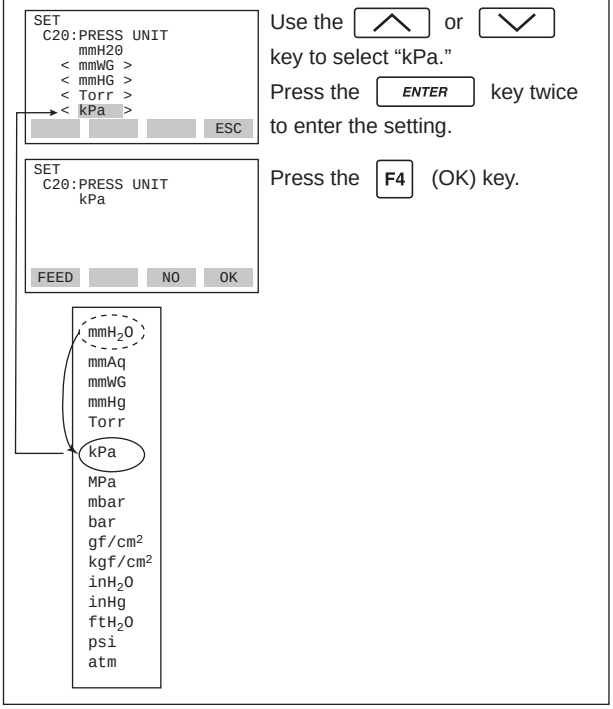
F0811.EPS

(2) Calibration Range Setup

a. Setting Calibration Range Unit (C20: PRESS UNIT)

The unit is set at the factory before shipment if specified at the time of order. Follow the procedure below to change the unit.

• Example: Change the unit from **mmH$_2$O** to **kPa**.



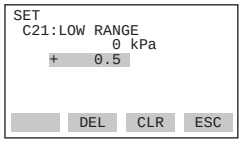
F0812.EPS

b. Setting Calibration Range Lower Range Value and Higher Range Value (C21: LOW RANGE, C22: HIGH RANGE)

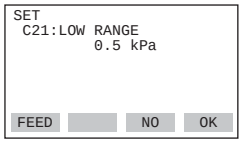
These range values are set as specified in the order before the instrument is shipped. Follow the procedure below to change the range.

- The measurement span is determined by the high and low range limit values. In this instrument, changing the low range value also automatically changes the high range value, keeping the span constant.

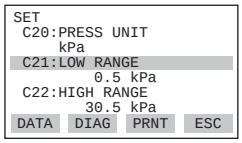
• Example 1: With present settings of 0 to 30 kPa, set the lower range value to 0.5 kPa.



Set **0.5**.
Press the ENTER key twice to enter the setting.



Press the F4 (OK) key.



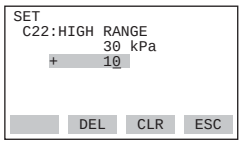
The higher range value is changed while the span remains constant.

⟨ Span = Higher range value – Lower range value ⟩

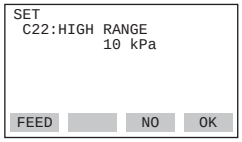
F0813.EPS

- Note, however, that changing the higher range value does not cause the lower range value to change. Thus, changing the higher range value also changes the span.
- Calibration range can be specified with range value specifications up to 5 digits (excluding any decimal point) for low or high range limits within the range of –32000 to 32000.

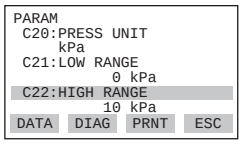
• Example 2: With present settings of 0 to 30 kPa, set the Higher range value to10 kPa.



Set **10**.
Press the ENTER key twice to enter the setting.



Press the F4 (OK) key.



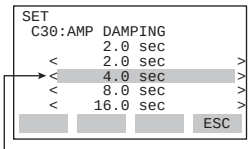
The low range value is not changed, so the span changes.

F0814.EPS

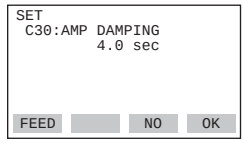
(3) Damping Time Constant Setup (C30: AMP DAMPING)

When the instrument is shipped, the damping time constant is set at 2.0 seconds. Follow the procedure below to change the time constant.

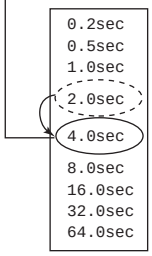
• Example: Change from 2.0 sec to 4.0 sec.



Use the ^ or v key to select **4.0 sec**.
Press the ENTER key twice to enter the setting.



Press the F4 (OK) key.



F0815.EPS

Note: The damping time constant set here is the damping time constant for the amplifier assembly. The damping time constant for the entire transmitter is the sum of the values for the amplifier assembly and for the capsule assembly. For the capsule assembly damping time constant (fixed), see the "General Specifications" found at the end of this manual. (See Chapter 10.)

(4) Output Mode and Integral Indicator Display Mode Setup (C40: OUTPUT MODE)

The mode setting for the output signal and the integral indicator coordinate as shown in the table below.

BT200 Display	Output Mode	Integral Indicator Display Mode
OUT: LIN DSP: LIN	Linear	Linear
OUT: LIN DSP: SQR	Linear	Square root
OUT: SQR DSP: SQR	Square root	Square root

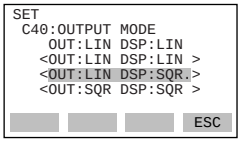
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This mode is set as specified in the order when the instrument is shipped. Follow the procedure below to change the mode.

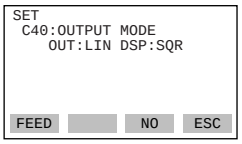
If the instrument is equipped with an integral indicator and the display mode is "square root", "√‾" is displayed on the integral indicator.

For details, see Chapter 3.

• Example: Set output mode to **Linear** and display mode to **Square root**.



Use the ^ or v key to select "OUT: LIN, DSP: SQR."
Press the ENTER key twice to enter the setting.



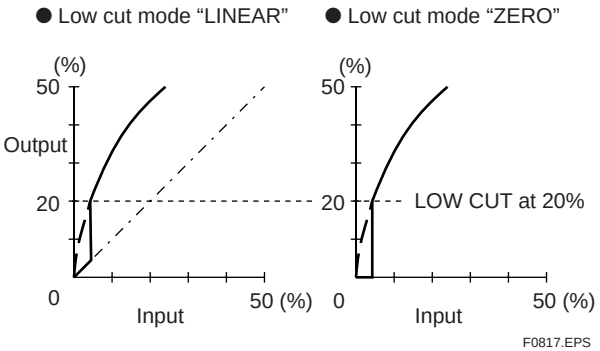
Press the F4 (OK) key.

F0816.EPS

(5) Output Signal Low Cut Mode Setup (D10: LOW CUT, D11: LOW CUT MODE)

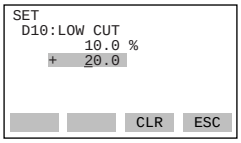
Low cut mode can be used to stabilize the output signal near the zero point. The low cut point can be set in a range from 0 to 20% of output. (Hysteresis: ±1%)

Either "**LINEAR**" or "**ZERO**" can be selected as the low cut mode.

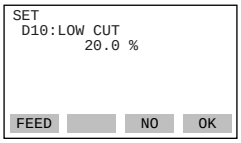


F0817.EPS

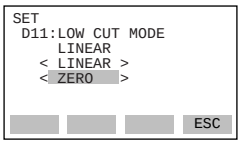
• Example: Change the low cut setting range from 10% to 20%, and the low cut mode from **LINEAR** to **ZERO**.



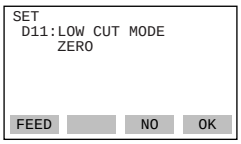
Set "20."
Press the ENTER key twice to enter the setting.



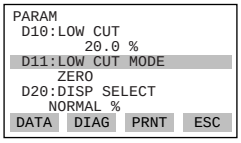
Press the F4 (OK) key.
Next, the [D11: LOW CUT MODE] setting panel is displayed.



Use the ^ or v key to select "ZERO."
Press the ENTER key twice to enter the setting.



Press the F4 (OK) key.



F0818.EPS

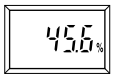
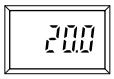
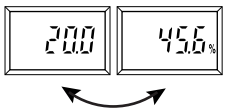
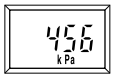
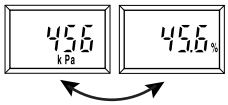
(6) Change Output Limits (D15: OUT LIMIT(L), D16: OUT LIMIT(H))

The range of normal output is preset at the factory from –5.0% to 110.0% unless otherwise specified or conditioned, and the output is limited with these upper and lower values. This output range can be changed, for example, to meet the requirements of NAMUR, within the settable range. Set the lower limit with D15: OUT LIMIT(L) and upper limit with D16: OUT LIMIT(H).

Settable range : –5.0 to 110.0 (%)
Lower limit < Upper limit

(7) Integral Indicator Scale Setup

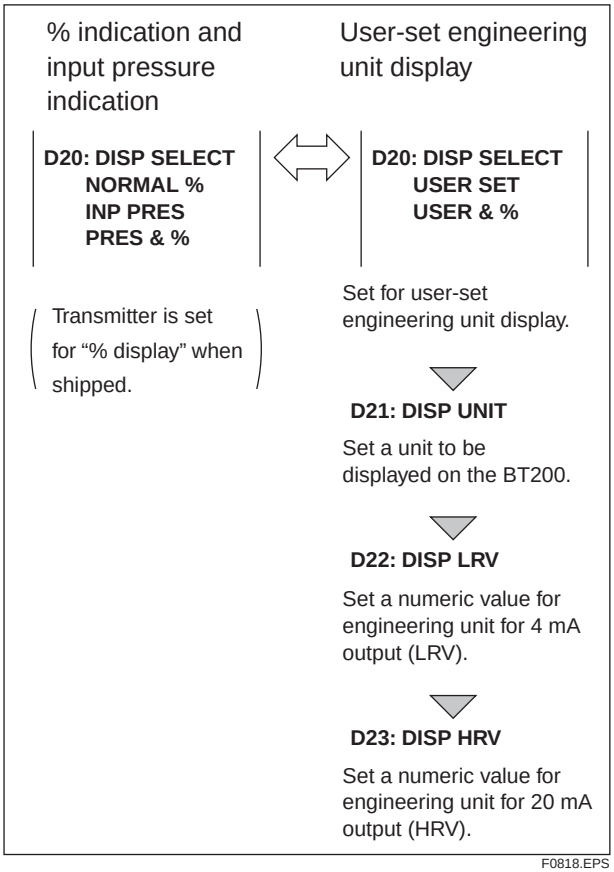
The following 5 displays are available for integral indicators.

D20: DISP SELECT and Display	Description and Related parameters
NORMAL % 	Indicates –5 to 110% range depending on the Measurement range (C21, C22). A10:OUTPUT (%) 45.6 %
USER SET 	Indicates values depending on the Engineering range (D22, D23).(Note 1) Units set using Engineering unit (D21) are not indicated. A11:ENGR.OUTPUT 20.0 M
USER & % 	Indicates user set and % alternately in 3 second intervals. A10:OUTPUT (%) 45.6 % A11:ENGR. OUTPUT 20.0 M
INP PRES 	Indicates input pressure.(Note 2) Indication limits –19999 to 19999. A40:INPUT 456 kPa
PRES & % 	Indicates input pressure and % alternately in 3 second intervals. A10:OUTPUT (%) 45.6 % A40:INPUT 456 kPa

(Note 1) Scale range can be specified with range limit specifications up to 5 digits (excluding any decimal point) for low or high range limits within the range of –19999 to 19999.
The range with decimals is available to the third decimal place.
(Note 2) It indicates the value after zeroing.

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See (a.) through (c.) for each setting procedure.

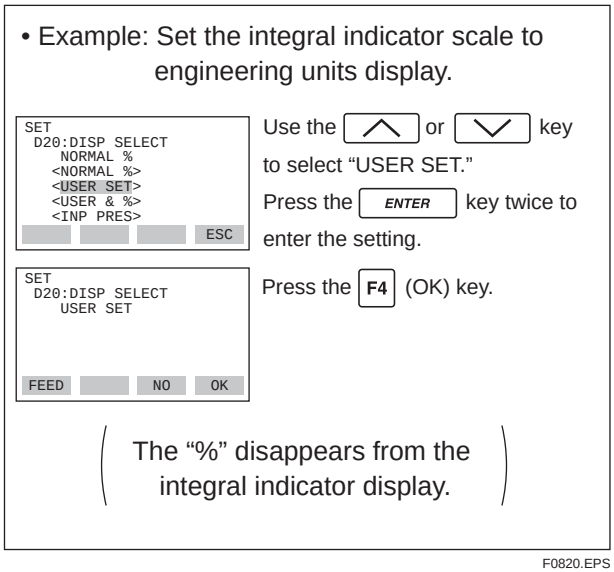


F0818.EPS

a. Display Selection (D20: DISP SELECT)

Follow the instructions given to the below to change the range of integral indication scales.

When **USER SET** is selected, the user set values of integral indication and **A11: ENGR. OUTPUT** parameter are indicated.



F0820.EPS

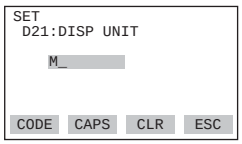
b. Setting User-set Engineering Unit (D21: DISP UNIT)

This parameter allows entry of the engineering units to be displayed on the BT200. When the instrument is shipped, this is set as specified in the order.

Follow the procedure below to change this setting.

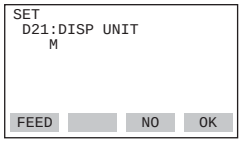
This parameter need not be set for % display.

• Example: Set an engineering unit **M**.



Set "M."

Press the ENTER key twice to enter the setting.



Press the F4 (OK) key.

F0821.EPS

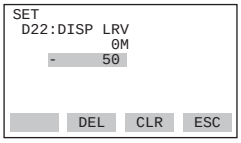
c. Lower and Higher Range Value Setup in Engineering Unit (D22: DISP LRV, D23: DISP HRV)

These parameter items are used to set the lower and higher range values for the engineering unit display.

When the instrument is shipped, these are set as specified in the order. Follow the procedure below to change these settings. Note that these parameters need not be set for % display.

• Example: Set lower range value (LRV) to **–50** and higher range value (HRV) to **50**.

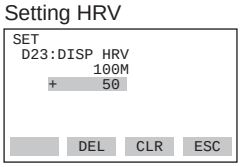
Setting LRV



Set "–50."

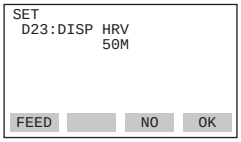
Press the ENTER key twice to enter the setting.

Setting HRV

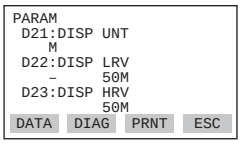


Set "50."

Press the ENTER key twice to enter the setting.



Press the F4 (OK) key.

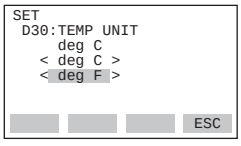


F0822.EPS

(8) Unit Setup for Displayed Temperature (D30: TEMP UNIT)

When the instrument is shipped, the temperature units are set to **degC**. Follow the procedure below to change this setting. Note that changing the unit here changes the unit for **A20: AMP TEMP** (amplifier temperature) and **A21: CAPSULE TEMP** (capsule temperature).

• Example: Change the unit for the temperature display.



Use the ^ or v key to select "deg F."

Press the ENTER key twice to enter the setting.

F0823.EPS

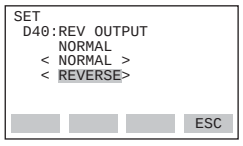
(9) Unit Setup for Displayed Static Pressure (D31: STAT.P.UNIT)

Follow the procedure below to change the static pressure units.
Changing this parameter changes the unit for the **A30: STATIC PRESS** (static pressure) display.

(10) Operation Mode Setup (D40: REV OUTPUT)

This parameter allows the direction of the 4 to 20 mA output to be reversed with respect to input. Follow the procedure below to make this change.

• Example: Change 4 to 20 mA output to 20 to 4 mA output.



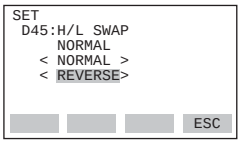
Use the [^] or [v] key to select REVERSE.
Press the [ENTER] key twice to enter the setting.

F0825.EPS

(11) Impulse Line Connection Orientation Setup (D45: H/L SWAP)

This parameter allows the impulse line connections to be reversed at the transmitter. The parameter is not applicable for capsule code V. Follow the figure below to make this change.

• Example: Change the impulse line connection from high pressure on right to high pressure on left.



Use the [^] or [v] key to select REVERSE.
Press the [ENTER] key twice to enter the setting.

F0826.EPS

(12) Output Status Display/Setup when a CPU Failure (D52: BURN OUT)

This parameter displays the status of 4 to 20 mA DC output if a CPU failure occurs. In case of a failure, communication is disabled.

Setting of HIGH or LOW is enabled. This is done with the pin (CN4) on the CPU assembly. See Chapter 3 for details.

Standard specifications
The parameter is set to HIGH. If a failure, the transmitter outputs the signal of 110% or higher. The parameter **D53: ERROR OUT** is set to HIGH from the factory.

Optional code/C1
The parameter is set to LOW. If a failure, output which is –5% or lower is generated. The parameter **D53: ERROR OUT** is set to LOW from the factory.

• Example: Standard specifications



pin (CN4) position: H

• Example: Optional code/C1



pin (CN4) position: L

F0827.EPS

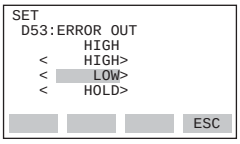
(13) Output Status Setup when a Hardware Error Occurs (D53: ERROR OUT)

This parameter allows the setting of the output status when a hardware error occurs. The following three selections are available.

(a) HOLD; Outputs the last value held before the error occurred.
(b) HIGH; Outputs an output of 110% when an error has occurred.
(c) LOW; Outputs an output of –5% when an error has occurred.

Note: A hardware error means CAP MODULE FAULT of Er.01 or AMP MODULE FAULT of Er. 02 which are shown in 8.5.2 “Errors and Countermeasures.”)

• Example: Set the output status to LOW when a hardware error occurs.



Use the [^] or [v] key to select “LOW.”
Press the [ENTER] key twice to enter the setting.

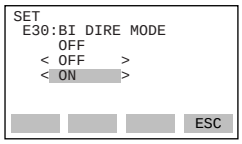
F0828.EPS

(14) Bi-directional Flow Measurement Setup (E30: BI DIRE MODE)

(a) This parameter enables selection of 50% output at an input of 0 kPa.
Procedure is shown in the figure below.

(b) Combining this with **C40: OUTPUT MODE** provides a square root output computed independently for 0% to 50% output and for 50% to 100% output.

• Example: If measurement range is 0 to 10 kPa (LRV=0 kPa, HRV=10 kPa)

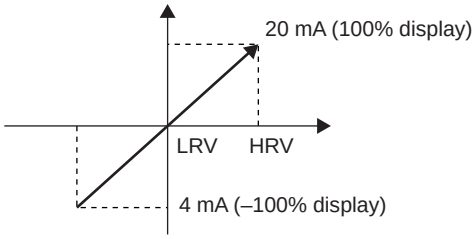


Use the ^ or v key to select "ON."
Press the ENTER key twice to enter the setting.

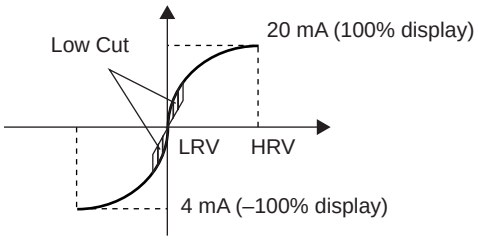
The measurement range changes to –10 to 0 to 10 kPa (output 0% to 50% to 100).
Note that "**C21: LOW RANGE**" and "**C22: HIGH RANGE**" are not changed.

F0829.EPS

● Output mode "LINEAR"



● Output mode "SQUARE ROOT"



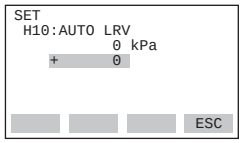
F0830.EPS

(15) Range Change while Applying Actual Inputs (H10: AUTO LRV, H11: AUTO HRV)

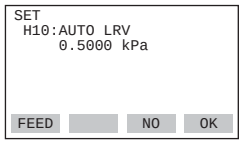
This feature allows the lower and higher range values to be set up automatically with the actual input applied. If the lower and higher range values are set, **C21: LOW RANGE** and **C22: HIGH RANGE** are changed at this same time.

Follow the procedure in the figure below.
The measurement span is determined by the higher and lower range values. Changing the lower range value results in the higher range value changing automatically, keeping the span constant.

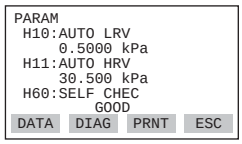
• Example 1: When changing the lower range value to 0.5 kPa for the present setting of 0 to 30 kPa, take the following action with input pressure of 0.5 kPa applied.



Press the ENTER key twice.
The lower range value is changed to 0.5 kPa.



Press the F4 (OK) key.

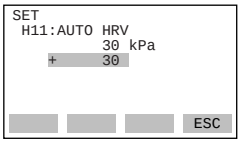


The higher range value is changed keeping the span constant.
Parameters **C21** and **C22** are changed at the same time.

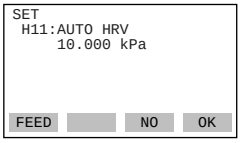
F0831.EPS

Note that changing the higher range value does not cause the lower range value to change but does change the span.

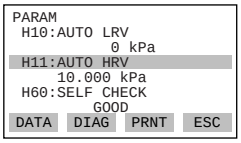
• Example 2: When the higher range value is to be changed to 10 kPa with the present setting of 0 to 30 kPa, take the following action with an input pressure of 10 kPa applied.



Press the ENTER key twice.
The higher range value is changed to 10 kPa.



Press the F4 (OK) key.



The lower range value is not changed, so the span changes.
Parameter **C22** is changed at the same time.

F0832.EPS

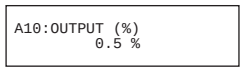
(16) Zero Point Adjustment (J10: ZERO ADJ, J11: ZERO DEV, J20: EXT ZERO ADJ)

The DPharp supports several adjustment methods. Select the method best suited for the conditions of your application.
Note that output signal can be checked by displaying parameter **A10:OUTPUT (%)** on the BT200.

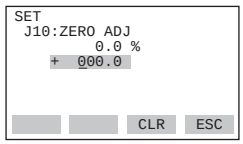
Adjustment Method	Description
Using the BT200	**Set the present input to 0%.** Adjust for 0% output at input level of 0%.
	Adjust output to the reference value obtained using other means. If the input level cannot easily be made 0% (because of tank level, etc.), adjust output to the reference value obtained using other means, such as a sight glass.
Using the external zero-adjustment screw	Adjust zero point using the zero-adjustment screw on the transmitter. This permits zero adjustment without using the BT200. Accurately adjust the output current to 4 mA DC or other target output value using an ammeter that accuratly reads output currents.

T0810.EPS

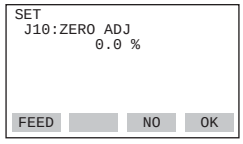
(a) Follow the procedure below when setting the present output to 0% (4 mA).



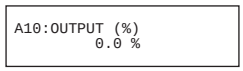
Output is 0.5%.



Press the ENTER key twice.



Zero adjustment is completed.
Press the F4 (OK) key.

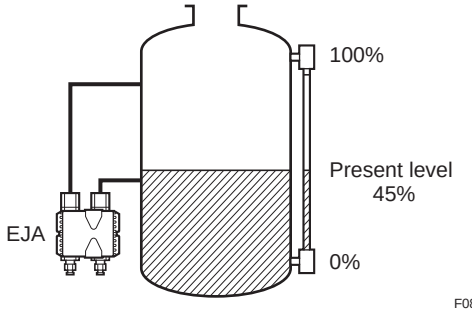


Output is 0%.

F0833.EPS

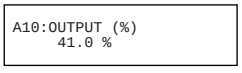
(b) In tank level measurement, if the actual level cannot be brought to zero for zero adjustment, then the output can be adjusted to correspond to the actual level obtained using another measuring instrument such as a glass gauge.

Present level: 45%
Present output: 41%

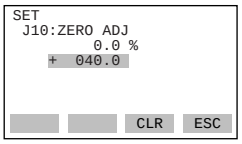


F0834.EPS

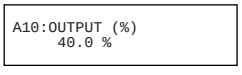
(b)-1 Follow the procedure below to use **J10: ZERO ADJ**.



Present output is 41.0%.



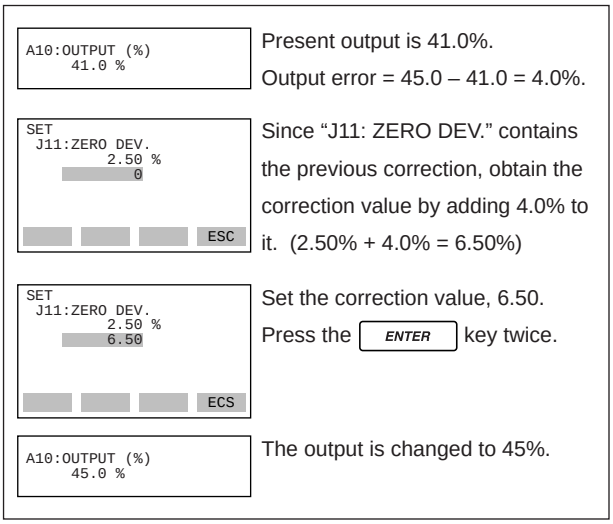
Enter the present actual level, 40%.
Press the ENTER key twice.



The output is changed to 40%.

F0835.EPS

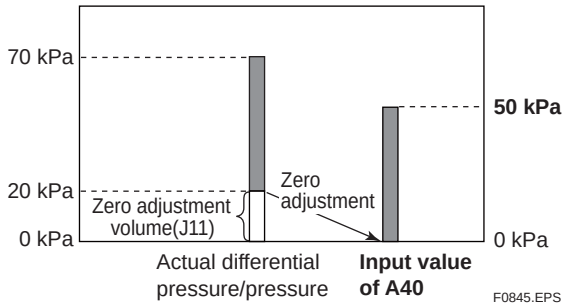
(b)-2 Follow the procedure below to use **J11: ZERO DEV**.



F0836.EPS

When the zero point is adjusted, the displayed value of A40 is as follows.

[Example]
When the zero point is shifted by 20 kPa for the actual pressure, the parameter of A40 indicates 50 kPa.



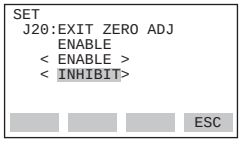
F0845.EPS

(c) Zero Point Adjustment Using the External Zero Adjustment Screw

• Enabling/inhibiting of zero point adjustment using the external zero-adjustment screw on the transmitter (J20: EXT ZERO ADJ)

Follow the procedure below to enable or inhibit zero point adjustment from the zero-adjustment screw on the transmitter.
This is set to "ENABLE" when the instrument is shipped.

• Example: Inhibiting zero adjustment by the external zero-adjustment screw



Use the ^ or v key to select "INHIBIT."
Press the ENTER key twice to enter the setting.

F0837.EPS

• Zero point adjustment using external zero-adjustment screw on the transmitter

Turn the zero-adjustment screw on the outside of the transmitter case using a slotted screwdriver. Turn the screw to the right to increase the zero point or to the left to decrease the zero output; the zero adjusts in increments of 0.01% of the range setting.
Note that the amount of adjustment to the zero point changes according to the speed at which the screw is turned. To make fine adjustments, turn the screw slowly; to make coarse adjustments, turn the screw quickly.

Note: When a zero point adjustment has been made, do not turn off the transmitter less than 30 seconds after adjustment.

(17) Span Adjustment

Each DPharp EJA series transmitter is factory characterized according to the specification. Mounting position effects or zero shifts caused by static pressure are typically compensated by a zero adjustment.

A span adjustment is a function to correct the slope error from a zero point in characterizing 100% point (HRV). This function can be used when span drifts may be caused or characterization to the specific pressure standard is required.

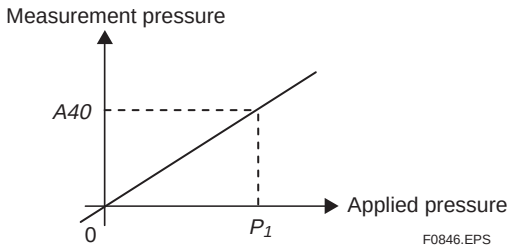
Therefore, the zero point adjustment should always be performed before the upper point adjustment in order to maintain the pitch between zero and 100% points within the calibration range.

You can manually perform the trimming procedure by using J15: SPAN ADJ.

• Span adjustment value
The span adjustment value is calculated as follows.

$$\textit{Span adjustment value}\ (\%) = \frac{P_1 - A40}{P_1} \times 100$$

P_1: Actual differential pressure/pressure value
A40: Input (indicated as the value after zeroing)



F0846.EPS

• Example: For the range of 0 to 30 kPa.
A40: INPUT = 30.15 kPa
J15: SPAN ADJ = 0.15 %

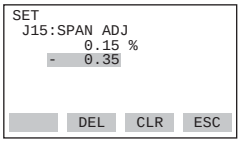
Suppose that a standard pressure of 30 kPa is applied and the value of the parameter of A40: INPUT is 30.15 kPa. Firstly, obtain the slope error for the span as follows;

$$\text{Span adjustment value (\%)} = \frac{P_1 - A40}{P_1} \times 100$$

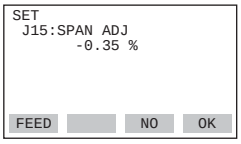
$$= \frac{30.00 - 30.15}{30.00} \times 100 = -0.5\ (\%)$$

Add −0.5% to 0.15% of the current value to calculate the accumulated span adjustment value.

0.15 + (−0.50) = −0.35



Set −**0.35**.
Press ENTER key twice.



Press the F4 (OK) key.

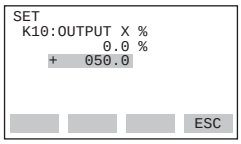
Note: Enter 0.00 to J15: SPAN ADJ to reset the span adjustment to the initial value at the shipment.

F0847.EPS

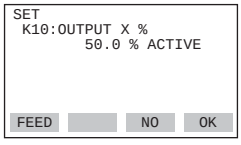
(18) Test Output Setup (K10: OUTPUT X%)

This feature can be used to output a fixed current from 3.2 mA (–5%) to 21.6 mA (110%) for loop checks.

• Example: Output 12 mA (50%) fixed current.



Set “50.0%.”
Press the ENTER key twice to output a fixed current at 50%.



“Active” is displayed while this is being executed.
Press the F4 (OK) key to cancel the fixed current output.

F0838.EPS

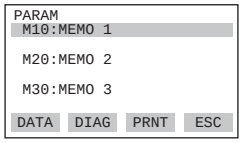
IMPORTANT

1. Test output is held for approximately 10 minutes, and then released automatically after the time has elapsed. Even if the BT200 power supply is turned off or the communication cable is disconnected during test output, it is held for approximately 10 minutes.
2. Press the F4 (OK) key to release test output immediately.

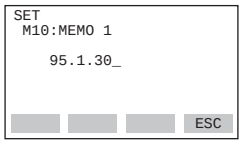
(19) User Memo Fields (M: MEMO)

This feature provides 5 user memo fields, each holding up to 8 alphanumeric characters. Up to 5 items such as inspection date, inspector, and other information can be saved in these fields.

• Example: Save an inspection date of January 30, 1995.



Set “95.1.30” in the order of year, month, and day.
Press the ENTER key twice to enter the setting.



F0839.EPS

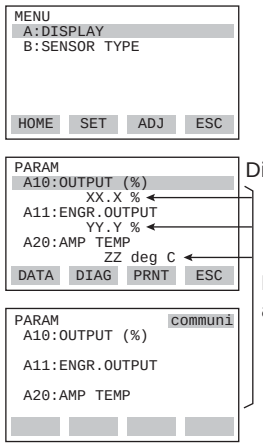
8.4 Displaying Data Using the BT200

8.4.1 Displaying Measured Data

The BT200 can be used to display measured data.

The measured data is updated automatically every 7 seconds. In addition, the display can be updated to the present data value at any time by pressing the F1 (DATA) key. For parameters associated with the display of measured data, see Subsection 8.3.1, "Parameter Summary."

• Example: Display output.



Display "A10: OUTPUT (%)."

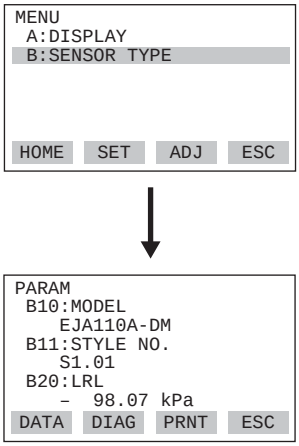
Data is updated automatically at 7-second intervals.

F0840.EPS

8.4.2 Display Transmitter Model and Specifications

The BT200 can be used to display the model and specifications of the transmitter.

• Example: View transmitter model name.



Press ENTER.

For the associated parameters, see Subsection 8.3.1, Parameter Summary.

F0841.EPS

8.5 Self-Diagnostics

8.5.1 Checking for Problems

(1) Identifying Problems with BT200

The following four areas can be checked.

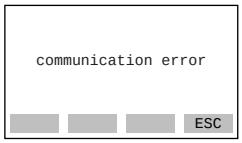
(a) Whether connections are good.
(b) Whether BT200 was properly operated.
(c) Whether settings were properly entered.
(d) History of the errors.

See examples below.

• Example 1: Connection errors

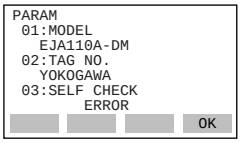


Press the ON/OFF key.
When the panel shown on the left appears, press the ENTER key.

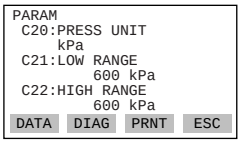


Since communications will be unsuccessful if there is a problem in the connection to the BT200, the display at the left will appear.
Recheck the connection.
Press the F4 (OK) key.

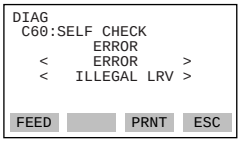
• Example 2: Setting entry errors



The initial data panel shows the result of current transmitter diagnostics.



Press the F2 (DIAG) key in the parameter panel to go to the diagnostics panel (C60: SELF CHECK).



An error message is displayed when an error occurs in the diagnostics panel.

F0842.EPS

• Example 3: Checking the history of the errors

```
MENU
 J:ADJUST
 K:TEST
 M:MEMO
 P:RECORD

HOME  SET  ADJ  ESC
```

Connect the BT200 to the transmitter, and call item “P.”

```
PARAM
 P10:ERROR REC 1
        ERROR
 P11:ERROR REC 2
        ERROR
 P12:ERROR REC 3
        GOOD
DATA  DIAG  PRNT  ESC
```

P10: “ERROR REC 1” displays the last error.
P11: “ERROR REC 2” displays the error one time before the last error occurred.
P12: “ERROR REC 3” displays the error two times before the last error occurred.
P13: “ERROR REC 4” displays the error three times before the last error occurred.

The history of up to four errors can be stored. When the 5th error has occurred, it is stored in “P10”. The error stored in “P13” will be deleted, and then, the error in “P12” will be copied to “P13”. In this sequence, the history of the most previously occurred error will be removed from memory. “GOOD” will be displayed if there was no previous error.

```
SET
 P10:ERROR REC 1
        ERROR
   <     ERROR     >
   <   ILLEGAL LRV >
   <   ILLEGAL HRV >

                ESC
```

Select P10: ERROR REC1 and press the ENTER key to display the error message.

<(a) SETUP PANEL>

For the details of the messages listed below, see Table 8.5.1 Error Message Summary.

CAP MODULE FAULT	OVER TEMP (CAP)	ILLEGAL LRV
AMP MODULE FAULT	OVER TEMP (AMP)	ILLEGAL HRV
OUT OF RANGE	OVER OUTPUT	ILLEGAL SPAN
OUT OF SP RANGE	OVER DISPLAY	ZERO ADJ OVER

Note 1: Press the ENTER key twice in the setting panel (panel 1) to clear all error message (P10 to P13) information.
Note 2: After two hours from when an error occurs, the error message of that error will be recorded. Therefore, if you switch off the transmitter within two hours from when the error occurs, there is no history of that error stored in the transmitter, and this function is meaningless.

F0843.EPS

(2) Checking with Integral Indicator

NOTE

If an error is detected in the self-diagnostic, an error number is displayed on the integral indicator. If there is more than one error, the error number changes at two-second intervals. See Table 8.5.1 regarding the error numbers.



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Figure 8.5.1 Identifying Problems Using the Integral Indicator

8.5.2 Errors and Countermeasures

The table below shows a summary of error messages.

Table 8.5.1 Error Message Summary

Integral Indicator Display	BT200 Display	Cause	Output Operation during Error	Countermeasure
None	GOOD			
----	ERROR			
Er. 01	CAP MODULE FAULT	Capsule problem.*1	Outputs the signal (Hold, High, or Low) set with parameter D53.	Replace the capsule when error keeps appearing even after restart.*2
Er. 02	AMP MODULE FAULT	Amplifier problem.	Outputs the signal (Hold, High, or Low) set with parameter D53.	Replace amplifier.
Er. 03	OUT OF RANGE	Input is outside measurement range limit of capsule.	Outputs high range limit value or low range limit value.	Check input.
Er. 04	OUT OF SP RANGE	Static pressure exceeds specified range.*3	Displays present output.	Check line pressure (static pressure).
Er. 05	OVER TEMP (CAP)	Capsule temperature is outside range (–50 to 130°C).	Displays present output.	Use heat insulation or make lagging to keep temperature within range.
Er. 06	OVER TEMP (AMP)	Amplifier temperature is outside range (–50 to 95°C).	Displays present output.	Use heat insulation or make lagging to keep temperature within range.
Er. 07	OVER OUTPUT	Output is outside high or low range limit value.	Outputs high or low range limit value.	Check input and range setting, and change them as needed.
Er. 08	OVER DISPLAY	Displayed value is outside high or low range limit value.	Displays high or low range limit value.	Check input and display conditions and modify them as needed.
Er. 09	ILLEGAL LRV	LRV is outside setting range.	Holds output immediately before error occurrence.	Check LRV and modify as needed.
Er. 10	ILLEGAL HRV	HRV is outside setting range.	Holds output immediately before error occurrence.	Check HRV and modify as needed.
Er. 11	ILLEGAL SPAN	SPAN is outside setting range.	Holds output immediately before error occurrence.	Check SPAN and change as needed.
Er. 12	ZERO ADJ OVER	Zero adjustment is too large.	Displays present output.	Readjust zero point.

*1: This error code appears at a capsule problem or when an illegal overpressure is applied to the pressure sensor.

*2: If the normal pressure is regained, the Er.01 will disappear according to the setting of the parameter of **E50: AUTO RECOVER**. When the **E50: AUTO RECOVER** is set to **ON**(defalut setting), the Er.01 will disappear automatically. When the **E50: AUTO RECOVER** is set to **OFF**, restart the transmitter to cancel Er.01. If no error code appears then, perform necessary adjustment such as zero-adjustment to continue the operation. If the error code still exists, replace the capsule assembly.

*3: For Model EJA120A, static pressure cannot be measured. The display is always 0 MPa, but this is not a measured value.

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9. MAINTENANCE

9.1 Overview

WARNING

Since the accumulated process fluid may be toxic or otherwise harmful, take appropriate care to avoid contact with the body, or inhalation of vapors during draining condensate or venting gas in transmitter pressure-detector section and even after dismounting the instrument from the process line for maintenance.

Maintenance of the transmitter is easy due to its modular construction. This chapter describes the procedures for calibration, adjustment, and the disassembly and reassembly procedures required for component replacement.

Since the transmitters are precision instruments, carefully and thoroughly read the following sections for proper handling during maintenance.

IMPORTANT

- As a rule, maintenance of this transmitter should be implemented in a maintenance service shop where the necessary tools are provided.
- The CPU assembly contains sensitive parts that may be damaged by static electricity. Exercise care so as not to directly touch the electronic parts or circuit patterns on the board, for example, by preventing static electrification by using grounded wrist straps when handling the assembly. Also take precautions such as placing a removed CPU assembly into a bag with an antistatic coating.

9.2 Calibration Instruments Selection

Table 9.2.1 shows the instruments required for calibration. Select instruments that will enable the transmitter to be calibrated or adjusted to the required accuracy.

The calibration instruments should be handled carefully so as to maintain the specified accuracy.

9.3 Calibration

Use the procedure below to check instrument operation and accuracy during periodic maintenance or trouble-shooting.

1) Connect the instruments as shown in Figure 9.3.1 and warm up the instruments for at least five minutes.

IMPORTANT

- To adjust the transmitter for highest accuracy, make adjustments with the power supply voltage and load resistance including leadwire resistances set close to the conditions under which the transmitter is installed.
- If the measurement range 0% point is 0 kPa or shifted in the positive direction (suppressed zero), the reference pressure should be applied as shown in the figure.
  If the measurement range 0% point is shifted in the negative direction (elevated zero), the reference pressure should be applied using a vacuumpump.
- Do not perform the calibration procedures until the transmitter is at room temperature.

2) Apply reference pressures of 0%, 50%, and 100% of the measurement range to the transmitter. Calculate the errors (differences between digital voltmeter readings and reference pressures) as the pressure is increased from 0% to 100% and is decreased from 100% to 0%, and confirm that the errors are within the required accuracy.

Table 9.2.1 Instruments Required for Calibration

Name	Yokogawa-recommended Instrument	Remarks
Power supply	Model SDBT or SDBS distributor	4 to 20 mA DC signal
Load resistor	Model 2792 standard resistor [250 Ω ±0.005%, 3 W]	
	Load adjustment resistor [100 Ω ±1%, 1 W]	
Voltmeter	Model 2501 A digital multimeter Accuracy (10V DC range): ±(0.002% of rdg + 1 dgt)	
Digital manometer	Model MT220 precision digital manometer 1) For 10 kPa class Accuracy: ±(0.015% of rdg + 0.015% of F.S.) . . . . . for 0 to 10 kPa ±(0.2% of rdg + 0.1% of F.S.) . . . . . for -10 to 0 kPa 2) For 130 kPa class Accuracy: ±0.02% of rdg . . . . . for 25 to 130 kPa ±5digits . . . . . for 0 to 25 kPa ±(0.2% of rdg + 0.1% of F.S.) . . . . . for -80 to 0 kPa 3) For 700 kPa class Accuracy: ±(0.02% of rdg + 3digits) . . . . . for 100 to 700 kPa ±5 digits . . . . . for 0 to 100 kPa ±(0.2% of rdg + 0.1% of F.S.) . . . . . for -80 to 0 kPa 4) For 3000 kPa class Accuracy: ±(0.02% of rdg + 10 digits) . . . . . for 0 to 3000 kPa ±(0.2% of rdg + 0.1% of F.S.) . . . . . for -80 to 0 kPa 5) For 130 kPa abs class Accuracy: ±(0.03% of rdg + 6 digits) . . . . . for 0 to 130 kPa abs	Select a manometer having a pressure range close to that of the transmitter.
Pressure generator	Model 7674 pneumatic pressure standard for 200 kPa {2 kgf/cm^2}, 25 kPa {2500 mmH_2O} Accuracy: ±0.05% of F.S.	Requires air pressure supply.
	Dead weight gauge tester 25 kPa {2500mmH_2O} Accuracy: ±0.03% of setting	Select the one having a pressure range close to that of the transmitter.
Pressure source	Model 6919 pressure regulator (pressure pump) Pressure range: 0 to 133 kPa {1000 mmHg}	Prepare the vacuum pump for negative pressure ranges.

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Note: The above table contains the instruments capable of performing calibration to the 0.2% level. Since special maintenance and management procedures involving traceability of each instrument to higher-level standards are required for calibration to the 0.1% level, there are difficulties in calibration to this level in the field. For calibration to the 0.1% level, contact Yokogawa representatives from which the instrument was purchased or the nearest Yokogawa office.

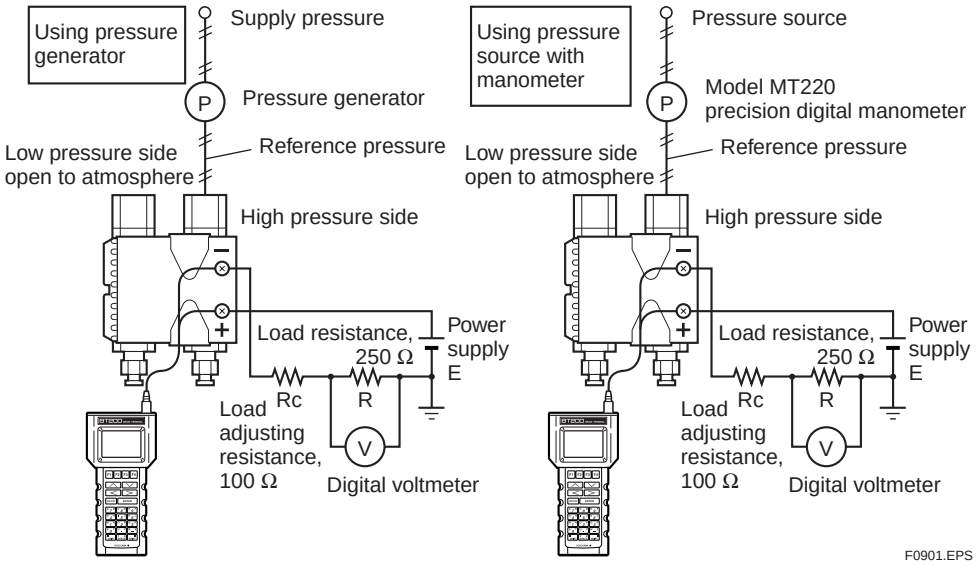


Figure 9.3.1 Instrument Connections

9.4 Disassembly and Reassembly

This section describes procedures for disassembly and reassembly for maintenance and component replacement.

Always turn OFF power and shut off and release pressures before disassembly. Use proper tools for all operations. Table 9.4.1 shows the tools required.

Table 9.4.1 Tools for Disassembly and Reassembly

Tool	Quantity	Remarks
Phillips screwdriver	1	JIS B4633, No. 2
Slotted screwdriver	1	
Allen wrenches	2	JIS B4648 One each, nominal 3 and 5 mm Allen wrenches
Wrench	1	Width across flats, 17 mm
Torque wrench	1	
Adjustable wrench	1	
Socket wrench	1	Width across flats, 16 mm
Socket driver	1	Width across flats, 5.5 mm
Tweezers	1	

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CAUTION

Precautions for CENELEC and IECEx Flameproof Type Transmitters

- Flameproof type transmitters must be, as a rule, removed to a non-hazardous area for maintenance and be disassembled and reassembled to the original state.
- On the flameproof type transmitters the two covers are locked, each by an Allen head bolt (shrouding bolt). When a shrouding bolt is driven clockwise by an Allen wrench, it is going in and cover lock is released, and then the cover can be opened.

When a cover is closed it should be locked by a shrouding bolt without fail. Tighten the shrouding bolt to a torque of 0.7 N·m.

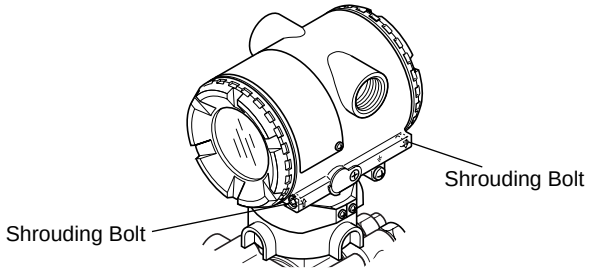


Figure 9.4 Shrouding Bolts

9.4.1 Replacing the Integral Indicator

CAUTION

Cautions for Flameproof Type Transmitters

Users are prohibited by law from modifying the construction of a flameproof type transmitter. This would invalidate the agency approval and the transmitter's use in such rated area.
Thus the user is prohibited from using a flameproof type transmitter with its integral indicator removed, or from adding an integral indicator to a transmitter. If such modification is absolutely required, contact Yokogawa.

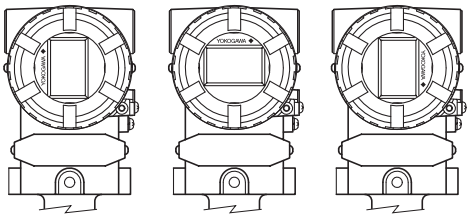
This subsection describes the procedure for replacing an integral indicator. (See Figure 9.4.2)

■ Removing the Integral Indicator

1) Remove the cover.
2) Supporting the integral indicator by hand, loosen its two mounting screws.
3) Dismount the LCD board assembly from the CPU assembly.
   When doing this, carefully pull the LCD board assembly straight forward so as not to damage the connector pins between it and the CPU assembly.

■ Attaching the Integral Indicator

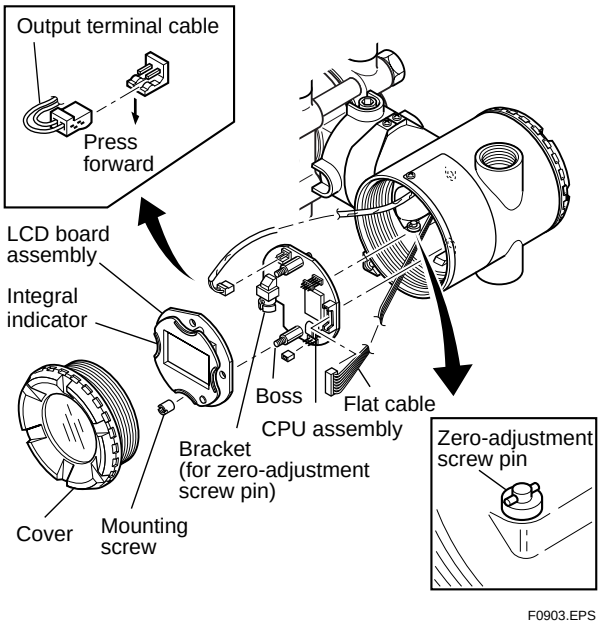
Integral indicator can be installed in the following three directions.



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Figure 9.4.1 Installation Direction of Indicator

1) Align both the LCD board assembly and CPU assembly connectors and engage them.
2) Insert and tighten the two mounting screws.
3) Replace the cover.



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Figure 9.4.2 Removing and Attaching LCD Board Assembly and CPU Assembly

9.4.2 Replacing the CPU Board Assembly

This subsection describes the procedure for replacing the CPU assembly. (See Figure 9.4.2)

■ Removing the CPU Assembly

1) Remove the cover. If an integral indicator is mounted, refer to Subsection 9.4.1 and remove the indicator.
2) Turn the zero-adjustment screw to the position (where the screw head slot is horizontal) as shown in Figure 9.4.2.
3) Disconnect the output terminal cable (cable with brown connector at the end). When doing this, lightly press the side of the CPU assembly connector and pull the cable connector to disengage.
4) Use a socket driver (width across flats, 5.5mm) to loosen the two bosses.
5) Carefully pull the CPU assembly straight forward to remove it.
6) Disconnect the flat cable (cable with black connector at the end) that connects the CPU assembly and the capsule.

NOTE

Be careful not to apply excessive force to the CPU assembly when removing it.

■ Mounting the CPU Assembly

1) Connect the flat cable (with black connector) between the CPU assembly and the capsule.
2) Connect the output terminal cable (with brown connector).

NOTE

Make certain that the cables are free of pinching between the case and the CPU assembly edge.

3) Align and engage the zero-adjustment screw pin with the groove on the bracket on the CPU assembly. Then insert the CPU board assembly straight onto the post in the amplifier case.
4) Tighten the two bosses. If the transmitter is equipped with an integral indicator, refer to Subsection 9.4.1 to mount the indicator.

NOTE

Confirm that the zero-adjustment screw pin is placed properly in the groove on the bracket prior to tightening the two bosses. If it is not, the zero-adjustment mechanism will be damaged.

5) Replace the cover.

9.4.3 Cleaning and Replacing the Capsule Assembly

This subsection describes the procedures for cleaning and replacing the capsule assembly. (See Figure 9.4.3.)

CAUTION

Cautions for Flameproof Type Transmitters
Users are prohibited by law from modifying the construction of a flameproof type transmitter. If you wish to replace the capsule assembly with one of a different measurement range, contact Yokogawa.
The user is permitted, however, to replace a capsule assembly with another of the same measurement range. When doing so, be sure to observe the following.

- The replacement capsule assembly must have the same part number as the one being replaced.
- The section connecting the transmitter and capsule assembly is a critical element in preservation of flameproof performance, and must be checked to verify that it is free of dents, scratches, and other defects.
- After completing maintenance, be sure to securely tighten the Allen screws that fasten the transmitter section and pressure-detector section together.

■ Removing the Capsule Assembly

IMPORTANT

Exercise care as follows when cleaning the capsule assembly.

- Handle the capsule assembly with care, and be especially careful not to damage or distort the diaphragms that contact the process fluid.
- Do not use a chlorinated or acidic solution for cleaning.
- Rinse thoroughly with clean water and dry thoroughly after cleaning.

1) Remove the CPU assembly as shown in Subsection 9.4.2.
2) Remove the two Allen screws that connect the transmitter section and pressure-detector section.
3) Separate the transmitter section and pressure-detector section.
4) Remove the nuts from the four flange bolts.
5) Hold the capsule assembly by hand and remove the cover flange.
6) Remove the capsule assembly.
7) Clean the capsule assembly or replace with a new one.

■ Reassembling the Capsule Assembly

1) Insert the capsule assembly between the flange bolts, paying close attention to the relative positions of the H (high pressure side) and L (low pressure side) marks on the capsule assembly.
   Replace the two capsule gaskets with new gaskets.
2) Install the cover flange on the high pressure side, and use a torque wrench to tighten the four nuts uniformly to a torque shown below.

Model	EJA110A	EJA120A	EJA130A
Torque(N·m) {kgf·m}	39{4}		147 {15}

3) After the pressure-detector section has been reassembled, a leak test must be performed to verify that there are no pressure leaks.
4) Reattach the transmitter section to the pressure-detector section.
5) Tighten the two Allen screws. (Tighten the screws to a torque of 5 N·m)
6) Install the CPU assembly according to Subsection 9.4.2.
7) After completing reassembly, adjust the zero point and recheck the parameters.

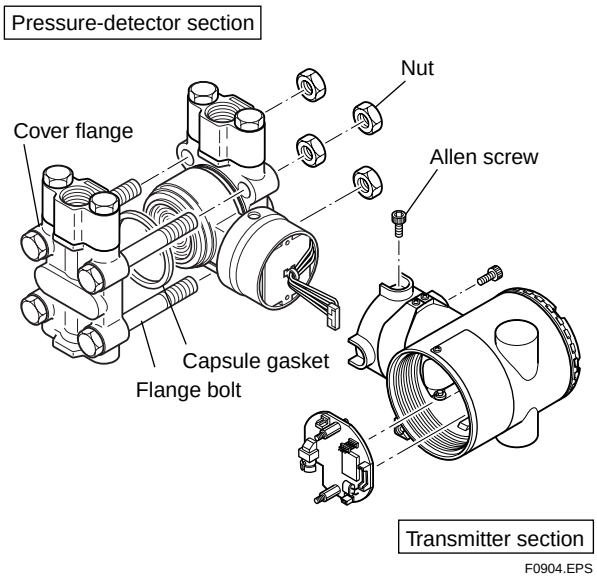


Figure 9.4.3 Removing and Mounting the Pressure-detector Section

9.4.4 Replacing the Process Connector Gaskets

This subsection describes process connector gasket replacement. (See Figure 9.4.4.)

(a) Loosen the two bolts, and remove the process connectors.
(b) Replace the process connector gaskets.
(c) Remount the process connectors. Tighten the bolts securely and uniformly to a torque of 39 to 49 N·m {4 to 5 kgf·m}, and verify that there are no pressure leaks.

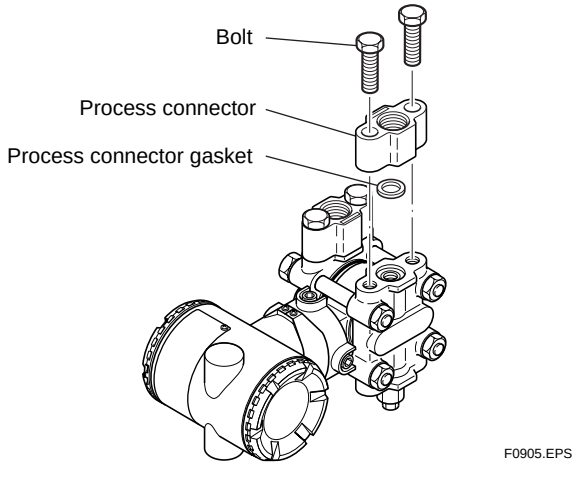


Figure 9.4.4 Removing and Mounting the Process Connector

9.5 Troubleshooting

If any abnormality appears in the measured values, use the troubleshooting flow chart below to isolate and remedy the problem. Since some problems have complex causes, these flow charts may not identify all. If you have difficulty isolating or correcting a problem, contact Yokogawa service personnel.

9.5.1 Basic Troubleshooting

First determine whether the process variable is actually abnormal or a problem exists in the measurement system.

If the problem is in the measurement system, isolate the problem and decide what corrective action to take.

This transmitter is equipped with a self-diagnostic function which will be useful in troubleshooting; see Section 8.5 for information on using this function.

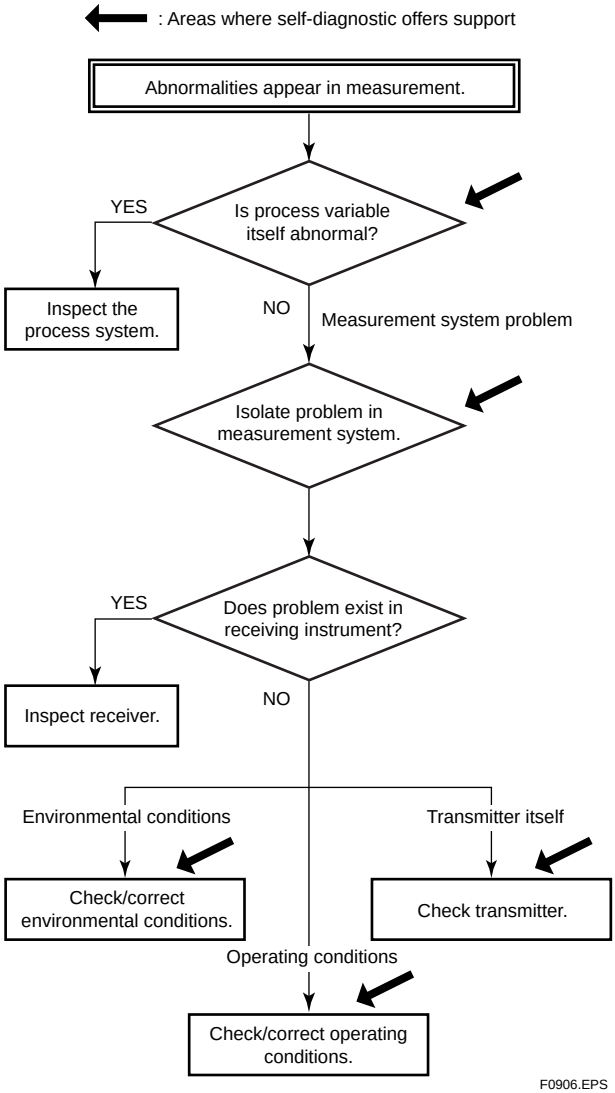
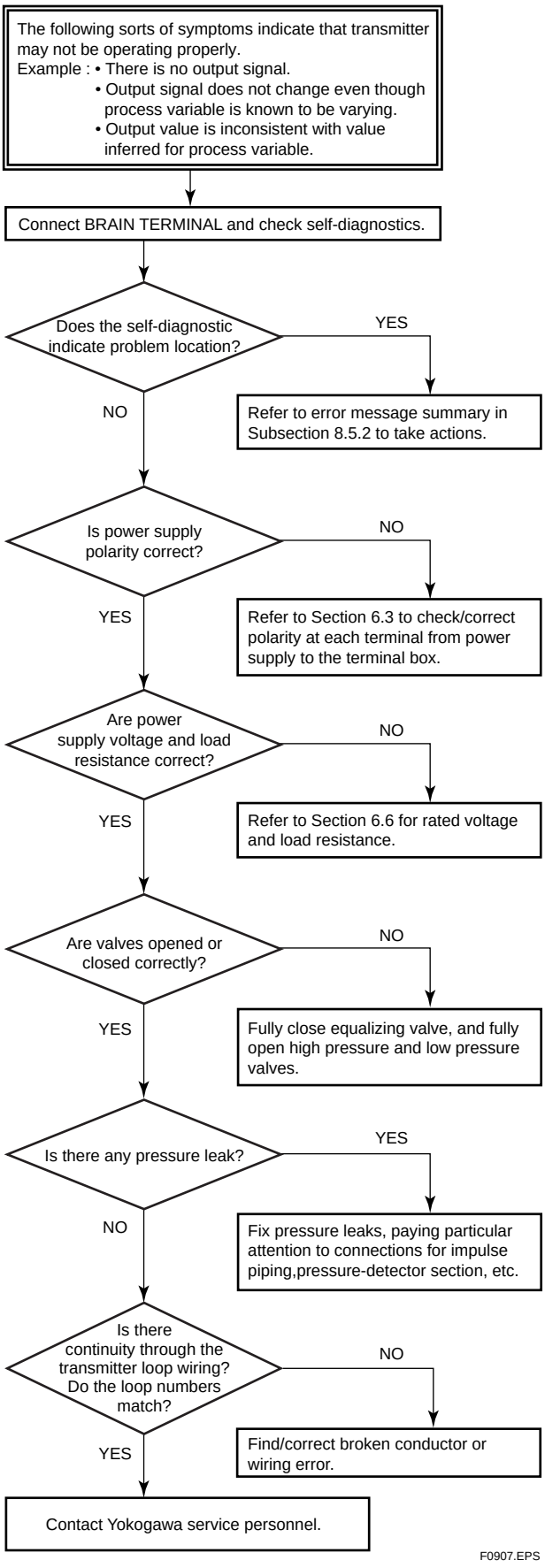
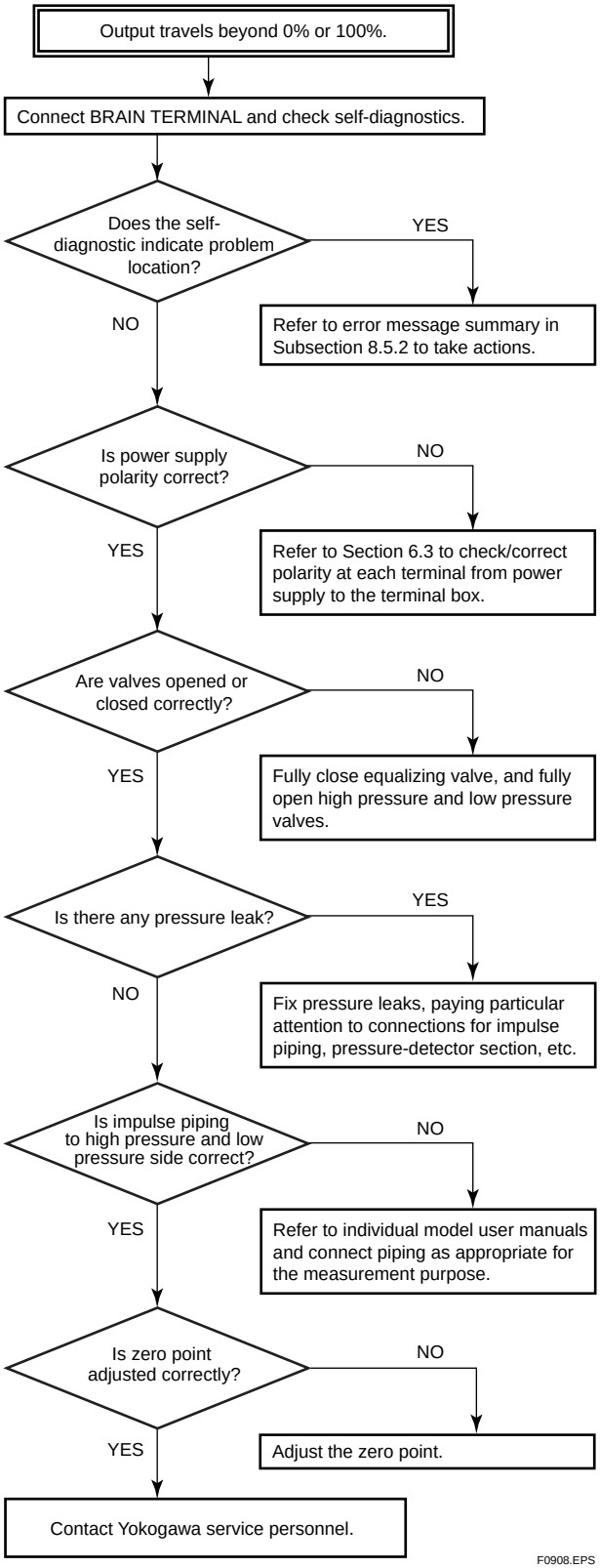
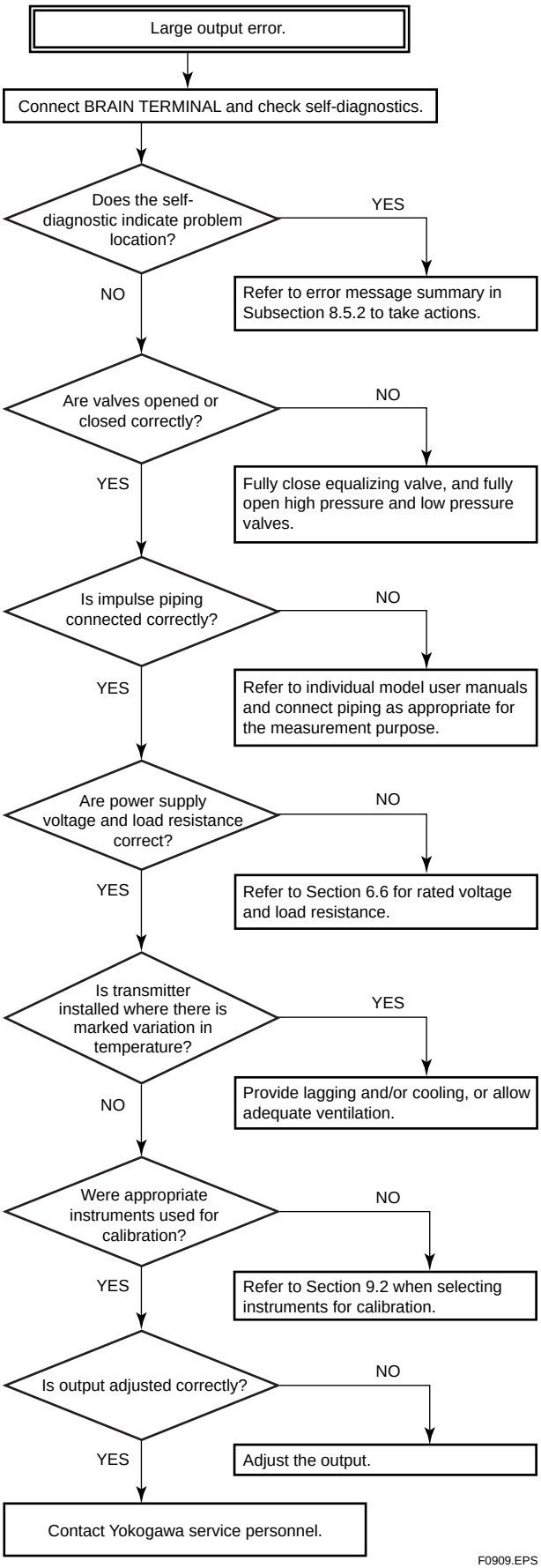


Figure 9.5.1 Basic Flow and Self-Diagnostics

9.5.2 Troubleshooting Flow Charts






Large output error.
Connect BRAIN TERMINAL and check self-diagnostics.
Does the self-diagnostic indicate problem location?
YES
Refer to error message summary in Subsection 8.5.2 to take actions.
NO
Are valves opened or closed correctly?
NO
Fully close equalizing valve, and fully open high pressure and low pressure valves.
YES
Is impulse piping connected correctly?
NO
Refer to individual model user manuals and connect piping as appropriate for the measurement purpose.
YES
Are power supply voltage and load resistance correct?
NO
Refer to Section 6.6 for rated voltage and load resistance.
YES
Is transmitter installed where there is marked variation in temperature?
YES
Provide lagging and/or cooling, or allow adequate ventilation.
NO
Were appropriate instruments used for calibration?
NO
Refer to Section 9.2 when selecting instruments for calibration.
YES
Is output adjusted correctly?
NO
Adjust the output.
YES
Contact Yokogawa service personnel.
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10. GENERAL SPECIFICATIONS

10.1 Standard Specifications

Refer to IM 01C22T02-01E for FOUNDATION Fieldbus communication type and IM 01C22T03-00E for PROFIBUS PA communication type marked with "◇".

● Performance Specifications

See General Specifications sheet, GS 01C21B01-00E, GS 01C21B03-00E, and GS 01C21B04-00E.

● Functional Specifications

Span & Range Limits

EJA110A and EJA130A:

Measurement Span and Range		kPa	inH_2O (/D1)	mbar (/D3)	mmH_2O (/D4)
L	Span	0.5 to 10	2 to 40	5 to 100	50 to 1000
	Range	–10 to 10	–40 to 40	–100 to 100	–1000 to 1000
M	Span	1 to 100	4 to 400	10 to 1000	100 to 10000
	Range	–100 to 100	–400 to 400	–1000 to 1000	–10000 to 10000
H	Span	5 to 500	20 to 2000	50 to 5000	0.05 to 5 kgf/cm^2
	Range	–500 to 500	–2000 to 2000	–5000 to 5000	–5 to 5 kgf/cm^2
V*	Span	0.14 to 14 MPa	20 to 2000 psi	1.4 to 140 bar	1.4 to 140 kgf/cm^2
	Range	–0.5 to 14 MPa	–71 to 2000 psi	–5 to 140 bar	–5 to 140 kgf/cm^2

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* For Wetted parts material code other than S, the ranges are 0 to 14 MPa, 0 to 2000 psi, 0 to 140 bar, and 0 to 140 kgf/cm^2.

EJA120A:

Measurement Span and Range		kPa	inH_2O (/D1)	mbar (/D3)	mmH_2O (/D4)
E	Span	0.1 to 1	0.4 to 4	1 to 10	10 to 100
	Range	–1 to 1	–4 to 4	–10 to 10	–100 to 100

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URL is define as the Upper Range Limit from the table above.

Zero Adjustment Limits:

Zero can be fully elevated or suppressed, within the Lower and Upper Range Limits of the capsule.

External Zero Adjustment "◇":

External zero is continuously adjustable with 0.01% incremental resolution of span. Span may be adjusted locally using the digital indicator with range switch.

Output "◇":

Two wire 4 to 20 mA DC output with digital communications, linear or square root programmable. BRAIN or HART FSK protocol are superimposed on the 4 to 20 mA signal.

Failure Alarm:

Output status at CPU failure and hardware error;
Up-scale: 110%, 21.6 mA DC or more(standard)
Down-scale: -5%, 3.2 mA DC or less
-2.5%, 3.6 mA DC or less(Optional code /F1)

Note: Applicable for Output signal code D and E

Damping Time Constant (1st order):

The sum of the amplifier and capsule damping time constant must be used for the overall time constant. Amp damping time constant is adjustable from 0.2 to 64 seconds.

Capsule (Silicone Oil)	L	M	H	V	E
Time Constant (approx. sec)	0.4	0.3	0.3	0.3	0.2

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Ambient Temperature Limits:

* Safety approval codes may affect limits.
EJA110A, EJA130A
–40 to 85°C (–40 to 185°F)
–30 to 80°C (–22 to 176°F) with LCD Display
EJA120A
–25 to 80°C (–13 to 176°F)

Process Temperature Limits:

* Safety approval codes may affect limits.
EJA110A, EJA130A
–40 to 120°C (–40 to 248°F)
EJA120A
–25 to 80°C (–13 to 176°F)

Maximum Overpressure:

See General Specifications sheet.

Working Pressure Limits (Silicone Oil)

Maximum Pressure Limit:

See 'Model and Suffix Codes'

Minimum Pressure Limit:

Capsule	Pressure
L, M, H (EJA110A)	See Figure 1.
M, H (EJA130A)	See Figure 1.
E (EJA120A)	–50 kPa {–7.25 psig}

● Installation

Supply & Load Requirements "◇":

* Safety approvals can affect electrical requirements. See Section 6.6, 'Power Supply Voltage and Load Resistance.'

Supply Voltage "◇":

10.5 to 42 V DC for general use and flameproof type
10.5 to 32 V DC for lightning protector (Optional code /A)
10.5 to 30 V DC for intrinsically safe, Type n, nonincendive, or non-sparking type
Minimum voltage limited at 16.4 V DC for digital communications, BRAIN and HART

EMC Conformity Standards"◇": CE , N200

EN61326-1 Class A, Table 2 (For use in industrial lications)
EN61326-2-3

Communication Requirements "◇":

BRAIN

Communication Distance;

Up to 2 km (1.25 miles) when using CEV polyethylene-insulated PVC-sheathed cables.
Communication distance varies depending on type of cable used.

Load Capacitance;

0.22 μF or less (see note)

Load Inductance;

3.3 mH or less (see note)

Input Impedance of communicating device;

10 kΩ or more at 2.4 kHz.

Note: For general-use and Flameproof type. For Intrinsically safe type, please refer to 'Optional Specifications.'

HART

Communication Distance;

Up to 1.5 km (1 mile) when using multiple twisted pair cables. Communication distance varies depending on type of cable used.
Use the following formula to determine cable length for specific applications:

$$L = \frac{65 \times 10^6}{R \times C} - \frac{(C_f + 10{,}000)}{C}$$

Where:
L = length in meters or feet
R = resistance in Ω (including barrier resistance)
C = cable capacitance in pF/m or pF/ft
C_f = maximum shunt capacitance of receiving devices in pF/m or pF/ft

● Physical Specifications

Wetted Parts Materials:

Diaphragm, Cover flange, Process connector and Drain/Vent Plug;

See 'Model and Suffix Codes'

Capsule Gasket;

Teflon-coated SUS316L

Process Connector Gasket;

PTFE Teflon (EJA110A and EJA120A)
Fluorinated Rubber (EJA110A and EJA120A with Optional code /N2 and /N3 and EJA130A with Process connection code 3 and 4)
Glass reinforced Teflon (EJA130A with Process connection code 1 and 2)

Non-wetted Parts Materials:

Bolting;

SCM435, SUS630, or SUH660

Housing;

Low copper cast-aluminum alloy with polyurethane paint (Munsell 0.6GY3.1/2.0)

Degrees of Protection

IP67, NEMA4X, JIS C0920 immersion proof

Cover O-rings;

Buna-N

Data plate and tag;

SUS304 or SUS316(optional)

Fill Fluid;

Silicone or Fluorinated oil (optional)

Weight:

3.9 kg (8.6 lb) without mounting bracket or process connector (EJA110A)

Connections:

Refer to the 'Model and Suffix Codes' to specify the process and electrical connection type.

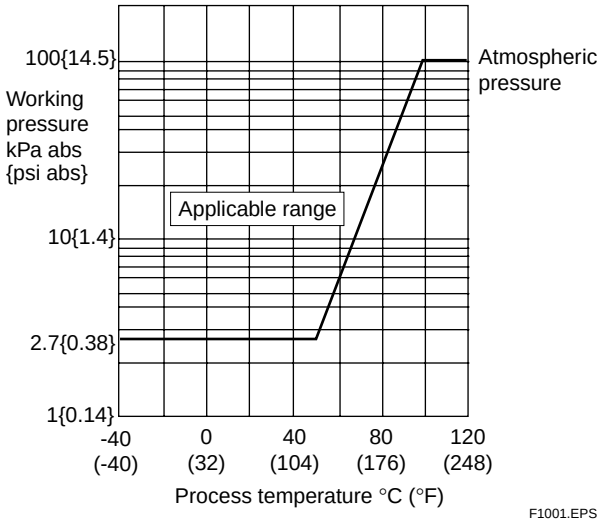
< Settings When Shipped > "◇"

Tag Number	As specified in order *1
Output Mode	'Linear' unless otherwise specified in order
Display Mode	'Linear' unless otherwise specified in order
Operation Mode	'Normal' unless otherwise specified in order
Damping Time Constant *2	'2 sec.'
Calibration Range Lower Range Value	As specified in order
Calibration Range Higher Range Value	As specified in order
Calibration Range Units	Selected from mmH_2O, mmAq, mmWG, mmHg, Pa, hPa, kPa, MPa, mbar, bar, gf/cm^2, kgf/cm^2, inH_2O, inHg, ftH_2O, or psi. (Only one unit can be specified)

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*1: Up to 16 alphanumeric characters (including - and ·) will be entered in the amplifier memory.

*2: If using square root output, set damping time constant to 2 sec. or more.



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Figure 1. Working Pressure and Process Temperature

10.2 Model and Suffix Codes

● Model EJA110A

Model	Suffix Codes	Description		
EJA110A		Differential pressure transmitter		
Output Signal	**-D**	4 to 20 mA DC with digital communication (BRAIN protocol)		
	-E	4 to 20 mA DC with digital communication (HART protocol, see IM 01C22T01-01E)		
	-F	Digital communication (FOUNDATION Fieldbus protocol, see IM 01C22T02-01E)		
	-G	Digital communication (PROFIBUS PA protocol, see IM 01C22T03-00E)		
Measurement span(capsule)	**L**	0.5 to 10 kPa {50 to 1000 mmH_2O}		
	M	1 to 100 kPa {100 to 10000 mmH_2O}		
	H	5 to 500 kPa {0.05 to 5 kgf/cm^2}		
	V	0.14 to 14 MPa {1.4 to 140 kgf/cm^2}		
Wetted parts material		[Body] (Note 3)	[Capsule]	[Vent plug]
	S	SCS14A	SUS316L (Note 1)	SUS316
	H	SCS14A	Hastelloy C-276 (Note 2)	SUS316
	M	SCS14A	Monel (Note 3)	SUS316
	T	SCS14A	Tantalum (Note 3)	SUS316
	A	Hastelloy C-276 equiv. (Note 4)	Hastelloy C-276 (Note 2)	Hastelloy C-276
	D	Hastelloy C-276 equiv. (Note 4)	Tantalum (Note 2)	Hastelloy C-276
	B	Monel equivalent (Note 5)	Monel	Monel
Process connections	**0**	without process connector (Rc1/4 female on the cover flanges)		
	1	with Rc1/4 female process connector		
	2	with Rc1/2 female process connector		
	3	with 1/4 NPT female process connector		
	4	with 1/2 NPT female process connector		
	5	without process connector (1/4 NPT female on the cover flanges)		
Bolts and nuts material			[Maximum working pressure]	
	A	SCM435	16 MPa {160 kgf/cm^2}(Note 6)	
	B	SUS630	16 MPa {160 kgf/cm^2}(Note 6)	
	C	SUH660	16 MPa {160 kgf/cm^2}(Note 6)	
Installation	**-2**	Vertical impulse piping type, right side high pressure, process connector upside		
	-3	Vertical impulse piping type, right side high pressure, process connector downside		
	-6	Vertical impulse piping type, left side high pressure, process connector upside		
	-7	Vertical impulse piping type, left side high pressure, process connector downside		
	-8	Horizontal impulse piping type, right side high pressure		
	-9	Horizontal impulse piping type, left side high pressure		
Electrical connection	**0**	G1/2 female, one electrical connection		
	2	1/2 NPT female, two electrical connections without blind plug		
	3	Pg 13.5 female, two electrical connections without blind plug		
	4	M20 female, two electrical connections without blind plug		
	5	G1/2 female, two electrical connections and a blind plug		
	7	1/2 NPT female, two electrical connections and a blind plug		
	8	Pg 13.5 female, two electrical connections and a blind plug		
	9	M20 female, two electrical connections and a blind plug		
	A	G1/2 female, two electrical connections and a SUS316 blind plug		
	C	1/2 NPT female, two electrical connections and a SUS316 blind plug		
	D	M20 female, two electrical connections and a SUS316 blind plug		
Integral indicator	**D**	Digital indicator		
	E	Digital indicator with the range setting switch		
	N	(None)		
Mounting bracket	**A**	SECC Carbon steel	2-inch pipe mounting (flat type)	
	B	SUS304	2-inch pipe mounting (flat type)	
	J	SUS316	2-inch pipe mounting (flat type)	
	C	SECC Carbon steel	2-inch pipe mounting (L type)	
	D	SUS304	2-inch pipe mounting (L type)	
	K	SUS316	2-inch pipe mounting (L type)	
	N	(None)		
Optional codes		/□ Optional specification		

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Example: EJA110A-DMS5A-92NN/□

Note 1: Diaphragm; Hastelloy C-276. Other wetted parts materials; SUS316L

Note 2: Diaphragm and other wetted parts.

Note 3: Body; Material of cover flanges and process connectors.

Note 4: Indicated material is equivalent to ASTM CW-12MW.

Note 5: Indicated material is equivalent to ASTM M35-2.

Note 6: For Capsule code L when combined with Wetted parts material code H, M, T, A, D, and B, the maximum working pressure is 3.5 MPa{35 kgf/cm^2}.

● Model EJA120A

Model	Suffix Codes	Description
EJA120A	·····	Differential pressure transmitter (for draft application)
Output Signal	**-D** ·····	4 to 20 mA DC with digital communication (BRAIN protocol)
	-E ····· (Note 1)	4 to 20 mA DC with digital communication (HART protocol)
	-F ····· (Note 4)	Digital communication (FOUNDATION Fieldbus protocol)
	-G ····· (Note 5)	Digital communication (PROFIBUS PA protocol)
Measurement span (capsule)	**E** ·····	0.1 to 1 kPa {10 to 100 mmH_2O}
Wetted parts material	**S** ·····	[Body] (Note 3) SCS14A; [Capsule] SUS316L (Note 2); [Vent plug] SUS316
Process connections	**0** ·····	without process connector (Rc1/4 female on the cover flanges)
	1 ·····	with Rc1/4 female process connector
	2 ·····	with Rc1/2 female process connector
	3 ·····	with 1/4 NPT female process connector
	4 ·····	with 1/2 NPT female process connector
	5 ·····	without process connector (1/4 NPT female on the cover flanges)
Bolts and nuts material		[Maximum working pressure]
	A ·····	SCM435 50 kPa {0.5 kgf/cm^2}
	B ·····	SUS630 50 kPa {0.5 kgf/cm^2}
	C ·····	SUH660 50 kPa {0.5 kgf/cm^2}
Installation	**-2** ·····	Vertical impulse piping type, right side high pressure, process connector upside
	-3 ·····	Vertical impulse piping type, right side high pressure, process connector downside
	-6 ·····	Vertical impulse piping type, left side high pressure, process connector upside
	-7 ·····	Vertical impulse piping type, left side high pressure, process connector downside
	-8 ·····	Horizontal impulse piping type, right side high pressure
	-9 ·····	Horizontal impulse piping type, left side high pressure
Electrical connection	**0** ·····	G1/2 female, one electrical connection
	2 ·····	1/2 NPT female, two electrical connections without blind plug
	3 ·····	Pg 13.5 female, two electrical connections without blind plug
	4 ·····	M20 female, two electrical connections without blind plug
	5 ·····	G1/2 female, two electrical connections and a blind plug
	7 ·····	1/2 NPT female, two electrical connections and a blind plug
	8 ·····	Pg 13.5 female, two electrical connections and a blind plug
	9 ·····	M20 female, two electrical connections and a blind plug
	A ·····	G1/2 female, two electrical connections and a SUS316 blind plug
	C ·····	1/2 NPT female, two electrical connections and a SUS316 blind plug
	D ·····	M20 female, two electrical connections and a SUS316 blind plug
Integral indicator	**D** ·····	Digital indicator
	E ·····	Digital indicator with the range setting switch
	N ·····	(None)
Mounting bracket	**A** ·····	SECC Carbon steel 2-inch pipe mounting (flat type)
	B ·····	SUS304 2-inch pipe mounting (flat type)
	J ·····	SUS316 2-inch pipe mounting (flat type)
	C ·····	SECC Carbon steel 2-inch pipe mounting (L type)
	D ·····	SUS304 2-inch pipe mounting (L type)
	K ·····	SUS316 2-inch pipe mounting (L type)
	N ·····	(None)
Optional codes		/□ Optional specification

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Example: EJA120A-DES5A-92NN/□

Note 1: Refer to IM 01C22T01-01E for HART Protocol version.

Note 2: Diaphragm; Hastelloy C-276. Other wetted parts materials; SUS316L.

Note 3: Body; Material of cover flanges and process connectors.

Note 4: Refer to IM 01C22T02-01E for Fieldbus communication.

Note 5: Refer to IM 01C22T03-00E for PROFIBUS PA communication.

● Model EJA130A

Model	Suffix Codes	Description
EJA130A	·····	Differential pressure transmitter
Output Signal	**-D** ·····	4 to 20 mA DC with digital communication (BRAIN protocol)
	-E ····· (Note 1)	4 to 20 mA DC with digital communication (HART protocol)
	-F ····· (Note 4)	Digital communication (FOUNDATION Fieldbus protocol)
	-G ····· (Note 6)	Digital communication (PROFIBUS PA protocol)
Measurement span(capsule)	**M** ·····	1 to 100 kPa {100 to 10000 mmH_2O}
	H ·····	5 to 500 kPa {0.05 to 5 kgf/cm^2}
Wetted parts material		[Body] (Note 3) / [Capsule] / [Vent plug]
	S ·····	SUS316 / SUS316L (Note 2) / SUS316
Process connection	**0** ·····	without process connector (Rc1/4 female on the cover flange)
	1 ·····	with Rc1/4 female process connector
	2 ·····	with Rc1/2 female process connector
	3 ·····	with 1/4 NPT female process connector (Note 5)
	4 ·····	with 1/2 NPT female process connector (Note 5)
	5 ·····	without process connector (1/4 NPT female on the cover flanges)
Bolts and nuts material		[Maximum working pressure]
	A ·····	SCM435 — 32 MPa {320 kgf/cm^2}
	B ·····	SUS630 — 32 MPa {320 kgf/cm^2}
	C ·····	SUH660 — 32 MPa {320 kgf/cm^2}
Installation	**-2** ·····	Vertical impulse piping type, right side high pressure, process connector upside
	-3 ·····	Vertical impulse piping type, right side high pressure, process connector downside
	-6 ·····	Vertical impulse piping type, left side high pressure, process connector upside
	-7 ·····	Vertical impulse piping type, left side high pressure, process connector downside
	-8 ·····	Horizontal impulse piping type, right side high pressure
	-9 ·····	Horizontal impulse piping type, left side high pressure
Electrical connection	**0** ·····	G1/2 female, one electrical connection
	2 ·····	1/2 NPT female, two electrical connections without blind plug
	3 ·····	Pg 13.5 female, two electrical connections without blind plug
	4 ·····	M20 female, two electrical connections without blind plug
	5 ·····	G1/2 female, two electrical connections and a blind plug
	7 ·····	1/2 NPT female, two electrical connections and a blind plug
	8 ·····	Pg 13.5 female, two electrical connections and a blind plug
	9 ·····	M20 female, two electrical connections and a blind plug
	A ·····	G1/2 female, two electrical connections and a SUS316 blind plug
	C ·····	1/2 NPT female, two electrical connections and a SUS316 blind plug
	D ·····	M20 female, two electrical connections and a SUS316 blind plug
Integral indicator	**D** ·····	Digital indicator
	E ·····	Digital indicator with the range setting switch
	N ·····	(None)
Mounting bracket	**A** ·····	SECC Carbon steel — 2-inch pipe mounting (flat type)
	B ·····	SUS304 — 2-inch pipe mounting (flat type)
	J ·····	SUS316 — 2-inch pipe mounting (flat type)
	C ·····	SECC Carbon steel — 2-inch pipe mounting (L type)
	D ·····	SUS304 — 2-inch pipe mounting (L type)
	K ·····	SUS316 — 2-inch pipe mounting (L type)
	N ·····	(None)
Optional codes		/ □ Optional specification

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Example: EJA130A-DMS5A-92NN/□

Note 1: Refer to IM 01C22T01-01E for HART Protocol version.
Note 2: Diaphragm; Hastelloy C-276. Other wetted parts materials; SUS316L.
Note 3: Body; Material of cover flanges: SUS316, Process connectors: SCS14A.
Note 4: Refer to IM 01C22T02-01E for Fieldbus communication.
Note 5: Lower limit of ambient and process temperature is –15°C.
Note 6: Refer to IM 01C22T03-00E for PROFIBUS PA communication.

10.3 Optional Specifications

For FOUNDATION Fieldbus explosion protected type, see IM 01C22T02-01E.

For PROFIBUS PA explosion protected type, see IM 01C22T03-00E.

Item	Description	Code
Factory Mutual (FM)	FM Explosionproof Approval *1 Explosionproof for Class I, Division 1, Groups B, C and D Dust-ignitionproof for Class II/III, Division 1, Groups E, F and G Hazardous (classified) locations, indoors and outdoors (NEMA 4X) Temperature class: T6 Amb. Temp.: –40 to 60°C (–40 to 140°F)	**FF1**
	FM Intrinsically safe Approval *1 Intrinsically Safe for Class I, Division 1, Groups A, B, C & D, Class II, Division 1, Groups E, F & G and Class III, Division 1 Hazardous Locations. Nonincendive for Class I, Division 2, Groups A, B, C & D, Class II, Division. 2, Groups E, F & G, and Class III, Division 1 Hazardous Locations. Enclosure: “NEMA 4X”, Temp. Class: T4, Amb. Temp.: –40 to 60°C (–40 to 140°F) Intrinsically Safe Apparatus Parameters [Groups A, B, C, D, E, F and G] Vmax=30 V, Imax=165 mA, Pmax=0.9 W, Ci=22.5 nF, Li=730 μH [Groups C, D, E, F and G] Vmax=30 V, Imax=225 mA, Pmax=0.9 W, Ci=22.5 nF, Li=730 μH	**FS1**
	Combined FF1 and FS1 *1	**FU1**
CENELEC ATEX	CENELEC ATEX (KEMA) Flameproof Approval *2 Certificate: KEMA 02ATEX2148 II 2G EExd IIC T4, T5, T6 Amb. Temp.: T5; –40 to 80°C (–40 to 176°F), T4 and T6; –40 to 75°C (–40 to 167°F) Max. process Temp.: T4; 120°C (248°F), T5; 100°C (212°F), T6; 85°C (185°F)	**KF2**
	CENELEC ATEX (KEMA) Intrinsically safe Approval *2 Certificate: KEMA 02ATEX1030X II 1G EEx ia IIC T4, Amb. Temp.: –40 to 60°C (–40 to 140°F) Ui=30 V, Ii=165 mA, Pi=0.9 W, Ci=22.5 nF, Li=730 μH	**KS2**
	Combined KF2, KS2 and Type n *2 Type n II 3G Ex nL IIC T4, Amb. Temp.: –40 to 60°C (–40 to 140°F) Ui=30 V DC, Ci=22.5 nF, Li=730 μH Dust II 1D maximum surface temperature T65°C (149°F) {Tamb.: 40°C (104°F)}, T85°C (185°F) {Tamb.: 60°C (140°F)}, T105°C (221°F) {Tamb.: 80°C (176°F)}	**KU2**

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*1: Applicable for Electrical connection code 2 and 7 (1/2 NPT female).
*2: Applicable for Electrical connection code 2, 4, 7 and 9 (1/2 NPT and M20 female).

Item	Description	Code
Canadian Standards Association (CSA)	CSA Explosionproof Approval *1 Certificate: 1089598 Explosionproof for Class I, Division 1, Groups B, C and D Dustignitionproof for Class II/III, Division 1, Groups E, F and G Division2 'SEALS NOT REQUIRED' , Temp. Class: T4, T5, T6 Encl Type 4x Max. Process Temp.: T4; 120°C (248°F), T5; 100°C (212°F), T6; 85°C (185°F) Amb. Temp.: –40 to 80°C (–40 to 176°F) Process Sealing Certification Dual seal certified by CSA to the requirement of ANSI/ISA 12.27.01 No additional sealing required. Primary seal failure annunciation : at the zero adjustment screw	**CF1**
	CSA Intrinsically safe Approval *1 Certificate: 1053843 Intrinsically Safe for Class I, Groups A, B, C and D Class II and III, Groups E, F and G Nonincendive for Class I, Division 2, Groups A, B, C and D Class II, Division 2, Groups F and G and Class III (not use Safety Barrier) Encl Type 4x, Temp. Class: T4, Amb. Temp.: –40 to 60°C (–40 to 140°F) Vmax=30 V, Imax=165 mA, Pmax=0.9 W, Ci=22.5 nF, Li=730 μH Process Sealing Certification Dual seal certified by CSA to the requirement of ANSI/ISA 12.27.01 No additional sealing required. Primary seal failure annunciation : at the zero adjustment screw	**CS1**
	Combined CF1 and CS1 *1	**CU1**
IECEx Scheme	IECEx Intrinsically safe, type n and Flameproof Approval *2 Intrinsically safe and type n Certificate: IECEx KEM 06.0007X Ex ia IIC T4, Ex nL IIC T4 Enclosure: IP67 Amb. Temp.: –40 to 60°C (–40 to 140°F), Max. Process Temp.: 120°C (248°F) Electrical Parameters: [Ex ia] Ui=30 V, Ii=165 mA, Pi=0.9 W, Ci=22.5 nF, Li=730 μH [Ex nL] Ui=30 V, Ci=22.5 nF, Li=730 μH Flameproof Certificate: IECEx KEM 06.0005 Ex d IIC T6...T4 Enclosure: IP67 Max.Process Temp.: T4;120°C (248°F), T5;100°C (212°F), T6; 85°C (185°F) Amb.Temp.: –40 to 75°C (–40 to 167°F) for T4, –40 to 80°C (–40 to 176°F) for T5, –40 to 75°C (–40 to 167°F) for T6	**SU2**

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*1: Applicable for Electrical connection code 2 and 7 (1/2 NPT female).
*2: Applicable for Electrical connection code 2, 4 and 7 (1/2 NPT and M20 female).

Item		Description		Code
Painting	Color change	Amplifier cover only		**P□**
		Amplifier cover and terminal cover, Munsell 7.5 R4/14		**PR**
	Coating change	Epoxy resin-baked coating		**X1**
316 SST exterior parts		Exterior parts on the amprifier housing (nameplates, tag plates, zero-adjustment screw, stopper screw) will become 316 or 316L SST.		**HC**
Lightning protector		Transmitter power supply voltag: 10.5 to 32 V DC (10.5 to 30 V DC for intrinsically safe type, 9 to 32 V DC for FOUNDATION Fieldbus and PROFIBUS PA communication type.) Allowable current: Max. 6000 A (1×40 μs), Repeating 1000 A (1×40 μs) 100 times		**A**
Oil-prohibited use		Degrease cleansing treatment		**K1**
		Degrease cleansing treatment with fluorinated oilfilled capsule. Operating temperature –20 to 80 °C		**K2**
Oil-prohibited use with dehydrating treatment		Degrease cleansing and dehydrating treatment		**K5**
		Degrease cleansing and dehydrating treatment with fluorinated oilfilled capsule. Operating temperature –20 to 80 °C		**K6**
Calibration units		P calibration (psi unit)	(See Table for Span and Range Limits.)	**D1**
		bar calibration (bar unit)		**D3**
		M calibration (kgf/cm^2 unit)		**D4**
Sealing treatment to SUS630 nuts		Sealant (liquid silicone rubber) is coated on surfaces of SUS630 nuts used for cover flange mounting.		**Y**
Long vent		Total vent plug Length: 112 mm (standard, 32 mm), Material: SUS316		**U**
Fast response *4		Update time: 0.125 sec or less, see GS for response time		**F1**
Failure alarm down-scale *1		Output status at CPU failure and hardware error is –5%, 3.2 mA or less.		**C1**
NAMUR NE43 compliant *1		Output signal limits: 3.8 mA to 20.5 mA	Failure alarm down-scale: output status at CPU failure and hardware error is –5%, 3.2 mA or less.	**C2**
			Failure alarm up-scale: output status at CPU failure and hardware error is 110%, 21.6 mA or more.	**C3**
Stainless steel amplifier housing		Amplifier housing material: SCS14A stainless steel (equivalent to SUS316 cast stainless steel or ASTM CF-8M)		**E1**
Gold-plate		Gold-plated diaphragm		**A1**
Configuration		Custom software configuration (Applicable for Model EJA110A and EJA130A)		**R1**
Body option		Without drain and vent plugs		**N1**
		N1 and Process connection on both sides of cover flange with blind kidney flanges on back		**N2**
		N1, N2, and Mill certificate for cover flange, diaphragm, capsule body, and blind kidney flange		**N3**
Stainless steel tag plate		JIS SUS 304 stainless steel tag plate wired onto transmitter		**N4**
High Accuracy type		High Accuracy (Applicable for Model EJA120A)		**HAC**
European Pressure Equipment Directive *2		PED 97/23/EC (Applicable for Model EJA130A) CATEGORY: III, Module: H, Type of Equipment: Pressure Accessory - Vessel, Type of Fluid: Liquid and Gas, Group of Fluid: 1 and 2		**PE3**
Mill Certificate		Cover flange		**M01**
		Cover flange, Process connector		**M11**
Pressure test/Leak test Certificate		Test Pressure: 3.5 MPa{35 kgf/cm^2}	Nitrogen(N_2) Gas *3 Retention time: 10 minutes	**T01**
		Test Pressure: 16 MPa{160 kgf/cm^2}		**T12**
		Test Pressure: 50 kPa{0.5 kgf/cm^2}		**T04**
		Test Pressure: 32 MPa{320 kgf/cm^2}		**T09**

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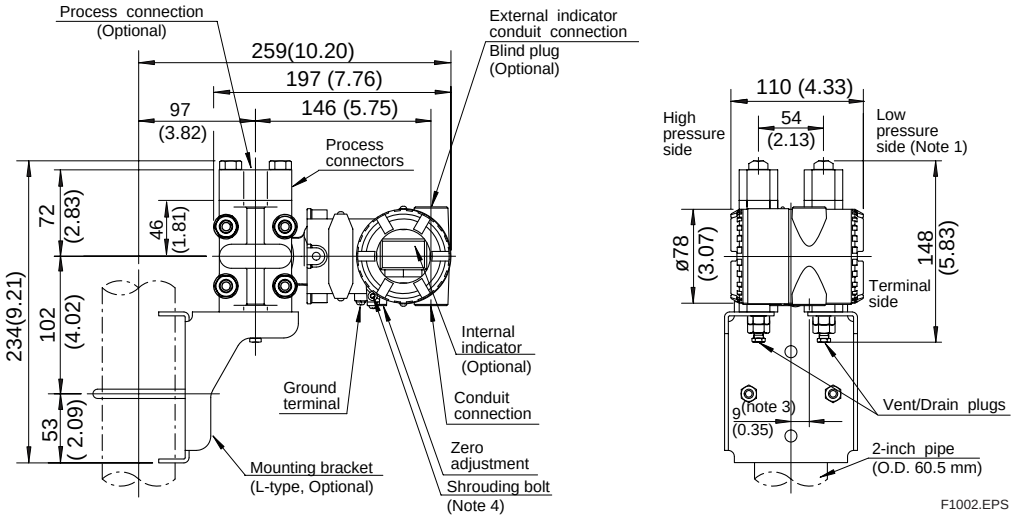
*1: Applicable for Output signal code D and E. The hardware error indicates faulty amplifier or capsule. When combining with Optional code F1, output status for down-scale is –2.5%, 3.6 mA DC or less.
*2: Lower limit of process temperature is –30°C when Bolts and nuts material code A is selected.
*3: Applicable for EJA110A and EJA120A. For EJA130A, the test fluid is water or Nitrogen (N_2) gas.
*4: Applicable for Output signal code D and E. Write protection switch is attached for Output code E.

10.4 Dimensions

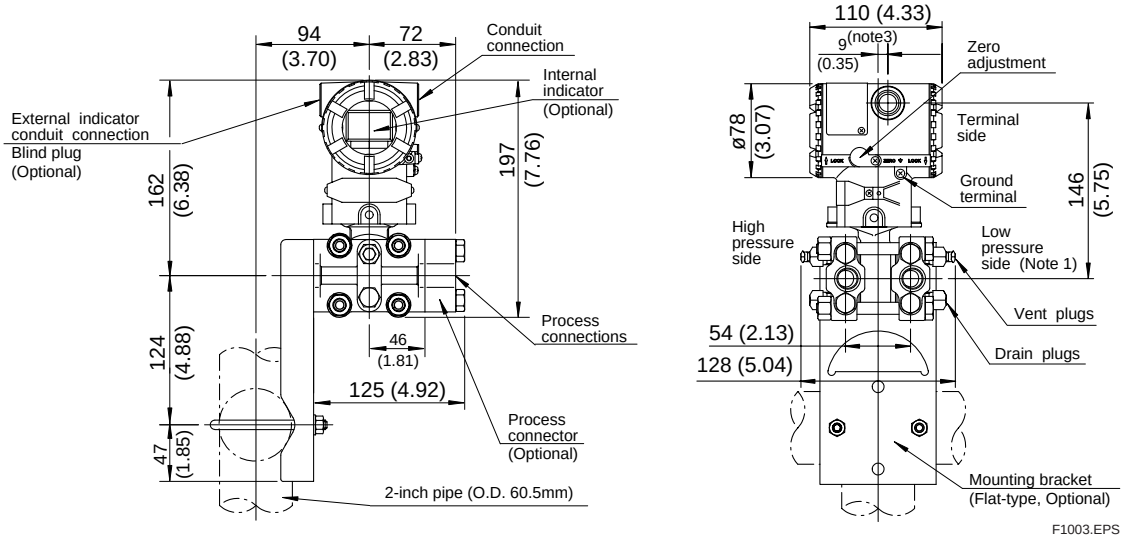
● Model EJA110A and EJA120A

Vertical Impulse Piping Type
Process connector upside (INSTALLATION CODE '6') (For CODE '2', '3' or '7', refer to the notes below.)

Unit: mm (approx. inch)



Horizontal Impulse Piping Type
(INSTALLATION CODE '9') (For CODE '8', refer to the notes below.)



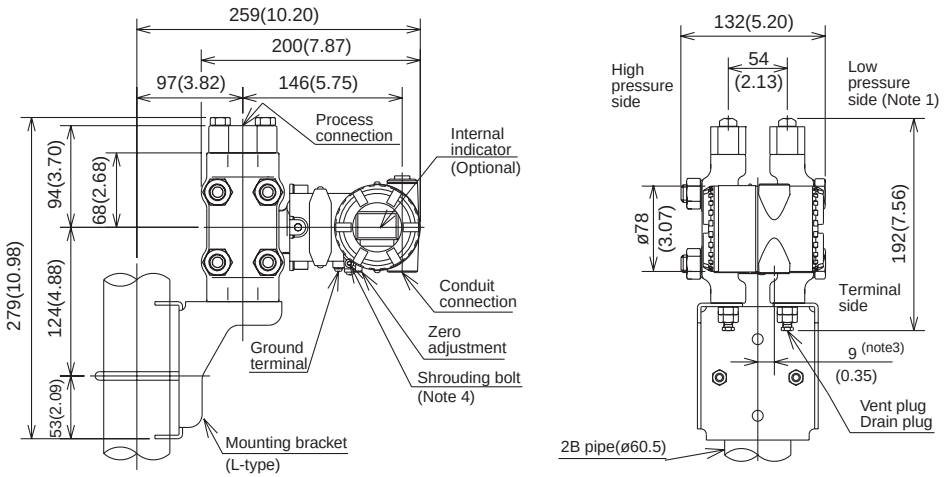
Note 1: When INSTALLATION CODE '2', '3' or '8' is selected, high and low pressure side on above figure are reversed.
(i. e. High pressure side is on the left side.)
Note 2: When INSTALLATION CODE '3' or '7' is selected, process connetion and mounting bracket on above figure are reversed.
Note 3: 15 mm (0.59 inch) for right side high pressure. (for CODE '2', '3' or '8')
12 mm (0.47 inch) for EJA120A.
Note 4: Applicable only for ATEX and IECEx Flameproof type.

● Model EJA130A

Vertical Impulse Piping Type

Process connector upside (INSTALLATION CODE '6') (For CODE '2', '3' or '7', refer to the notes below.)

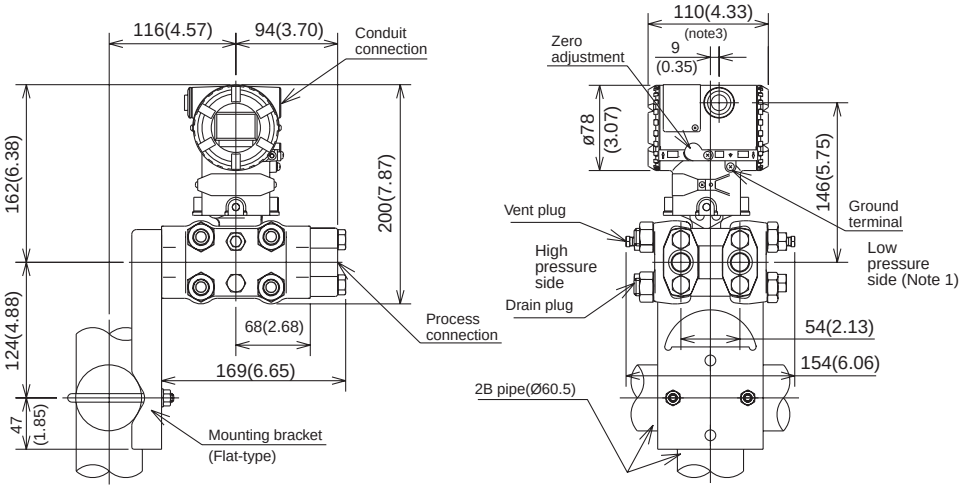
Unit: mm (approx. inch)



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Horizontal Impulse Piping Type

(INSTALLATION CODE '9') (For CODE '8', refer to the notes below)



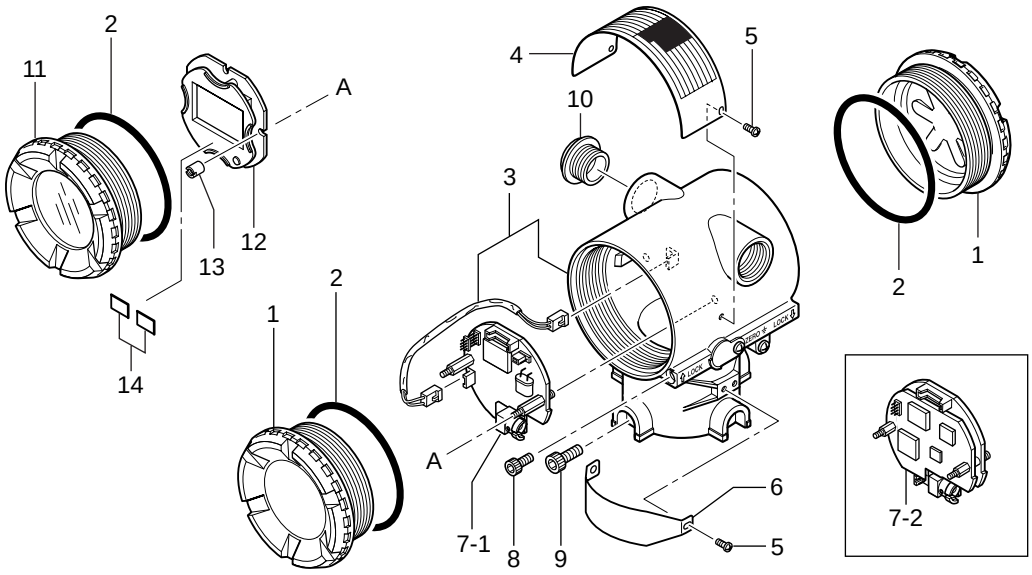
F1005.EPS

Note 1: When INSTALLATION CODE '2', '3' or '8' is selected, high and low pressure side on above figure are reversed.
(i. e. High pressure side is on the right side.)
Note 2: When INSTALLATION CODE '3' or '7' is selected, process connection and mounting bracket on above figure are reversed.
Note 3: 9 mm (0.35 inch) for right side high pressure type. (CODE '2', '3' or '8').
Note 4: Applicable only for ATEX and IECEx Flameproof type.

Customer Maintenance Parts List

DPharp EJA Series
Transmitter Section

DPharp



Item	Part No.	Qty	Description
1	Bellow	2	Cover
	F9341RA		Cast-aluminum alloy
	F9341RJ		SCS14A stainless steel
2	F9341JP	2	O-ring
3	Below	1	Case Assembly (Note 1)
	F9341AA		Cast-aluminum alloy for G1/2
	F9341AC		Cast-aluminum alloy for G1/2 (two electrical connections)
	F9341AE		Cast-aluminum alloy for 1/2 NPT (two electrical connections)
	F9341AH		Cast-aluminum alloy for M20 (two electrical connections)
	F9341AJ		Cast-aluminum alloy for Pg13.5 (two electrical connections)
	F9341AR		SCS14A stainless steel for 1/2 NPT (two electrical connections)
4	—	1	Name Plate
5	Bellow	4	Screw
	F9900RG		For cast-aluminum alloy case assembly
	F9900RR		For SCS14A stainless steel case assembly
6	F9341KL	1	Tag Plate
7-1	Below	1	CPU Assembly
	F9342AB		For BRAIN protocol version
	F9342AL		For HART protocol version
	F9342AF		For BRAIN protocol version(Optional code /F1)
	F9342AM		For HART protocol version with write protection switch (Optional code /F1)
7-2	F9342BF	1	For FOUNDATION Fieldbus protocol version
	F9342BG		For FOUNDATION Fieldbus protocol version with PID/LM function (Optional code /LC1)
8	F9900RP	2	Cap Screw
9	Y9612YU	2	Screw
10	Below	1	Plug
	F9340NW		For Pg13.5
	F9340NX		For M20
	G9330DP		For G1/2
	G9612EB		For 1/2 NPT
11	Bellow	1	Cover Assembly
	F9341FM		Cast-aluminum alloy
	F9341FJ		SCS14A stainless steel
12	Below	1	LCD Board Assembly
	F9342BL		Without range-setting switch
	F9342BM		With range-setting switch
13	F9342MK	2	Mounting Screw
14	F9300PB	2	Label

For integral indicator

(Note 1) Applicable for BRAIN and HART protocol versions (Output signal code D and E). For FOUNDATION Fieldbus protocol version (Output signal code F), consult Yokogawa local office.

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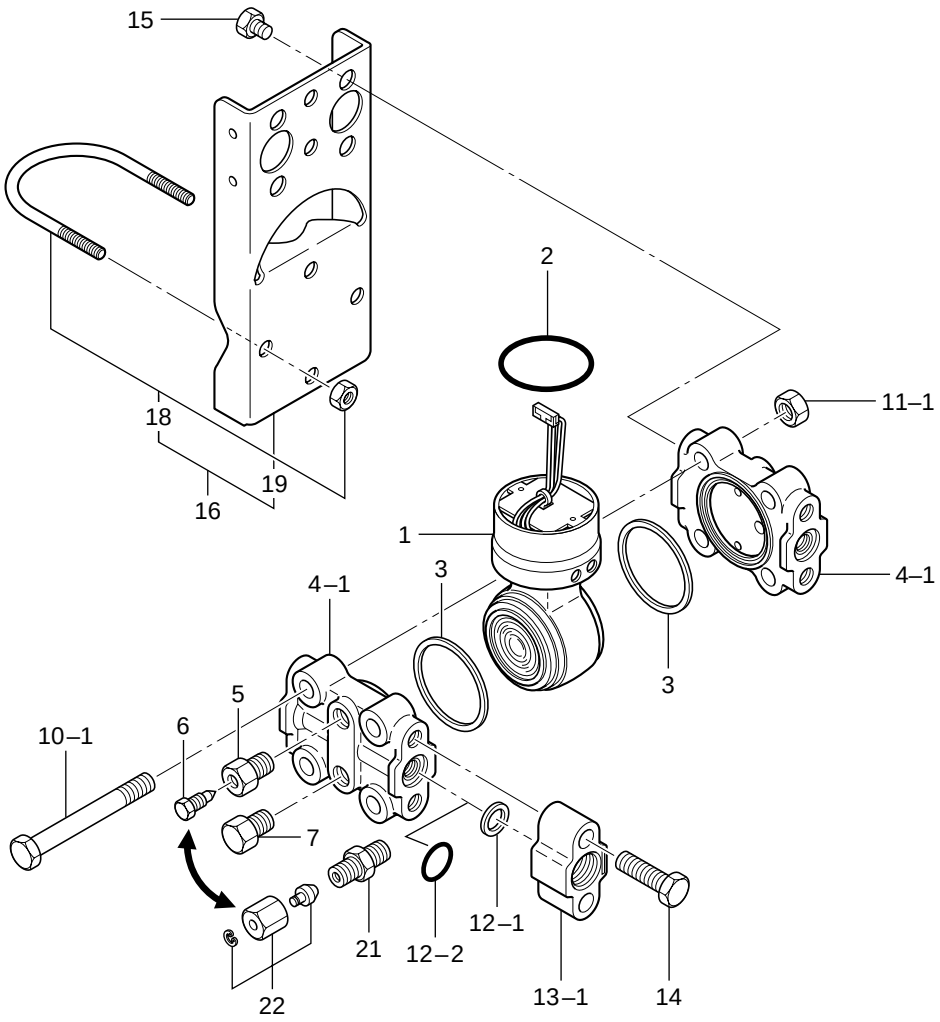
CMPL 01C21A01-02E
11th Edition: Oct. 2008(KP)

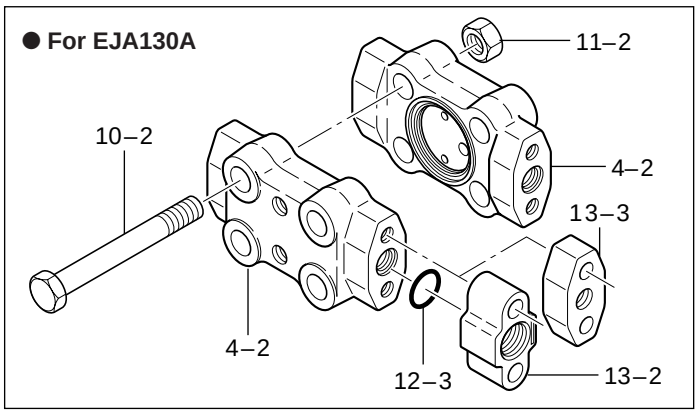
Customer Maintenance Parts List

Model EJA110A, EJA120A and EJA130A Differential Pressure Transmitter (Pressure-detector Section)

DPharp

Horizontal Impulse Piping Type



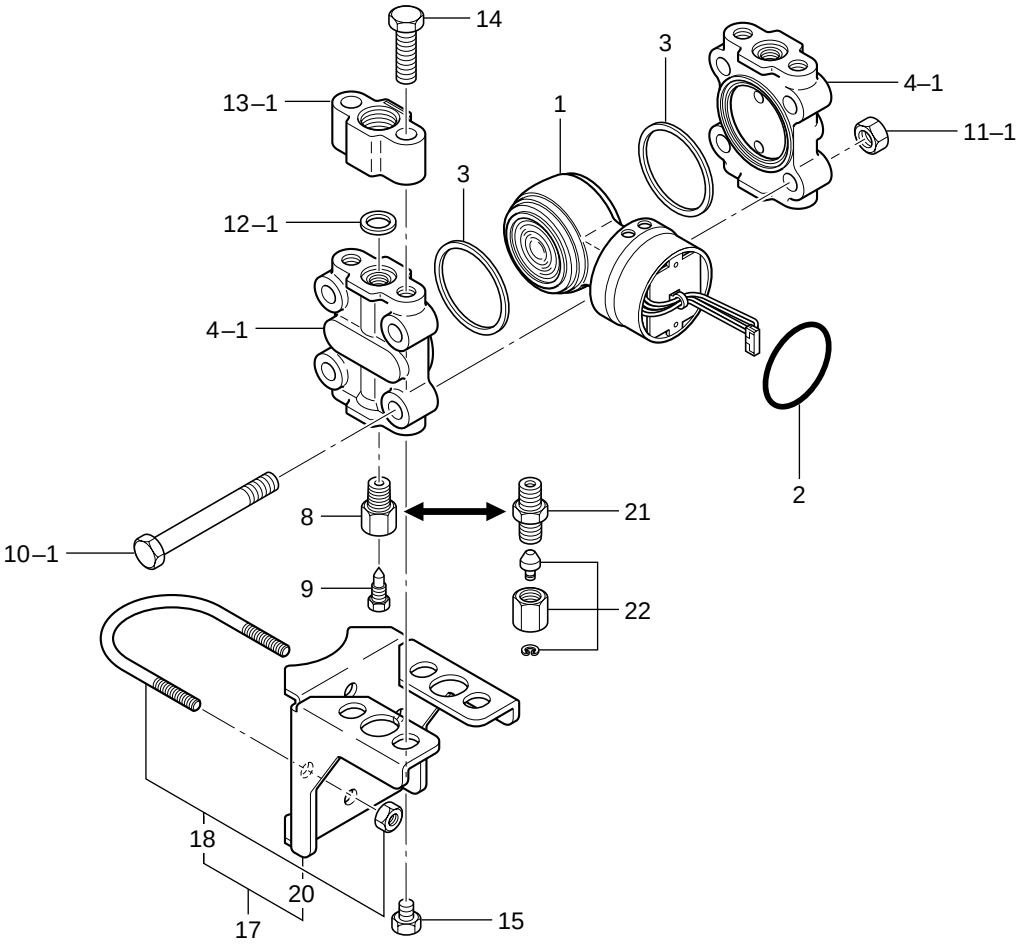


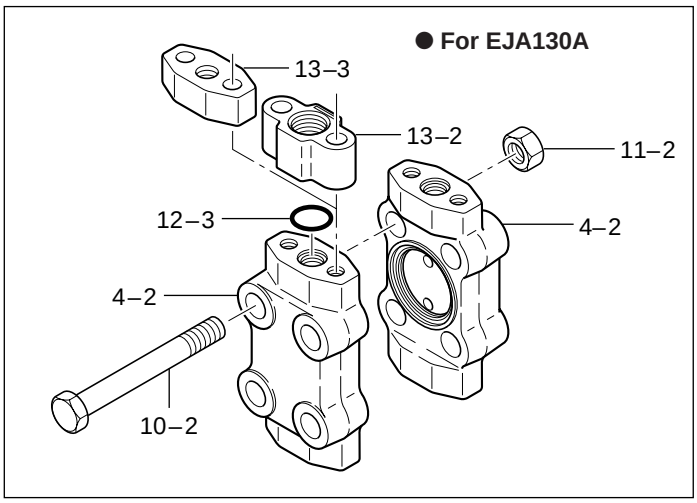
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CMPL 01C21B00-01E
5th Edition: May 2002(YK)

Vertical Impulse Piping Type





Item	Part No.	Qty	Description
1	—	1	Capsule Assembly (see Table 1, Table 2 and Table 3 on page 5) (Note 1)
2	F9300AJ	1	O-Ring
3	Below	2	Gasket
	F9340GA		Teflon-coated SUS316L Stainless Steel } (for EJA110A with Wetted
	F9340GC		Teflon-coated SUS316L Stainless Steel (degreased) } Parts Material code S)
	F9340GE		PTFE Teflon } (for EJA110A with Wetted Parts Material
	F9340GF		PTFE Teflon (degreased) } code H, M, T, A, D and B and EJA120A)
	F9300FD		Teflon-coated SUS316L Stainless Steel } (for EJA130A)
	F9300FR		Teflon-coated SUS316L Stainless Steel (degreased) }
4-1	Below	2	Cover Flange for EJA110A and EJA120A (Note 2)
	F9340VA		Rc 1/4 } SCS14A Stainless Steel (for EJA110A with Wetted Parts Material code S)
	F9340VB		1/4 NPT } For Horizontal Impulse Piping Type
	F9340VC		Rc 1/4 } SCS14A Stainless Steel (for EJA110A with Wetted Parts Material code S)
	F9340VD		1/4 NPT } For Vertical Impulse Piping Type
	F9340VP		Rc 1/4 } SCS14A Stainless Steel (for EJA110A with Wetted Parts Material code H, M and T
	F9340VR		1/4 NPT } and EJA120A) For Horizontal Impulse Piping Type
	F9340VN		Rc 1/4 } SCS14A Stainless Steel (for EJA110A with Wetted Parts Material code H, M and T
	F9340VQ		1/4 NPT } and EJA120A) For Vertical Impulse Piping Type
	F9340VS		Rc 1/4 } Hastelloy C-276 equivalent (for EJA110A with Wetted Parts Material code A and D)
	F9340VT		1/4 NPT } For Horizontal Impulse Piping Type
	F9340VU		Rc 1/4 } Hastelloy C-276 equivalent (for EJA110A with Wetted Parts Material code A and D)
	F9340VV		1/4 NPT } For Vertical Impulse Piping Type
	F9340TP		Rc 1/4 } Monel equivalent (for EJA110A with Wetted Parts Material code B)
	F9340TR		1/4 NPT } For Horizontal Impulse Piping Type
	F9340TN		Rc 1/4 } Monel equivalent (for EJA110A with Wetted Parts Material code B)
	F9340TQ		1/4 NPT } For Vertical Impulse Piping Type
4-2	Below	2	Cover Flange for EJA130A (Note 2)
	F9340UA		Rc 1/4 SUS316 Stainless Steel (for Horizontal Impulse Piping Type)
	F9340UC		Rc 1/4 SUS316 Stainless Steel (for Vertical Impulse Piping Type)
	F9340UH		1/4 NPT SUS316 Stainless Steel (for Horizontal Impulse Piping Type)
	F9340UJ		1/4 NPT SUS316 Stainless Steel (for Vertical Impulse Piping Type)
5	Below	2	Vent Plug
	F9340SA		R 1/4 } SUS316 Stainless Steel (for EJA110A with Wetted Parts
	F9340SB		1/4 NPT } Material code S, H, M and T, EJA120A and EJA130A)
	F9340SE		R 1/4 } Hastelloy C-276 (for EJA110A with Wetted Parts Material code A and D)
	F9340SF		1/4 NPT }
	F9340SS		R 1/4 } Monel (for EJA110A with Wetted Parts Material code B)
	F9340ST		1/4 NPT }
6	Below	2	Vent Screw
	D0114PB		SUS316 Stainless Steel (for Models except EJA110A with Wetted Parts Material codes A, D and B)
	F9340SK		Hastelloy C-276 (for EJA110A with Wetted Parts Material code A and D)
	F9270HG		Monel (for EJA110A with Wetted Parts Material code B)
7	Below	2	Drain Plug (Note 2)
	F9200CS		R 1/4 } SUS316 Stainless Steel (for EJA110A with Wetted Parts
	D0114RZ		1/4 NPT } Material code S, H, M and T, EJA120A and EJA130A)
	F9340SL		R 1/4 } Hastelloy C-276 (for EJA110A with Wetted Parts Material code A and D)
	F9340SM		1/4 NPT }
	F9340SW		R 1/4 } Monel (for EJA110A with Wetted Parts Material code B)
	D0117MS		1/4 NPT }
8	Below	2	Drain/Vent Plug
	F9340SC		R 1/4 } SUS316 Stainless Steel (for EJA110A with Wetted Parts
	F9340SD		1/4 NPT } Material code S, H, M and T, EJA120A and EJA130A)
	F9340SG		R 1/4 } Hastelloy C-276 (for EJA110A with Wetted Parts Material code A and D)
	F9340SH		1/4 NPT }
	F9340SU		R 1/4 } Monel (for EJA110A with Wetted Parts Material code B)
	F9340SV		1/4 NPT }
9	Below	2	Drain/Vent Screw
	F9270HE		SUS316 Stainless Steel (for Models except EJA110A with Wetted Parts Material code A, D and B)
	F9340SJ		Hastelloy C-276 (for EJA110A with Wetted Parts Material code A and D)
	D0117MR		Monel (for EJA110A with Wetted Parts Material code B)
10-1	Below	4	Bolt (for EJA110A and EJA120A)
	F9340AB		SCM435 Chrome Molybdenum Steel
	F9340AC		SUS630 Stainless Steel
	F9340AQ		SUH660 Stainless Steel
10-2	Below	4	Bolt (for EJA130A)
	F9340AF		SCM435 Chrome Molybdenum Steel
	F9340AG		SUS630 Stainless Steel
	F9340AS		SUH660 Stainless Steel
11-1	Below	4	Nut (for EJA110A and EJA120A)
	F9275KL		SCM435 Chrome Molybdenum Steel
	F9275KH		SUS630 Stainless Steel
	F9340BQ		SUH660 Stainless Steel
11-2	Below	4	Nut (for EJA130A)
	F9300GB		SCM435 Chrome Molybdenum Steel
	F9300GD		SUS630 Stainless Steel
	F9340BS		SUH660 Stainless Steel

Item	Part No.	Qty	Description
12-1	Below	2	Gasket (for EJA110A and EJA120A)
	D0114RB		PTFE Teflon
	U0102XC		PTFE Teflon (degreased)
12-2	Below	2	Gasket (for EJA110A and EJA120A with Optional code /N2 and /N3)
	F9340GN		Fluorinated Rubber
	F9340GP		Fluorinated Rubber (degreased)
12-3	Below	2	Gasket (for EJA130A)
	F9340GN		Fluorinated Rubber } For Process connection code 3 and 4
	F9340GP		Fluorinated Rubber (degreased) } For Process connection code 3 and 4
	F9202FJ		Glass Reinforced Teflon } For Process connection code 1 and 2
	F9201HA		Glass Reinforced Teflon (degreased) } For Process connection code 1 and 2
13-1	Below	2	Process Connector (for EJA110A and EJA120A)(Note 2)
	F9340XY		Rc 1/4 } SCS14A Stainless Steel (for EJA110A with Wetted Parts Material code S, H, M and T and EJA120A)
	F9340XW		Rc 1/2 } SCS14A Stainless Steel (for EJA110A with Wetted Parts Material code S, H, M and T and EJA120A)
	F9340XZ		1/4 NPT } SCS14A Stainless Steel (for EJA110A with Wetted Parts Material code S, H, M and T and EJA120A)
	F9340XX		1/2 NPT } SCS14A Stainless Steel (for EJA110A with Wetted Parts Material code S, H, M and T and EJA120A)
	F9340WY		Rc 1/4 } Hastelloy C-276 equivalent (for EJA110A with Wetted Parts Material code A and D)
	F9340WW		Rc 1/2 } Hastelloy C-276 equivalent (for EJA110A with Wetted Parts Material code A and D)
	F9340WZ		1/4 NPT } Hastelloy C-276 equivalent (for EJA110A with Wetted Parts Material code A and D)
	F9340WX		1/2 NPT } Hastelloy C-276 equivalent (for EJA110A with Wetted Parts Material code A and D)
	F9340TY		Rc 1/4 } Monel equivalent (for EJA110A with Wetted Parts Material code B)
	F9340TW		Rc 1/2 } Monel equivalent (for EJA110A with Wetted Parts Material code B)
	F9340TZ		1/4 NPT } Monel equivalent (for EJA110A with Wetted Parts Material code B)
	F9340TX		1/2 NPT } Monel equivalent (for EJA110A with Wetted Parts Material code B)
13-2	Below	2	Process Connector (for EJA130A with Process connection code 3 and 4)(Note 2)
	F9340XT		1/4 NPT } SCS14A Stainless Steel
	F9340XS		1/2 NPT } SCS14A Stainless Steel
13-3	Below	2	Process Connector (for EJA130A with Process connection code 1 and 2)(Note 2)
	F9271FD		Rc 1/4 } SUS316 Stainless Steel
	F9271FC		Rc 1/2 } SUS316 Stainless Steel
14	Below	4	Bolt
	X0100MN		SCM435 Chrome Molybdenum Steel
	F9273DZ		SUS630 Stainless Steel
	F9340AZ		SUH660 Stainless Steel
15	Below	4	Bolt
	F9270AY		S15C Carbon Steel
	F9273CZ	1	SUS XM7 Stainless Steel
16	Below		Bracket Assembly (Flat type)
	F9270AW		SECC Carbon Steel
	F9300TJ		SECC Carbon Steel (for Epoxy resin-baked coating)
	F9300TA		SUS304 Stainless Steel
17	Below	1	Bracket Assembly (L type)
	F9340EA		SECC Carbon Steel
	F9340EB		SECC Carbon Steel (for Epoxy resin-baked coating)
	F9340EC		SUS304 Stainless Steel
18	D0117XL-A	1	U-Bolt/Nut Assembly, SUS304 Stainless Steel
19	Below	1	Bracket (Flat type)
	F9270AX		SECC Carbon Steel
	F9300TN		SECC Carbon Steel (for Epoxy resin-baked coating)
	F9300TE		SUS304 Stainless Steel
20	Below	1	Bracket (L type)
	F9340EF		SECC Carbon Steel
	F9340EG		SECC Carbon Steel (for Epoxy resin-baked coating)
	F9340EM		SUS304 Stainless Steel
21	Below	2	Vent Plug (degreased), SUS316 Stainless Steel
	F9275EC		R 1/4
	F9275ED		1/4 NPT
22	F9275EE	2	Needle Assembly (degreased), SUS316 Stainless Steel

(Note 1) In case of degrease cleansing treatment (Optional code/K1 or K5), consult YOKOGAWA local office.
(However, see Table 1, Table 2 and Table 3 in case of Optional code/K2 or K6)
(Note 2) In case of degrease cleansing treatment (Optional code/K1, K2, K5 or K6), consult YOKOGAWA local office.

■ Capsule Assembly Part Number

● EJA110A

Table 1. Capsule Assembly Part Number (Item 1)
For General-use type, Flameproof type and Intrinsically safe type

Installation of Transmitter	High Pressure Side	Capsule Code	Wetted Parts Material Code				
			S(*1)	S(*2)	H, A	T, D	M, B
Horizontal Impulse Piping Type	Right	L	F9349AA	F9352AA	F9349AE	F9349AJ	F9349AN
		M	F9349BA	F9352BA	F9349BE	F9349BJ	F9349BN
		H	F9349CA	F9352CA	F9349CE	F9349CJ	F9349CN
		V	F9349DA	F9352DA	F9349DE	F9349DJ	F9349DN
	Left	L	F9349AB	F9352AB	F9349AF	F9349AK	F9349AP
		M	F9349BB	F9352BB	F9349BF	F9349BK	F9349BP
		H	F9349CB	F9352CB	F9349CF	F9349CK	F9349CP
		V	F9349DB	F9352DB	F9349DF	F9349DK	F9349DP
Vertical Impulse Piping Type	Right	L	F9349AC	F9352AC	F9349AG	F9349AL	F9349AQ
		M	F9349BC	F9352BC	F9349BG	F9349BL	F9349BQ
		H	F9349CC	F9352CC	F9349CG	F9349CL	F9349CQ
		V	F9349DC	F9352DC	F9349DG	F9349DL	F9349DQ
	Left	L	F9349AD	F9352AD	F9349AH	F9349AM	F9349AR
		M	F9349BD	F9352BD	F9349BH	F9349BM	F9349BR
		H	F9349CD	F9352CD	F9349CH	F9349CM	F9349CR
		V	F9349DD	F9352DD	F9349DH	F9349DM	F9349DR

● EJA120A

Table 2. Capsule Assembly Part Number (Item 1)
For General-use type, Flameproof type and Intrinsically safe type

Installation of Transmitter	High Pressure Side	Capsule Code	Part No. (*1)	Part No. (*2)
Horizontal Impulse Piping Type	Right	E	F9349EA	F9352EA
	Left	E	F9349EB	F9352EB
Vertical Impulse Piping Type	Right	E	F9349EC	F9352EC
	Left	E	F9349ED	F9352ED

● EJA130A

Table 3. Capsule Assembly Part Number (Item 1)
For General-use type, Flameproof type and Intrinsically safe type

Installation of Transmitter	High Pressure Side	Capsule Code	Part No. (*1)	Part No. (*2)
Horizontal Impulse Piping Type	Right	M	F9359AA	F9359EA
		H	F9359BA	F9359FA
	Left	M	F9359AB	F9359EB
		H	F9359BB	F9359FB
Vertical Impulse Piping Type	Right	M	F9359AC	F9359EC
		H	F9359BC	F9359FC
	Left	M	F9359AD	F9359ED
		H	F9359BD	F9359FD

*1. Silicone oil filled capsule (Standard)
*2. Fluorinated oil filled capsule (for oil-prohibited use: Optional code /K2 or K6)

REVISION RECORD

Title: Model EJA110A, EJA120A and EJA130A Differential Pressure Transmitter
Manual No.: IM 01C21B01-01E

Edition	Date	Page	Revised Item
1st	Jun. 1997	–	New publication
2nd	Mar. 1998	CONTENTS 1-1 5-3 6-1 11-1 11-3 11-7 2-9+ CMPL	Page 3 • Add REVISION RECORD. 1 • Add 'NOTE' notice for FOUNDATION Fieldbus and HART protcol versions. 5.1.1 • Correct the mounting procedure for Direct-Mounting Type 3-valve Manifold. 6.1 • Add Item to the Wiring Precautions. 11.1 • Add FOUNDATOIN Fieldbus protocol. 11.2 • Add Output signal code F and Wetted parts material code A and D. 11.3 • Add Optional code A1. • Change the figure of terminal configuration. CMPL 1C21A1-02E 1st ⇒2nd Page 2 • Add Item 7-2. CMPL 1C21B1-01E 1st ⇒2nd Page 3 • Add Part No. to Item 3, 4, 5, 6, 7, 8, 9, and 13. Page 4 • Add Wetted parts material code A and D. CMPL 1C21B3-01E 1st ⇒2nd Page 3, 4 • Add Optional code K5 and K6. CMPL 1C21B4-01E 1st ⇒2nd Page 3, 4 • Delete Optional code K5 and K6.
3rd	Sep. 1998	2-13 8-18 11-1 11-3 11-4 11-5 CMPL	2.10 • Delete EMC Conformity Standards Tables. 8.3.2(11) • Correction made in BURN OUT figure. 11.1 • Add Capsule code V. 11.2 • Add Capsule code V. • Add Wetted parts material code M. • Add Electrical connection code 7, 8, and 9. • Add Electrical connection code 7, 8, and 9. • Add Electrical connection code 7, 8, and 9. CMPL 1C21A1-02E 2nd ⇒ 3rd Page 2 • Add Part No. to Item 3 (For PG13.5 and M20). • Add Part No. to Item 10 (For 1/2NPT, PG13.5, and M20). CMPL 1C21B1-01E 2nd ⇒ 3rd Page 4 • Add Capsule code V and Wetted parts material code M to Table 1. CMPL 1C21B4-01E 2nd ⇒ 3rd Page 3 • Add Part No. to Item 13 (For Rc1/4 and Rc1/2). • Add Part No. to Item 4, 5, 7, and 8 (For Rc1/4).
4th	Oct. 1999	- 2-8 8-4 10-3 CMPL	Revised a book in a new format. (The location of contents and the associated page numbers may not coincide with the one in old editions.) 2.10 • Add AS/NZS 2064 1/2 to EMI, EMC Conformity Standards. 8.3.1 • Move Parameter Summary table to Chapter 8. 10.2 • Add Wetted parts material code B. CMPL 1C21A1-02E 3rd ⇒ 4th • Change a format. CMPL 1C21B0-01E 1st • Combine CMPL 1C21B1-01E, 1C21B3-01E, and 1C21B4-01E.
5th	Sep. 2000	2-8 8-5 9-5 10-2 10-3 10-4 10-5 10-6 10-7	2.9.4b • Change contents of NOTE 1 and 4. 8.3.1 • Add footnote 2 and 3. 9.4.3 • Add table for tightning torque for cover flange bolts. 10.1 • Add calibration units of Pa and hPa. 10.2 • Add Bolts and nuts material code C. • Add Bolts and nuts material code C. • Add Bolts and nuts material code C and footnote 5. 10.3 • Add Amb. Temp. for T6: –40 to 75°C under /KF1. • Add Optional code /F1, /N1, /N2, /N3, /N4, and /R1

REVISION RECORD.EPS

Edition	Date	Page	Revised Item
5th (Continued)	Sep. 2000	CMPL	CMPL 1C21A1-02E 4th ⇒ 5th(Manual Change) • Add part numbers to 7-1 CPU Assembly. F9342AF and F9342AM CMPL 1C21A1-02E 5th ⇒ 6th • Add part numbers to 7-2 CPU Assembly. F9342BG • Change part number of 7-1 CPU Assembly. F9342BC → F9342BB • Change part number of 10 Plug G9330DK → G9330DP CMPL 1C21B0-01E 1st ⇒ 2nd(Manual Change) Page 3 • Add part number to 10-1 and 10-2 Bolt. F9340AQ and F9340AS • Add part number to 11-1 and 11-2 Nut. F9340BQ and F9340BS CMPL 1C21B0-01E 2nd ⇒3rd Page 4 • Add part number to 14 Bolt. F9340AZ
6th	July 2001	2-10 8-4, 8-5 10-3 CMPL	2.10 • Change EMC Conformity number. 8.3.1 • Add footnote (*4) to B40, Maximum static pressure in Parameter Summary. 10.2 • Change the maximum working pressure to 16 MPa. CMPL 1C21A1-02E 6th ⇒ 7th(Manual Change) • Change Part No. of 7-1 CPU Assembly for BRAIN protocol. F9342BB → F9342AB CMPL 1C21A1-02E 7th ⇒ 8th(Manual Change) • Change Part No. of 7-1 CPU Assembly for HART protocol. F9342BH → F9342AL CMPL 1C21A1-02E 8th ⇒ CMPL 01C21A01-02E 9th • Delete Part No. of 4 Name Plate. • Change Part No. of 5 Screw. F9303JU → Y9303JU CMPL 1C21B0-01E 3rd ⇒ CMPL 01C21B00-01E 4th
7th	May 2002	1-2 2-7 10-6 10-7	1.1 • Add “1.1 For Safety Using.” 2.9.4 • Add descriptions based on ATEX directive. 10.3 • Add Optional code K□2. • Add Optional code C2 and C3.
8th	Apr. 2003	2-8 2-10 10-6 10-7	2.9.4 • Add Option code KU2. 2.11 • Add PED (Pressure Equipment Directive). 10.3 • Add Option code KU2. 10.3 • Add Option code PE3.
9th	Apr. 2006	1-2 1-3 2-6 2-11 10-6, 10-7 10-7 10-8	1.1 • Add (e) Explosion Protected Type Instrument and (f) Modification 1.3 • Add “1.3 ATEX Document” 2.9.3 • Add “IECEx Certification” and delete “SAA Certification” 2.12 • Add Low Voltage Directive 10.3 • Add Certificate numbers and Applicable standards • Add option code /SU2 and delete option code /SU1 • Add option code /PR
10th	Jan. 2008	1-1 1-4 2-3+ 2-10 4-4 5-4 8-15 9-3 10-1+ 10-6,-7 CMPL	• Add direct current symbol. • Add 11 European languages for ATEX documentation. 2.9.1 • Add applicable standard and certificate number for appovals. 2.10 • Add EMC caution note. 4.6 • Add section of changing the direction of integral indicator. 5.2 • Delete impulse connection examples for tank. 8.3.3 (15) • Add figure for A40. 9.4.1 • Add figure of integral indicator direction. 10.1,10.2 • Add PROFIBUS PA communication type. 10.3 • Delete applicable standard from the table. CMPL 01C21A01-02E 9th ⇒ CMPL 01C21A01-02E 10th • Delete logo from the tag plate.

REVISION RECORD2.EPS

Edition	Date	Page	Revised Item
11th (Continued)	Oct. 2008	2-9	2.9.4 • Change explosion protection marking for type n from EEx to Ex.
		2-11	2.10 • Update EMC conformity standards.
		7-1	7.1 • Modify layout.
			• Change the maximum working pressure to 16 MPa.
		8-4, 8-5	8.3.1 • Add new parameters.
		8-6	8.3.2 • Add items in table 8.3.1.
		8-9 and later	8-3.3 • Add (6)Change Output Limits and (17)Span Adjustment. Renumber the items.
		8-19	8.5.2 • Modify descriptions and notes for Er.01.
		9-1	9.3 • Add note for calibration.
		9-5	9.4.3 • Add note for cleaning.
		10-3 through 10-5	10.2 • Add new suffix codes.
		10-7, 10-8	10.3 • Add sealing statement for CSA standards. Add /HC.
		10-9, 10-10	10.4 • Correct errors.
		CMPL	CMPL 01C21A01-02E 10th ⇒11th
			• Change Part No. of items 5 and 8.

REVISION RECORD3.EPS

Appendix F

ASME B16.39-2009
[Revision of ASME B16.39-1998 (R2006)]

Malleable Iron Threaded Pipe Unions

Classes 150, 250, and 300

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

ASME
SETTING THE STANDARD

ASME B16.39-2009
[Revision of ASME B16.39-1998 (R2006)]

Malleable Iron Threaded Pipe Unions

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AN AMERICAN NATIONAL STANDARD

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ASME
SETTING THE STANDARD

Date of Issuance: October 9, 2009

The next edition of this Standard is scheduled for publication in 2014. There will be no addenda issued to this edition.

ASME issues written replies to inquiries concerning interpretations of technical aspects of this Standard. Interpretations are published on the ASME Web site under the Committee Pages at http://cstools.asme.org as they are issued.

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FOREWORD

In 1921, the American Engineering Standards Committee, later the American Standards Association (ASA), now the American National Standards Institute (ANSI), authorized the organization of a Sectional Committee on the Standardization of Pipe Flanges and Flanged Fittings, with the following organizations as joint sponsors: Heating, Piping, and Air Conditioning Contractors National Association, later the Mechanical Contractors Association of America (MCAA); Manufacturers Standardization Society of the Valve and Fittings Industry (MSS); and the American Society of Mechanical Engineers (ASME).

Threaded fittings were added to the scope of the B16 Committee, and Subcommittee No. 2 (now Subcommittee B) was made responsible for threaded fittings other than steel. Standards for cast and malleable iron fittings were approved by ASA as early as 1927.

For many years, the need for standardization of threaded malleable iron unions was met by Federal Specifications (published by the General Services Administration) and other documents published by the Association of American Railroads (AAR) and the Underwriters Laboratories (UL). As these standards continued to diverge, however, manufacturers concluded that a common practice would be desirable. Accordingly, beginning in 1967, MSS developed a standard practice embodying features of the existing standards and published it as MSS SP-76-1970.

During the next few years, ANSI recognition of the AAR and UL standards was withdrawn in favor of SP-76, and in 1975 MSS submitted its standards to Subcommittee B of American National Standards Committee B16 for consideration as an American National Standard. After several modifications and the addition of metric equivalents, the Standard was approved by the Committee, co-secretariat organizations, and ANSI. It was then published with the designation ANSI B16.39-1977.

In 1982 American National Standards Committee B16 was reorganized as an ASME Committee operating under procedures accredited by ANSI. The 1986 edition of B16.39 updated the referenced standards and specifications, established U.S. Customary units as the standard, and provided for electrodeposition as an alternative to hot dipping for any application of zinc coating. Following approval by the Standards Committee and ASME, approval as an American National Standard was given by ANSI on December 31, 1986, with the new designation ASME/ANSI B16.39-1986.

In the 1998 edition of ASME B16.39, reference standards were updated, a quality system program annex was added, and several editorial revisions were made. Following approval by ASME B16 Subcommittee B and the B16 Standards Committee, ANSI approved this American National Standard on November 20, 1998.

In this edition, metric units are now shown as the primary units in the body text and tables with U.S. Customary units shown in parentheses or in separate tables or in an Appendix. The *D* min. values in Table 3 have been replaced with the L2 values (external thread length) from ASME B1.20.2M-2006, *Pipe Threads, 60 deg, General Purpose* and the *D* min. values in Table I-3 have been replaced with the L2 values from ASME B1.20.1-1983, *Pipe Threads General Purpose (Inch)*.

Following approval by the B16 Standards Committee, ASME B16.39-2009 was approved as an American National Standard by ANSI on April 13, 2009.

ASME B16 COMMITTEE
Standardization of Valves, Flanges, Fittings, and Gaskets

(The following is the roster of the Committee at the time of approval of this Standard.)

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General. ASME Standards are developed and maintained with the intent to represent the consensus of concerned interests. As such, users of this Standard may interact with the Committee by requesting interpretations, proposing revisions, and attending Committee meetings. Correspondence should be addressed to:

Secretary, B16 Standards Committee
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As an alternative, inquiries may be submitted via e-mail to: SecretaryB16@asme.org.

Proposing Revisions. Revisions are made periodically to the Standard to incorporate changes that appear necessary or desirable, as demonstrated by the experience gained from the application of the Standard. Approved revisions will be published periodically.

The Committee welcomes proposals for revisions to this Standard. Such proposals should be as specific as possible, citing the paragraph number(s), the proposed wording, and a detailed description of the reasons for the proposal, including any pertinent documentation.

Interpretations. Upon request, the B16 Standards Committee will render an interpretation of any requirement of the Standard. Interpretations can only be rendered in response to a written request sent to the Secretary of the B16 Standards Committee.

The request for an interpretation should be clear and unambiguous. It is further recommended that the inquirer submit his/her request in the following format:

Subject:	Cite the applicable paragraph number(s) and the topic of the inquiry.
Edition:	Cite the applicable edition of the Standard for which the interpretation is being requested.
Question:	Phrase the question as a request for an interpretation of a specific requirement suitable for general understanding and use, not as a request for an approval of a proprietary design or situation. The inquirer may also include any plans or drawings that are necessary to explain the question; however, they should not contain proprietary names or information.

Requests that are not in this format may be rewritten in the appropriate format by the Committee prior to being answered, which may inadvertently change the intent of the original request.

ASME procedures provide for reconsideration of any interpretation when or if additional information that might affect an interpretation is available. Further, persons aggrieved by an interpretation may appeal to the cognizant ASME Committee or Subcommittee. ASME does not "approve," "certify," "rate," or "endorse" any item, construction, proprietary device, or activity.

Attending Committee Meetings. The B16 Standards Committee regularly holds meetings, which are open to the public. Persons wishing to attend any meeting should contact the Secretary of the B16 Standards Committee.

MALLEABLE IRON THREADED PIPE UNIONS

Classes 150, 250, and 300

1 SCOPE

1.1 General

This Standard covers threaded malleable iron unions, Classes 150, 250, and 300. It also contains provisions for using steel for NPS $\frac{1}{8}$ unions. This Standard includes

(a) design
(b) pressure–temperature ratings
(c) size
(d) marking
(e) materials
(f) joints and seats
(g) threads
(h) hydrostatic strength
(i) tensile strength
(j) air pressure test
(k) sampling
(l) coatings
(m) dimensions

Mandatory Appendix I provides tables in U.S. Customary units.

1.2 References

Standards and specifications adopted by reference in this Standard are shown in Mandatory Appendix II, which is part of this Standard. It is not considered practical to identify the specific edition of each referenced standard and specification in the text, when referenced. Instead, the specific editions of the referenced standards and specifications are listed in Mandatory Appendix II.

1.3 Quality Systems

Nonmandatory requirements relating to the fitting manufacturer's quality system programs are described in Nonmandatory Appendix A.

1.4 Relevant Units

This Standard states values in both SI (metric) and U.S. Customary units. These systems of units are to be regarded separately. Within the text, the U.S. Customary units are shown in parentheses or in separate tables. The values stated in each table are not exact equivalents; therefore, it is required that each system of units be used independently of the other. Combining values from the two systems may constitute nonconformance with the Standard.

1.5 Service Conditions

Criteria for selection of materials suitable for particular fluid service are not within the scope of this Standard.

1.6 Convention

For the purpose of determining conformance with this Standard, the convention for fixing significant digits where limits, maximum and minimum values are specified, shall be rounded as defined in ASTM E 29. This requires that an observed or calculated value shall be rounded off to the nearest unit in the last right-hand digit used for expressing the limit. Decimal values and tolerance do not imply a particular method of measurement.

1.7 Denotation

1.7.1 Pressure Rating Designation. Class, followed by a dimensionless number, is the designation for pressure–temperature ratings as follows:

Class	150	250	300

1.7.2 Size. NPS, followed by a dimensionless number, is the designation for nominal fitting size. NPS is related to the reference nominal diameter, DN, used in international standards. The relationship is, typically, as follows:

NPS	DN
$\frac{1}{4}$	8
$\frac{1}{2}$	15
1	25
$1\frac{1}{4}$	32
$1\frac{1}{2}$	40
2	50
$2\frac{1}{2}$	65
3	80
4	100

2 DESIGN

The complete union shall consist of a tail or male part, a head or female part, and a union nut. The type of joint may be ball-to-cone, ball-to-ball, or ball-and-socket with metal-to-metal seating surfaces of iron, copper, or copper alloy. The threaded ends shall be male or female pipe threads. The head or female part may be furnished as a coupling, an elbow, or a tee.

Table 1 Pressure–Temperature Ratings

Temperature, °C	Pressure, bar		
	Class 150 Unions	Class 250 Unions	Class 300 Unions
−29 to 66	20.7	34.5	41.4
100	17.5	30.6	37.5
125	15.2	27.7	34.6
150	12.9	24.8	31.7
175	10.6	22.0	28.9
200	8.2	19.1	26.0
225	5.9	16.2	23.1
232	5.2	...	...
250	...	13.4	20.3
275	...	10.5	17.4
288	...	9.0	15.9

GENERAL NOTES:
(a) 1 bar = 14.5 psi = 100 kPa
(b) $°C = \frac{°F - 32}{1.8}$

Table 2 Tensile Strength of Unions

NPS	Ultimate Load, kN		
	Class 150	Class 250	Class 300
1/8	11	11	18
1/4	17	17	27
3/8	24	24	36
1/2	34	34	45
3/4	47	47	62
1	69	69	80
1 1/4	95	95	100
1 1/2	115	115	125
2	135	135	180
2 1/2	155	155	245
3	180	180	335
4	220	220	490

3 PRESSURE–TEMPERATURE RATINGS

(a) Pressure–temperature ratings are shown in Table 1 and Table I-1.

(b) Unions with copper or copper alloy seats are not intended for use where temperature exceeds 232°C (450°F).

(c) All ratings are independent of the contained fluid and are the maximum pressures at the tabulated temperatures. Intermediate ratings may be obtained by linear interpolation between the temperatures shown.

(d) The temperatures shown for the corresponding pressure rating shall be the material temperature of the pressure-retaining structure. It may be assumed that the material temperature is the same as the fluid temperature. Use of a pressure rating at a material temperature other than that of the contained fluid is the responsibility of the user and subject to the requirements of any applicable code.

4 SIZE

4.1 Nominal Pipe Size

As applied in this Standard, the use of the phrase "nominal pipe size" or the designation NPS followed by a dimensionless number is for the purpose of identifying the end connection of unions. The number is not necessarily the same as the fitting inside diameter. The connecting pipe dimension can be found in ASME B36.10M.

5 MARKING

Unions shall be marked on the nut with the manufacturer's name or trademark and nominal pressure class except on bar stock unions, where marking is impractical. Additional markings permitted by MSS SP-25 may be used.

6 MATERIALS

(a) The mechanical properties of the malleable iron castings shall be at least equal to those specified in ASTM A 197.

(b) Steel bar stock having a yield strength of not less than 207 MPa (30 ksi) may be substituted for malleable iron in NPS 1/8 unions.

(c) Insert rings may be of suitable copper or copper alloy. Where copper alloy seats are furnished, either the head or tail part of unions produced from bar stock may be solid copper alloy. Such parts must meet the tensile strength requirements listed in Table 2 and Table I-2.

7 JOINTS AND SEATS

Inserts shall be secured into the ends to become a permanent part of them with no signs of cracking. Inserted seat rings shall be of sufficient width to allow ample bearing for the seating of the male end.

8 THREADING OF PIPE ENDS

8.1 Types of Threads

Pipe ends of head and tail parts shall be threaded with taper pipe threads (ASME B1.20.1) except that NPS 1/8 unions made from bar stock may have NPSC internal straight pipe threads.

8.2 Tolerances

The variation in taper threading shall be limited to one turn large and one turn small from the gaging face of the ring and gaging notch on the plug when using working gages.

The reference point for the internal product thread is the starting end of the fitting, providing the chamfer does not exceed the major diameter of the internal thread. When a chamfer on the product thread exceeds this limit, the reference point becomes the last thread scratch on the chamfer cone. Allowance must be made for depth of counterbore on counterbored fittings.

9 HYDROSTATIC STRENGTH

Assembled unions shall be capable of withstanding, without rupture or leakage through the shell or at the union joint, an internal hydrostatic pressure of five times the cold 66°C (150°F) pressure rating for 1 min.

10 TENSILE STRENGTH

(a) Assembled unions shall be capable of withstanding, without rupture, the tensile loads shown in Table 2 and Table I-2.

(b) Tests shall be conducted by attaching threaded steel bars or pipe to each end of the union using the pipe threads. Bars or pipe are to be secured in a tensile testing machine. Load shall be increased at a uniform rate until the tensile load is attained.

11 AIR PRESSURE TEST

Assembled unions selected in accordance with section 12 shall be tested with air at a minimum pressure of 2.8 bar (40 psi).

12 SAMPLING FOR AIR PRESSURE TEST

A random sample of unions representative of the production lot shall be submitted for testing in accordance with section 11. The average outgoing quality level (AOQL), as defined in ANSI/ASQ Z1.4, of the established acceptable sampling plans used shall not exceed 2%. A *lot*, for purposes of this Standard, is defined as the number of unions of the same size, design, and pressure rating submitted for testing at any one time.

13 COATINGS

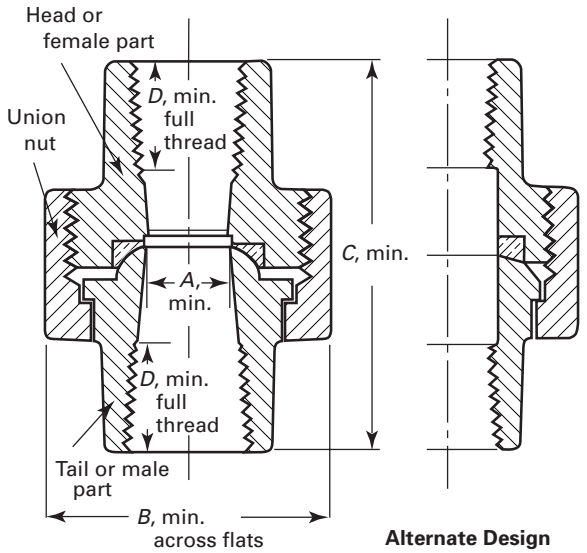
13.1 Malleable Iron Unions

When malleable iron unions are zinc coated, they shall be hot dipped in accordance with ASTM A 153 or have an electrodeposited zinc coating conforming to ASTM B 633, Type 1, Service Condition 4. Hot dipped coatings shall be a minimum thickness of 86 μm (0.0034 in.) and applied prior to threading. Electrodeposited zinc shall be a minimum thickness of 25 μm (0.001 in.) and may be applied either before or after threading.

13.2 Steel Unions

NPS $\frac{1}{8}$ unions made from steel bar, per para. 6(b) of this Standard, may be either uncoated or have an electrodeposited zinc coating conforming to ASTM B 633, Type 1, Service Condition 4. The electrodeposited zinc coatings may be applied either before or after threading.

Table 3 SI Dimensions of Class 150 Malleable Iron Threaded Unions



NPS	A, Min.	B, Min.	C, Min.	D, Min.
$\frac{1}{8}$	5.5	23.5	32.0	6.7
$\frac{1}{4}$	9.0	28.0	36.5	10.2
$\frac{3}{8}$	13.0	32.0	41.0	10.4
$\frac{1}{2}$	15.5	37.0	43.5	13.6
$\frac{3}{4}$	20.5	43.5	49.5	13.9
1	25.5	52.5	52.5	17.3
$1\frac{1}{4}$	33.5	63.5	57.5	18.0
$1\frac{1}{2}$	39.5	71.5	61.0	18.4
2	51.5	86.5	70.0	19.2
$2\frac{1}{2}$	60.5	104.5	82.0	28.9
3	76.0	120.5	89.0	30.5
4	102.5	152.5	98.0	33.0

GENERAL NOTE: Dimensions are in millimeters.

13.3 Union Seating Surfaces

Union seating surfaces shall not be coated.

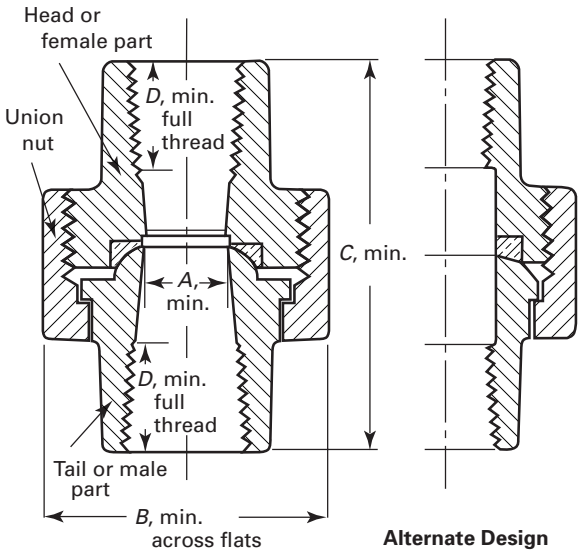
13.4 Other Coatings

Other coatings, specified by the purchaser, shall be furnished meeting the agreed requirements. Copper or copper alloy seats shall not have a zinc coating.

14 DIMENSIONS

Dimensions in millimeters are given in Tables 3 through 5. Dimensions in inches are given in Tables I-3 through I-5.

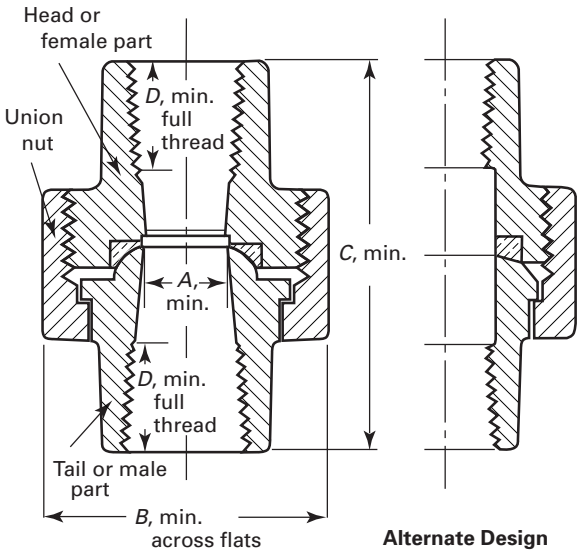
Table 4 SI Dimensions of Class 250 Malleable Iron Threaded Unions



NPS	A, Min.	B, Min.	C, Min.	D, Min.
1/8	5.5	23.5	32.0	7.5
1/4	7.5	28.5	39.5	11.0
3/8	10.5	32.0	43.5	12.0
1/2	13.5	37.0	46.0	14.5
3/4	19.0	43.5	52.5	16.5
1	24.0	52.5	58.5	19.0
1 1/4	32.5	65.5	66.5	21.5
1 1/2	38.0	73.5	70.5	22.0
2	49.0	88.5	79.5	25.5
2 1/2	59.0	105.5	89.5	29.5
3	73.5	126.0	97.5	31.0
4	97.0	164.5	111.5	34.0

GENERAL NOTE: Dimensions are in millimeters.

Table 5 SI Dimensions of Class 300 Malleable Iron Threaded Unions



NPS	A, Min.	B, Min.	C, Min.	D, Min.
1/8	5.5	23.5	32.0	7.5
1/4	7.5	34.0	39.5	11.0
3/8	10.5	38.0	43.5	12.0
1/2	13.5	44.5	46.0	14.5
3/4	19.0	54.5	54.0	16.5
1	24.0	63.0	58.5	19.0
1 1/4	32.5	76.5	67.5	21.5
1 1/2	38.0	83.5	72.5	22.0
2	49.0	100.5	82.0	25.5
2 1/2	59.0	120.0	84.5	29.5
3	73.5	136.5	104.0	31.0
4	97.0	178.0	113.5	34.0

GENERAL NOTE: Dimensions are in millimeters.

MANDATORY APPENDIX I
DIMENSIONS AND PRESSURE RATINGS OF UNIONS IN U.S. CUSTOMARY UNITS

This Appendix provides tables of the standard inch dimensions and pressure ratings for unions.

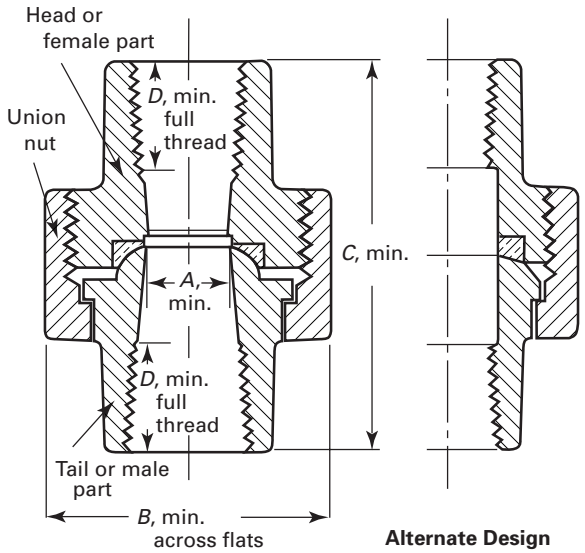
Table I-1 Pressure–Temperature Ratings

Temperature, °F	Pressure, psi		
	Class 150	Class 250	Class 300
−20 to 150	300	500	600
200	265	455	550
250	225	405	505
300	185	360	460
350	150	315	415
400	110	270	370
450	75	225	325
500	...	180	280
550	...	130	230

Table I-2 Tensile Strength of Unions

NPS	Ultimate Load, lbf		
	Class 150	Class 250	Class 300
1/8	2,500	2,500	4,000
1/4	3,800	3,800	6,000
3/8	5,300	5,300	8,000
1/2	7,700	7,700	10,000
3/4	10,600	10,600	14,000
1	15,500	15,500	18,000
1 1/4	21,300	21,300	23,000
1 1/2	25,800	25,800	28,000
2	30,000	30,000	40,000
2 1/2	35,000	35,000	55,000
3	40,000	40,000	75,000
4	50,000	50,000	110,000

Table I-3 Dimensions of Class 150 Malleable Iron Threaded Unions

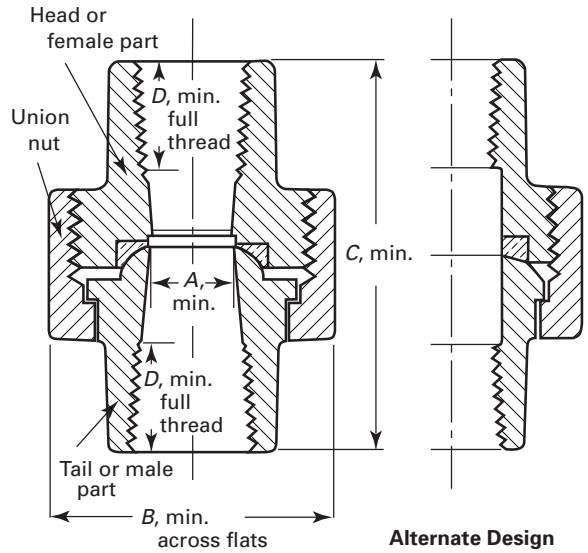


Alternate Design

NPS	A, Min.	B, Min.	C, Min.	D, Min.
1/8	0.21	0.93	1.26	0.26
1/4	0.36	1.10	1.44	0.40
3/8	0.52	1.26	1.61	0.41
1/2	0.61	1.45	1.72	0.53
3/4	0.80	1.71	1.94	0.55
1	1.00	2.07	2.06	0.68
1 1/4	1.31	2.50	2.26	0.71
1 1/2	1.55	2.82	2.41	0.72
2	2.03	3.41	2.75	0.76
2 1/2	2.38	4.12	3.22	1.14
3	3.00	4.75	3.50	1.20
4	4.03	6.00	3.85	1.30

GENERAL NOTE: Dimensions are in inches.

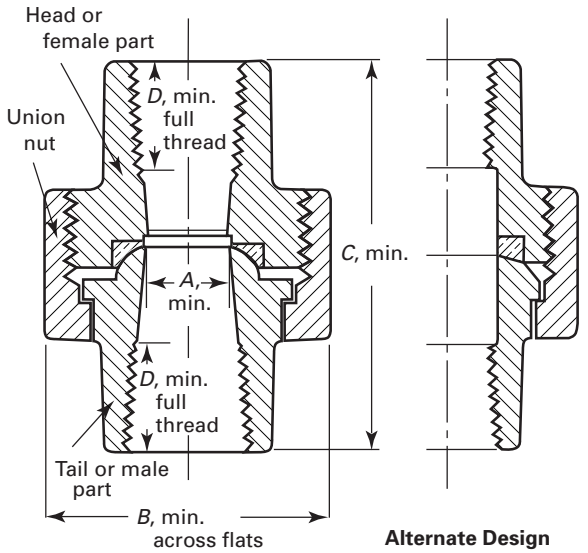
Table I-4 Dimensions of Class 250 Malleable Iron Threaded Unions



NPS	A, Min.	B, Min.	C, Min.	D, Min.
1/8	0.21	0.93	1.26	0.30
1/4	0.30	1.11	1.55	0.43
3/8	0.42	1.26	1.71	0.47
1/2	0.54	1.45	1.81	0.57
3/4	0.74	1.71	2.07	0.64
1	0.95	2.07	2.31	0.75
1 1/4	1.27	2.57	2.62	0.84
1 1/2	1.50	2.89	2.78	0.87
2	1.93	3.48	3.13	1.00
2 1/2	2.32	4.15	3.52	1.17
3	2.90	4.96	3.84	1.23
4	3.82	6.47	4.39	1.33

GENERAL NOTE: Dimensions are in inches.

Table I-5 Dimensions of Class 300 Malleable Iron Threaded Unions



NPS	A, Min.	B, Min.	C, Min.	D, Min.
1/8	0.21	0.93	1.26	0.30
1/4	0.30	1.33	1.55	0.43
3/8	0.42	1.50	1.71	0.47
1/2	0.54	1.76	1.81	0.57
3/4	0.74	2.15	2.12	0.64
1	0.95	2.48	2.31	0.75
1 1/4	1.27	3.02	2.66	0.84
1 1/2	1.50	3.28	2.85	0.87
2	1.93	3.96	3.23	1.00
2 1/2	2.32	4.72	3.33	1.17
3	2.90	5.37	4.09	1.23
4	3.82	7.00	4.47	1.33

GENERAL NOTE: Dimensions are in inches.

MANDATORY APPENDIX II
REFERENCES

The following is a list of publications referenced in this Standard.

ANSI/ASQC Z1.4-2003, Sampling Procedures and Tables for Inspection by Attributes

Publisher: American Society for Quality (ASQ), P.O. Box 3005, Milwaukee, WI 53201-3005 (www.asq.org)

ASME B1.20.1-1983 (R2006), Pipe Threads, General Purpose (Inch)[1]

ASME B36.10M-2004, Welded and Seamless Wrought Steel Pipe[1]

Publisher: The American Society of Mechanical Engineers (ASME), Three Park Avenue, New York, NY 10016-5990; Order Department: 22 Law Drive, Box 2300, Fairfield, NJ 07007-2300 (www.asme.org)

ASTM A 153/A 153M-95, Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM B 633-2007, Specification for Electrodeposited Coatings of Zinc on Iron and Steel

[1] May also be obtained from the American National Standards Institute (ANSI), 25 West 43rd Street, New York, NY 10036.

ASTM A 197/A 197M-2000 (R2006), Specification for Cupola Malleable Iron

Publisher: American Society for Testing and Materials (ASTM), 100 Barr Harbor Drive, West Conshohocken, PA 19428 (www.astm.org)

ISO 9000: 2005, Quality Management Systems – Fundamentals and Vocabulary

ISO 9001: 2000, Quality Management Systems – Requirements

ISO 9004: 2000, Quality Management Systems – Guidelines for Performance Improvements

Publisher: International Organization for Standardization (ISO), 1 ch. de la Voie-Creuse, Case postale 56, CH-1211 Genève 20, Switzerland/Suisse (www.iso.org)

MSS SP-25-1998, Standard Marking System for Valves, Fittings, Flanges, and Unions

Publisher: Manufacturers Standardization Society of the Valve and Fittings Industry (MSS), 127 Park Street, NE, Vienna, VA 22180 (www.mss-hq.org)

NONMANDATORY APPENDIX A
QUALITY SYSTEM PROGRAM

The products manufactured in accordance with this Standard shall be produced under a quality system program following the principles of an appropriate standard from the ISO 9000 series.[1] A determination of the need for registration, certification, or both, of the product manufacturer's quality system program by an independent organization shall be the responsibility of the manufacturer. Detailed documentation demonstrating program compliance shall be available to the purchaser at the manufacturer's facility. A written, summarized description of the program used by the product manufacturer shall be available to the purchaser upon request. The product manufacturer is defined as the entity whose name or trademark appears on the product in accordance with the marking or identification requirements of this Standard.

[1] The series is also available from the American National Standards Institute (ANSI) and the American Society for Quality (ASQ) as American National Standards that are identified by a prefix "Q" replacing the prefix "ISO." Each standard of the series is listed in Mandatory Appendix II.

B16 AMERICAN NATIONAL STANDARDS FOR PIPING, PIPE FLANGES, FITTINGS, AND VALVES

Gray Iron Pipe Flanges and Flanged Fittings (Classes 25, 125, and 250) B16.1-2005
Malleable Iron Threaded Fittings: Classes 150 and 300 . . . . . B16.3-2006
Gray Iron Threaded Fittings: Classes 125 and 250 . . . . . B16.4-2006
Pipe Flanges and Flanged Fittings NPS $\frac{1}{2}$ Through NPS 24 Metric/Inch Standard B16.5-2009
Factory-Made Wrought Buttwelding Fittings B16.9-2007
Face-to-Face and End-to-End Dimensions of Valves B16.10-2000 (R2003)
Forged Fittings, Socket-Welding and Threaded B16.11-2009
Cast Iron Threaded Drainage Fittings B16.12-2009 (R2006)
Ferrous Pipe Plugs, Bushings, and Locknuts with Pipe Threads B16.14-1991
Cast Copper Alloy Threaded Fittings B16.15-2006
Cast Copper Alloy Solder Joint Pressure Fittings B16.18-2001 (R2005)
Metallic Gaskets for Pipe Flanges: Ring-Joint, Spiral-Wound, and Jacketed B16.20-2007
Nonmetallic Flat Gaskets for Pipe Flanges B16.21-2005
Wrought Copper and Copper Alloy Solder Joint Pressure Fittings B16.22-2001 (R2005)
Cast Copper Alloy Solder Joint Drainage Fittings: DWV B16.23-2002 (R2006)
Cast Copper Alloy Pipe Flanges and Flanged Fittings: Classes 150, 300, 600, 900, 1500, and 2500 . . . . . B16.24-2006
Buttwelding Ends B16.25-2007
Cast Copper Alloy Fittings for Flared Copper Tubes B16.26-2006
Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings — DWV B16.29-2007
Manually Operated Metallic Gas Valves for Use in Gas Piping Systems up to 125 psi
(Sizes NPS $\frac{1}{2}$ Through NPS 2) B16.33-2002 (R2007)
Valves — Flanged, Threaded, and Welding End B16.34-2004
Orifice Flanges B16.36-2006
Large Metallic Valves for Gas Distribution Manually Operated, NPS $2\frac{1}{2}$ (DN 65)
to NPS 12 (DN 300), 125 psig (8.6 bar) Maximum B16.38-2007
Malleable Iron Threaded Pipe Unions: Classes 150, 250, and 300 . . . . . B16.39-2009
Manually Operated Thermoplastic Gas Shutoffs and Valves in Gas Distribution Systems B16.40-2008
Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300 . . . . . B16.42-1998 (R2006)
Manually Operated Metallic Gas Valves for Use in Aboveground Piping Systems Up To 5 PSI B16.44-2002 (R2007)
Cast Iron Fittings for Sovent® Drainage Systems B16.45-1998 (R2006)
Large Diameter Steel Flanges NPS 26 Through NPS 60 Metric/Inch Standard B16.47-2006
Steel Line Blanks B16.48-2005
Factory-Made Wrought Steel Buttwelding Induction Bends for Transportation and Distribution Systems B16.49-2007
Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings B16.50-2001 (R2008)

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ISBN-10: 0-7918-3200-7





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Appendix G

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Flaring Hard Brake Lines Made Easy

Posted on May 24, 2022

Brake Tech hard lines How To Install

With Some Practice, You Can Flare Lines with Flair

One of the most difficult little detail jobs in the mechanics of building a vehicle is creating custom length hard brake lines. For all but the most popular models, you eventually have to custom bend, cut, and flare hard metal lines to plumb the master cylinder to brake calipers. But with a bit of practice, and the right tools, it isn't that difficult to make professional, leak free flares.

For the sake of simplicity, and to eliminate points of failure, you should always try to plumb long straight runs of line with as few junctions and adapter fittings as possible. Of course, that is easier said than done. You can buy a 25-foot-long brake line, but often you can't easily run it unbroken from the rear axle junction block to the master cylinder.

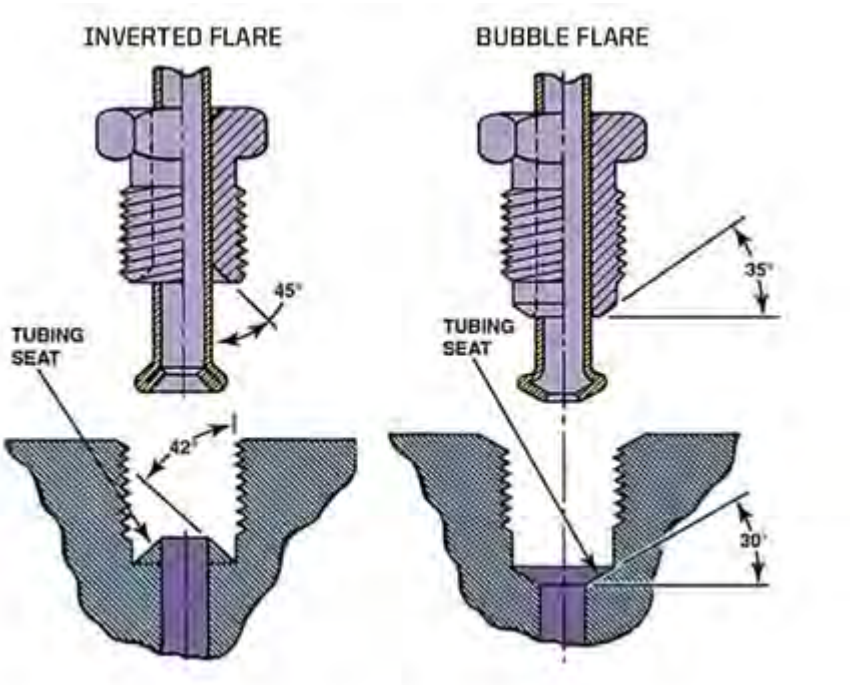
There are basically three materials brake line tubing is made out of: steel, stainless steel, and cupronickel. Steel is the least expensive and typically available at your local auto parts store in lengths from about 10-inches to 5-feet, flaring and bending it is about medium difficulty, but it does rust. Stainless steel last forever and can often be found in pre-bent, pre-sized lines for popular cars, but it is more expensive and hard to bend and flare. Cupronickel is a nickel-copper alloy that is softer than steel, bends easy and doesn't rust, flaring it is easy and it is less expensive than stainless. If you are plumbing a whole car, cupronickel makes forming custom line easy, so that is what we used in our project.

Chances are no matter what length brake line you need, the standard lengths available from your local auto parts store are going to be just a little too long or short, and you are going to have to cut and flare a custom length yourself. Here's some information and advice, based on our years of installing brakes.

Types of Flare

There are two types of flair usually found on OEM brake lines and a third found in custom and racing vehicles. No thread sealing tape or paste is needed with flare fittings because the seal is between the flared line and a corresponding seat on the other side. No matter which type you are using, be careful not to overtighten them and ruin the seat in the caliper, master cylinder, or other connection (this is one reason why Wilwood uses banjo bolts or pipe thread for most connections, with easily replaceable adapter fittings).

Inverted Flare aka Double Flair - Technically, this is the S.A.E. (Society of Automotive Engineers) 45-degree double inverted flare. The end of the metal line is flared wider, then folded back in on itself to create a stronger flare for high-pressure applications, namely brake fluid. When done correctly, this concave flare is a perfect 45-degree angle and seals against a

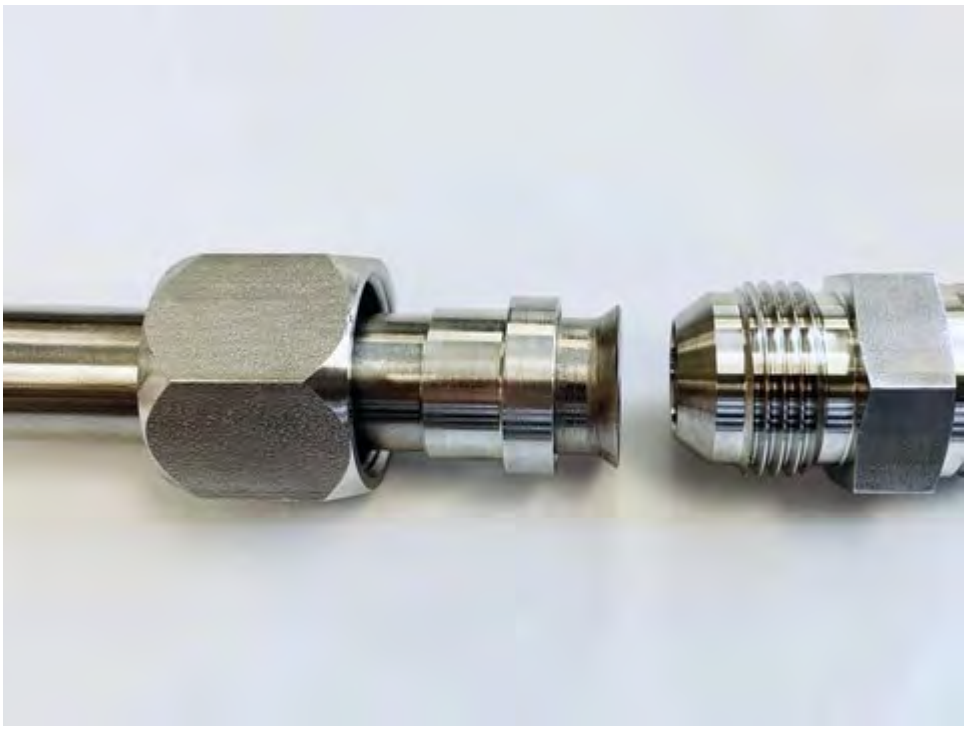


corresponding, convex seat.

Most classic American cars use hard brake lines with this type of flare. Fuel, power brake, and transmission fluid lines sometimes use single flare ends, because they operate under lower internal pressure, and are larger diameter, and therefore stronger lines.

Bubble Flare - Technically, this is the D.I.N./I.S.O. (Deutsche Institut für Normung/International Organization for Standardization) bubble flare. The end of the line is mushroomed out, and folded back, but not all the way, creating a rounded end. There is also a similar S.A.E. bubble flare that mostly differs where the fitting presses on it. Bubble flairs seat into a concave surface in the corresponding part it is being connected to.

You typically find bubble flares on European and some Asian and modern American cars and trucks.



AN Fittings - These were developed by the American military to standardize things between equipment and literally stand for Army Navy. These are the fittings on most braided stainless lines and feature a 37-degree flared end. They are seldom applied directly to hard lines, but the tools exist to do it. The issue is that the AN male threaded fittings typically have a convex flare so that the corresponding concave flare hard line would need a female threaded fitting.

AN fittings are found on military vehicles, of course, and all manner of high-performance machines. Typically adapters mate the AN fitting to an inverted or bubble flare line. You can also flare hard lines to the 37-degree angle to mate with AN, as long as you have the correct hard line fitting.

Flaring Tools

We will concentrate on the tools to make double flared lines since those are the most common. Most of these tools can also make other types of flares with a change of the die.



Wingnut Type - These are the least expensive, and you have probably seen them at your local auto parts store. Unfortunately, it is nearly impossible to make a good flare with the inexpensive



the inexpensive (typically about $30) version you find many places. If you are only flaring 3/16" mild steel tubing, you should be able to do it with one of these with a bit of practice.

Do a little bit of research online, and you will see in customer reviews that some examples struggle to get three stars, while others consistently rate more than four. Quality control is sketchy on the generic versions, and often they don't hold the brake line tight enough for a proper flare. You really do get what you pay for in this instance, and the $100 you spend now will save you much frustration later.



On-Car Type - Not as common as the wingnut type, but working on the same principle is the on-car type of flaring tool. These are more compact than the others and were created for cutting and replacing lines while working under a car in limited space. They often cost less than the high-quality wingnut type, but only work on one diameter of brake line per tool.

You don't have to use these on the car, but they have a handle to give you enough leverage to use it without a bench vise. You can still use it with a vise if you prefer. Since most cars use the same size tubing everywhere, these tools are a bit of a bargain.



Lever Type - Much quicker than the two previous is the lever type of flaring tool, which instead of a screw has a long lever to provide enough force to make the flair. These often cost in the neighborhood of $200, and do require a bench vise. The advantage is that instead of



tightening a screw, changing the die, then tightening the wingnut again, you pull the lever, release and rotate the tool to the next die, then pull it again. It even has a die to set the tube at the perfect length before flaring.

If you are going to be building more than one car in your lifetime, the savings in time (especially time spent trying again after a botched flare), plus the better quality of the flares are worth the extra money invested.



Hydraulic Type - The hydraulic brake line flaring tool is what the professionals use. It is a handheld version of similar machines used in factories where lines are made for production cars. This works similarly to the lever type, but incorporates a hydraulic piston and pump handle for more leverage in a compact package. These are great for flaring lines already installed on the car as well, and you don't need a bench vise.

The downside to the hydraulic type is they are often more than $300, but if you are the sort who is going to plumb an entire car, with fuel, transmission, brake, and other lines, this is the tool you want.

Tips For Making Perfect Flairs

It can be very frustrating when you come down to the final stage of a project and only have to plumb it to be done, but can't seem to get the brake lines right. Here are some tips to make your flares better, though it will still take practice and quality tools to make them perfect.

Straight Clean Cuts - in order to get a good double or bubble flare on a line, you have to start with a perfectly uniform, square end on the hard line. Never use a hacksaw. Use a tubing cutter with rollers and a round blade that clamps on and rotates until it cuts through. These tubing cutters are inexpensive, and you may find the cutting wheel becomes dull with time and needs to be replaced after a few projects, especially if you are making stainless lines.



Deburr the Line, Inside and Out - Most tubing cutters have a

pointy blade for deburring the inside of the tube, but a dedicated deburring tool works better. Clean the outside of the tube as well with a wire brush, fine sandpaper, or Scotch-Brite so the sealing surface of the flare is smooth after you fold it back.



DON'T FORGET THE NUT! - At some point, everybody makes a perfectly formed flare, only to discover they have forgotten to slide the brake line fitting on the line before making it. Or, slide the nut too far and trapped it around a bend in the tube. Even worse than forgetting the fitting is putting it on backwards. Double-check your work before flaring.



Lubricate the End - In order to get good, smooth flares, it is important that the die slides on the tube easily. Many tools come with a little container of grease to dip the end in before you flair it. Otherwise, a little brake fluid can be used, or other oil, as long as you clean it well afterward.



Measure, Then Clamp - One of the reasons most flares are poorly formed is that there is too much, or not enough, of the line projecting from the clamp. The better tools have an "operation zero" die that sets the depth flush with the face of the die before you clamp the line tightly. On the more basic wingnut type tools, the proper depth can be determined by using the edge of the die; the amount sticking out should match the height of the die.



Routing - This is more important when bending than when flaring, but it is important to keep in mind when measuring. The reason all OEM systems have multiple, gradual bends in the line and loops up to the master cylinder is that the car can flex and move, and brake line needs slack so they don't pull and stress the fittings, or break, as the body and frame flex and move. Also, avoid routing the brake line close to the exhaust and avoid any pinch points or places it might rub against a sharp edge.



How To Flare

like anything that takes a little skill, you need practice before you get good and consistent at it. If you have

never made brake line flares before, buy a spare piece of brake line at your local auto parts store and flare it a few times before you try to make the ones you need on your project.



1) **Measure, Cut and Clean the Line** - The old adage of measure twice, cut once applies here, but don't forget you lose a little length when you flare it.

1a) **DON'T FORGET TO INSTALL THE NUT!**



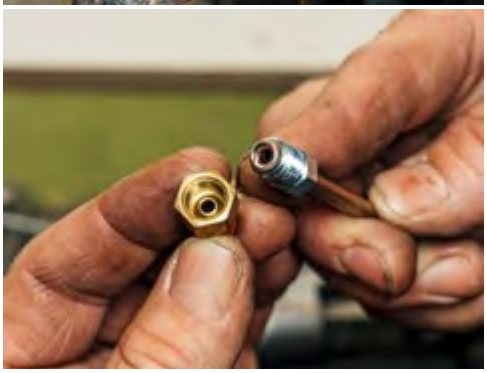
2) **Position Hard Line in Clamp -** If you are using the wingnut type flaring tool, position the tube so it projects from the clamp the proper amount, as measured against the edge of the die. In the other types of tool, the "operation zero" die will set the tube so that just enough is sticking out.



3) **Operation One: The Flare** - With the wingnut type tool, insert the nipple of the adapter into the end of the hard line and tighten the wingnut until it bottoms. With the handheld tool, tighten the **OP 1** die until it bottoms. With the lever or hydraulic tools, pull the lever or pump the jack until the **OP 1** die bottoms.



4) **Operation Two: The Double Flare -** With the wingnut tool, just change the adapter and tighten the wingnut down again and the pointed end will fold the line back in on itself while pressing the other end against the outside of the clamp. For the other tools, switch to the **OP 2** die, and once again press it against the line like you did for **OP 1.**



5) **Clean and Polish** - If you did everything right, you should have nothing left to do except clean up. Make sure any grease and oil is cleaned off the end so it doesn't contaminate your brake fluid. Lapping tools exist to ensure the flare is perfectly shaped to seal properly, but if you formed it right, you shouldn't need anything more than a Scotch-Brite pad. Any cracks, or a misshapen, uneven flare, mean you have to cut it off and flare again, but if there are just small burrs you may be able to save it.

4 comments

Bryan at Wilwood: August 10, 2023



Robert,

If the brake line is 5"-6" away from the header, it should be fine made of either material. I did not know off the top of my head, but a quick search for heat conductivity of metals reveals copper-nickel to have a thermal conductivity of 29, while steel varies all over the place, from a low of 10 to about 60 (higher numbers means it conducts heat more).
More important is going to be keeping the lines as far away from the hot exhaust header as possible, which suggests using the softer metal that is easier to bend.

Robert Brighton: August 09, 2023



I purchased pre-bent steel lines for my build, but need to go custom from the MC to the block on the frame (early Bronco). This runs about 5-6" away from the headers. Would nicopp or steel be better in this application? I know steel is harder, more heat resistant, but it's a tight area that will require a lot of bends. Is nicopp acceptable?

Al Lloyd : February 27, 2023



Great article , makes all process perfectly clear , recommendations are top notch and concise.
I am using wilwood products and wanted to hear from the horses mouth about flare types , frankly I wasn't sure about my selection of tool to make the flares (double) and discovered the tool I am employing is sited in the article ! Woooohooo ! Thank you Wilwood 😎

David Henry: July 21, 2022



Great article, very informative and easily understood. Enjoy the upgraded web site ,lots of great info. Awesome company!!

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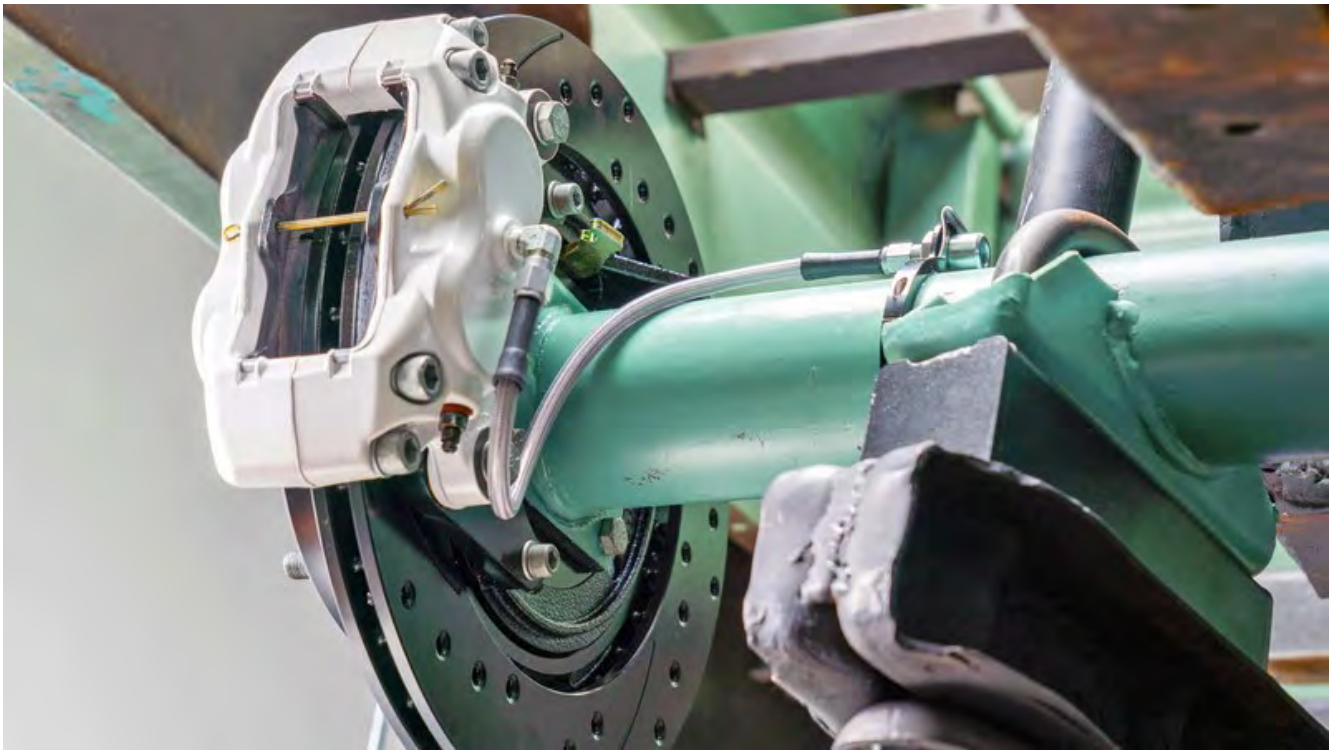


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Appendix H

Technical Information
TI 297P/01/en

Operating Instructions
52012119

Flow Measurement with Primary Devices
deltatop DPO 10, 12, 15 / DPP 10
deltaset DPO 50, 51, 52, 53 / DPP 50

Flowmeter system with orifice plate or Pitot tube and Deltabar S differential pressure transmitter



Deltatop

Deltaset



Application of Deltatop
Deltatop is a compact, ready-to-use flowmeter system. The primary device (orifice plate or Pitot tube) and Deltabar S differential pressure transmitter (with manifold, for steam also with condensate chambers) are readily mounted and optimised using process data supplied by the customer.

Application of Deltaset
Deltaset is the modular flow rate measurement section. The primary device, manifold (and for steam: condensat chambers) are pre-mounted and, with the Deltabar S differential pressure transmitter, optimised to the operating data.

Your benefits
❑ Deltatop and Deltaset
- Complete device, optimised to minimum pressure loss and highest accuracy
- Deltabar S differential pressure transmitter ready adjusted
- Optimum configuration for application
- Display either with flow rate, differential pressure or 0...100% display

❑ Deltatop
- Operational compact version
- No impulse pipes

❑ Deltaset
- Medium temperatures of up to 1000 °C and pressures of up to 400 bar
- Completely modular product range

Endress + Hauser
The Power of Know How

Overview of Contents

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Deltaset selection guide	6	Deltatop versions	25
The measuring system	8	Deltaset versions	42
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Selecting the measuring device

Deltatop or Deltaset?

Device type	Deltatop	Deltaset
Differential pressure transmitter	Deltabar S mounted above manifold on primary device **Compact version**- see page 1	Deltabar S and primary device mounted separately **Separate version** - see page 1
Application	Flow measurement (volume or mass) for liquids, gases or steam	
Nominal diameter of pipe	Orifice plate DN 10 ... DN 1000 (standard) Pitot tube DN 50 ... DN 2000 (optional 12000)	
Process pressure	to PN 160 bar	to PN 400
Process temperature	to 200 °C for gases/liquids to 300 °C for steam (due to the condensat chambers)	to 500 °C for standard materials to 1000 °C for special material
Measuring point	Easily accessible mounting location • Compact version	Difficult to access mounting location • Separate version
Selection guide	Page 4	Page 6

Tab. 1: Selection of optimum device type — Deltatop or Deltaset?

Type overview

	Deltatop	Deltaset
Undivided orifice plate with corner taps	DPO 10E-□□□□□□□ DPO 10A-□□□□□□□	DPO 50E-□□□□□□□ DPO 50A-□□□□□□□
Annular chamber orifice with corner taps		DPO 51E-□□□□□□□ DPO 51A-□□□□□□□
Orifice flange	DPO 12E-□□□□□□□ DPO 12A-□□□□□□□	DPO 52E-□□□□□□□ DPO 52A-□□□□□□□
Orifice plate		DPO 53E-□□□□ DPO 53A-□□□□
Orifice pipe unit	DPO 15E-□□□□□□□ DPO 15A-□□□□□□□	
Pitot tube	DPP 10-□□□□□□□□	DPP 50-□□□□□□□□

Tab. 2: Type name, depending on primary device.
DIN and ANSI versions are available for each orifice plate type. DIN versions have the ending -E, ANSI versions have the ending -A. Example:DPO 10A-... is a standard orifice plate in the ANSI version.

Selection of primary device

Orifice plates

Orifice plates are used with media (steam, gas, liquids) where the viscosity is not too high (limit value 50 mPas = 50 cSt). The versions differ in the tapping point of the differential pressure. The orifice plates with annular chamber tapping give slightly more accurate differential pressure values than the alternatives (orifice plate with corner or flange tapping). The orifice plate with corner tapping (Deltatop DPO 10) is the cheapest version for new installations. Orifice pipe units (Deltatop DPO15) are used for diameters smaller than DN 50.

Pitot tubes

Pitot tubes are primarily used with large pipe diameters (from approx. DN 200 to DN 12000), but, on account of their countless benefits, are also used at smaller diameters. A considerable advantage is their small installation cost and easy expandability are their constant very low static pressure loss. This makes Pitot tubes the sensible choice for installation at a later date (possible as a “flow tap” version without interrupting operation!). As they can be machined from many different materials, and are also suitable for soiled media, they can be used universally.

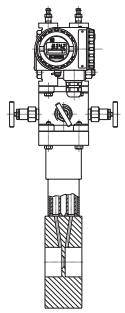
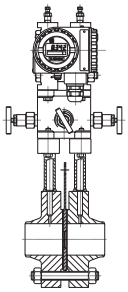
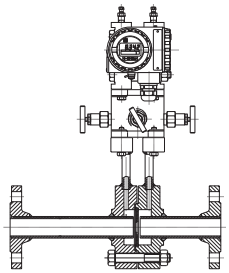
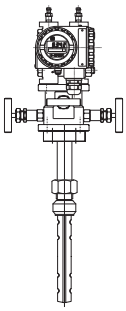
Orifice plate or Pitot tube?

		Orifice plate	Pitot tube
Pipe	Nominal diameter DN	DN 10...DN 2000 DN 10...DN 40: Orifice pipe unit (optionally from DN 4)	DN 25 ... DN 2000 (optionally 12000, single measuring principle for DN > 2,000)
	shape	Round section	Round or square section
Media	State	Steam, gas (also mixtures or moist gases), liquids	
	Max. viscosity	50 mPas (50 cSt)	80 mPas (80 cSt)
	Sensitivity for abrasion	Sharp plate edges can wear away. But: low-cost orifice plate replacement possible	Considerably less than for orifice plate (dynamic pressure in front of probe prevents ingress
	Measures against corrosion	Low-cost through use of corrosion-resistant materials	
	Sensitivity for dirt	Dirt may collect in front of the orifice plate and reduce accuracy	Considerably less than for orifice plate (dynamic pressure in front of probe prevents ingress)
	Inaccuracy at constant density	approx. 1 % of measured value	approx. 1.5 % of measured value
Technical Data	Reproducibility R	0.1 % of max. flow	
	Dynamics	up to 6:1 under constant conditions (p, T)	
	Constant static pressure loss Δw	typically < 1 % of p_{stat} 10 %...80 % of differential pressure Δp relating to β	typically < 1 % of p_{stat} 10 % of calculated differential pressure Δp
	Max. flow velocity v	Liquids up to 12 m/s Gases/steam: up to 60 m/s	Liquids up to 40 m/s Gases/steam: up to 60 m/s
	Min. Reynolds number Re	2.800	4.000
	Typical differential pressure Δp	Liquids 40...600 mbar Gases: 5...200 mbar Steam: 60...2500 mbar	Liquids 5...80 mbar Gases: 1...80 mbar Steam: 3...50 mbar
Installation	Installation type	Open piping, mount with - Adapter flange - Welding neck flange - Measuring flange	Drill piping, mount with - Welding socket and cutting ring screw union - Flange
	Inlet/outlet runs	10/4 x D, dependent on β and obstacles	7/3 x D Less dependent on flow profile than orifice plates due to distribution of bore holes

Tab. 3: Selection of the primary device - orifice plate or Pitot tube

Deltatop selection guide

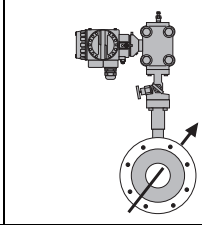
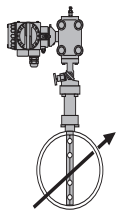
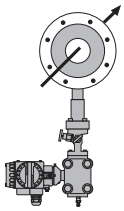
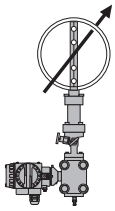
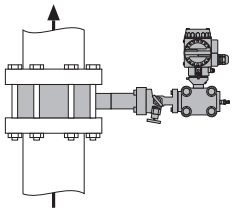
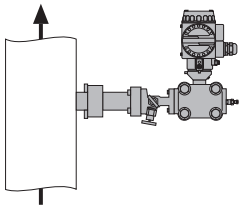
Versions

Primary device	Version Deltatop always incl. manifold; with steam additionally with condensat chambers	
Undivided orifice plate with corner taps	DPO 10E: DN 50...DN 1000 DPO 10A: ANSI 2" ... ANSI 24" to DIN 19205, design type B	 P01-DPO10xxx-14-xx-xx-xx-001
Orifice flange	DPO 12E: DN 50...DN 500 DPO 12A: ANSI 2" ...ANSI 24" to DIN 19214 (Part 1) or ANSI 1636	 P01-DPO12xxx-14-xx-xx-xx-001
Orifice pipe unit	DPO 15E: DN 10...DN 40 DPO 15A: ANSI 1/2" ...ANSI 1 1/2" Orifice plate with piping extension	 P01-DPO15xxx-14-xx-xx-xx- 001
Pitot tube	DPP 10E: DN 25...DN 2000 DPP 10A: ANSI 1" ...ANSI 80"	 P01-DPP10xxx-14-xx-xx-xx-001

Tab. 4: Version of Deltatop
E = DIN version
A = ANSI version

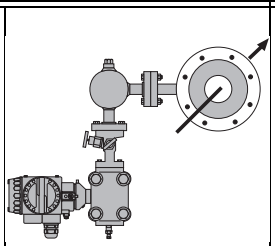
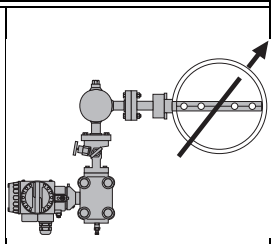
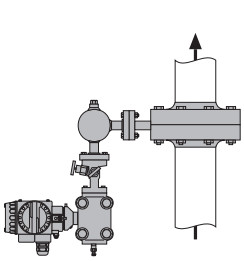
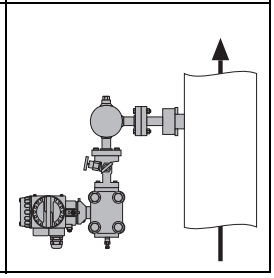
Installation arrangements for Deltatop

Deltatop measuring point for gas/liquids

	Orifice plate		Pitot tube	
Piping horizontal Gas	DPO10E/A-A DPO12E/A-A DPO15E/A-A		DPP 10-A	
Liquids	DPO10E/A-C DPO12E/A-C DPO15E/A-C		DPP 10-C	
Piping vertical Gas Liquids	DPO10E/A-B DPO12E/A-B DPO15E/A-B DPO10E/A-D DPO12E/A-D DPO15E/A-D		DPP10-B DPP10-D	

Tab. 5: Structure of a Deltatop measuring point for liquids and gases
So that there are always constant pressure relationships at the differential pressure transmitter, the pulse lines must always be filled solely with gas or with liquid.
***Piping horizontal:** Arrangement for gas: mounting the differential pressure transmitter above the piping ensures that any condensate always flows towards the piping.*
Arrangement for mediums: installation of the differential pressure transmitter below the piping ensures that any gas bubbles always move towards the piping.
***Vertical piping:** For vapourous liquids, it is recommended that you use Deltaset to avoid gas bubbles in the transmitter flange (which could lead to measuring errors).*

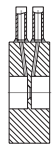
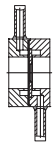
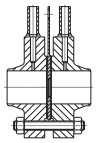
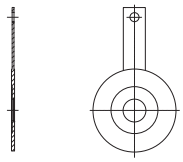
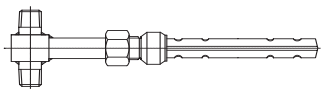
Deltatop measuring point for steam

	Orifice plate		Pitot tube	
Piping horizontal Steam	DPO10E/A-E/F DPO12E/A-E/F DPO15E/A-E/F		DPP 10-K	
Piping Vertical Steam	DPO 10E/A-G/H DPO 12E/A-G/H DPO 15E/F-G/H		DPP 10-L	

Tab. 6: Structure of a Deltatop measuring point for steam
Hot steam must not come into contact with the membrane of the transmitter. To avoid damage through high temperatures, make sure before commissioning that the condensat chambers are completely filled. During installation, make sure that the condensat chambers are aligned symmetrically (same geodetic height). This ensure a constant column of water as the condensing steam forms a constant liquid level in the condensat chambers. With steam, the differential pressure transmitter must always be mounted below the condensat chambers.

Deltaset selection guide

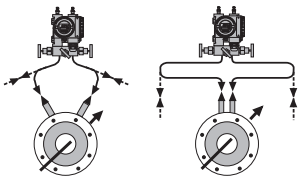
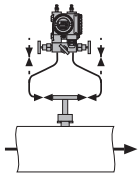
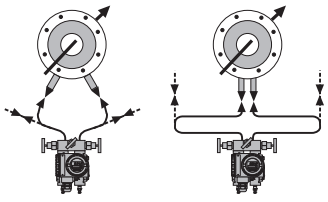
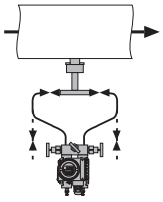
Versions

Primary device	Version	
Undivided orifice plate with corner taps	DPO 50E: DN 50...DN 1000 DPO 50A: ANSI 2" ...ANSI 24" to DIN 19205, design type B	 P01-DPO50xxx-14-xx-x
Annular chamber orifice with corner taps	DPO 51E: DN 50...DN 1000 DPO 51A: ANSI 2" ...ANSI 24" to DIN 19205, design type A	 P01-DPO51xxx-14-xx-
Orifice flange	DPO 52E: DN 25...DN 500 DPO 52A: ANSI 2" ...ANSI 24" to DIN 19214 (Part 1) or ANSI B 16.36	 P01-DPO52xxx-14-80-I
Orifice plate	DPO 53E: DN 50 ... 1000 DPO 53A: ANSI 2" ...ANSI 40"	 P01-DPO53xxx-14-xx-xx-x
Pitot tube	DPP 50E: DN 25...DN 2000 DPP 50A: ANSI 1" ...ANSI 80"	 P01-DPP50xxx-14-xx-x

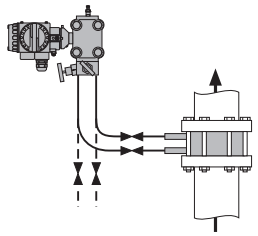
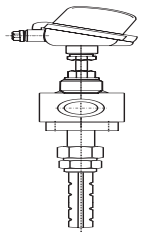
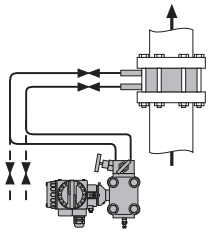
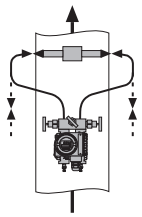
Tab. 7: Versions of Deltaset; E = DIN version / A = ANSI version

Installation arrangements for Deltaset

Deltaset measuring point for gas/liquids

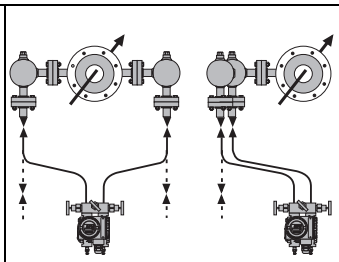
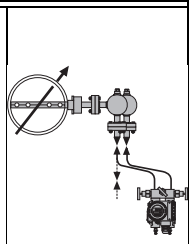
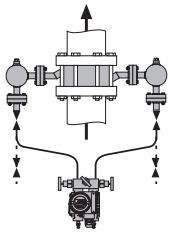
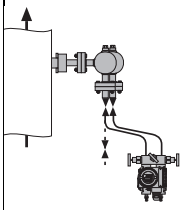
	Orifice plate		Pitot tube	
Piping horizontal Gas	DPO50E/A-A, DPO51E/A-A, DPO52E/A-A		DPP 50-A	
Liquids	DPO50E/A-C, DPO51E/A-C, DPO52E/A-C		DPP 50-C	

Tab. 8: Structure of a Deltaset measuring point for liquids and gases (refer to notes in table 5)

	Orifice plate		Pitot tube	
Piping vertical Gas	DPO50E/A-B DPO51E/A-B DPO52E/A-B		DPP 50-B	
Liquids	DPO50E/A-D DPO51E/A-D DPO52E/A-D		DPP 50-D	

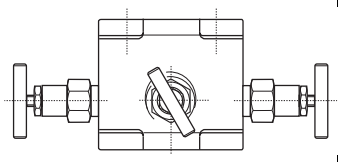
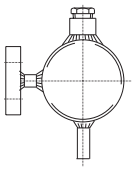
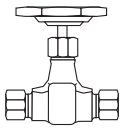
Tab. 8: Structure of a Deltaset measuring point for liquids and gases (refer to notes in table 5)

Deltaset measuring point for steam

	Orifice plate		Pitot tube	
Piping horizontal Steam	DPO50E/A-E DPO51E/A-E DPO52E/A-E		DPP 50-K	
Piping vertical Steam	DPO 50E/A-G/H DPO 51E/A-G/H DPO 52E/A-G/H		DPP 50-L	

Tab. 9: Systematic structure of a Deltaset measuring point for steam (refer to notes in table 6)

Components (Accessories)

manifold	Condensate trap	Shut-off valves
DPM 50 	DPC 50 	DPV 50 
Use always	Use always for steam applications	Use always as shut-off on primary device or as additional rinse or ventilation accesses

Tab. 10: Components for Deltaset

The measuring system

Applications

Differential pressure flow measurement can be used universally. This is true both in the relationship to the pipe diameter (DN 4 to DN 12000) and to the range of media (gases, steam and liquids).

The applications can be basically split into flow measurement for substance currents (= products) and flow measurement for supply currents (= auxiliary material).

Flow measurement with primary devices is particularly used in the following branches:

- Power stations
- Petrochemicals
- Chemicals
- Cement
- Paper/Cellulose
- Biology, pharmaceuticals

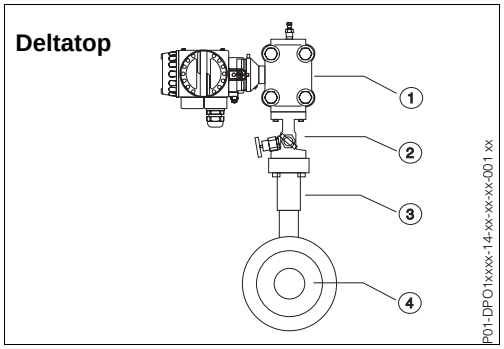
Measuring device

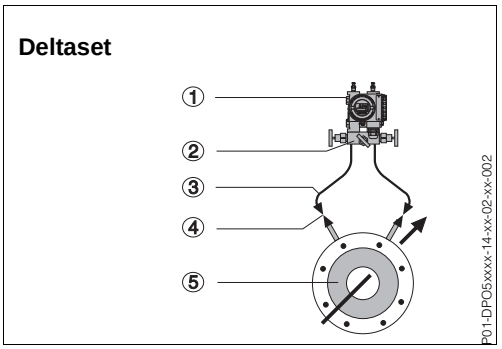
The Deltatop or Deltaset differential pressure flow measuring point consists of several components, the version and assembly depends on the application. The components of the measuring device are:

1. Deltabar S differential pressure transmitter
2. manifold
3. Tapping gland or impulse pipes
4. Shut-off valves (Deltaset)
5. Primary device (orifice plate or Pitot tube)

Two condensat chambers are integrated for steam applications. The applications can be split primarily into the following three criteria:

- Media state: vapourous, gaseous or fluid
- Type of primary device (orifice plate, Pitot tube)
- Process conditions, particularly pressure and temperature



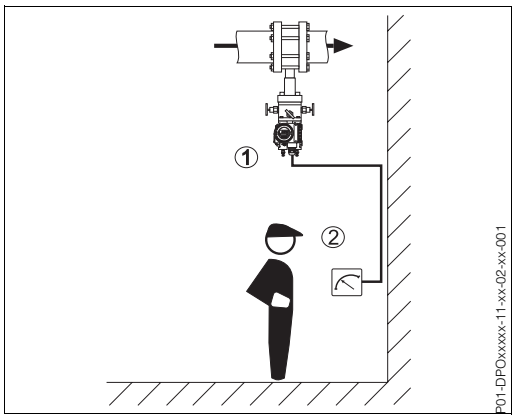


Deltatop with remote display

If you require a separation of the primary device and the measured value display, then there is a low-cost alternative to impulse pipes: Deltatop + remote display. A two-wire signal cable runs from the Deltabar e.g. to the display unit RIA 250 from Endress+Hauser and thus offers:

- Reliable measured value display
- 2 limit relays
- RS-232 interface

① Deltatop
② Display unit

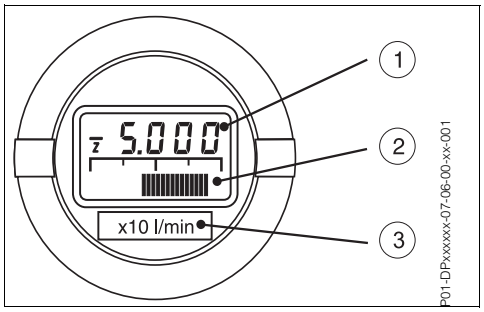


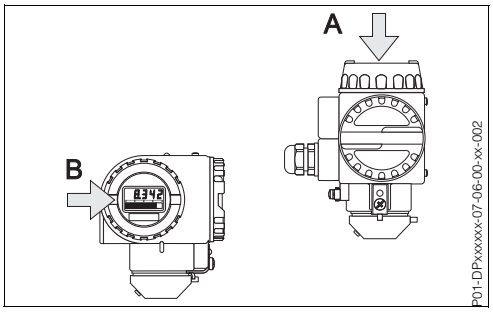
Deltabar S differential pressure transmitter

Deltabar S differential pressure transmitter

The Deltabar S differential pressure transmitter is ordered in addition to Deltatop and/or Deltaset. The scope of supply then comes complete with a mounted Deltabar S.







The display on the Deltabar is selectable - see below, the current differential pressure can be exported to:

① 4 digit digital display
② Bargraph as a trend display (4...20 mA)
③ Inscription specifying the displayed unit

There are two versions for this:
A housing T5 with display at top
B housing T4 with display at side

Deltabar S - benefits at a glance

- High accuracy
- Linearity deviation smaller than 0.1 % of the span
- In the “Platinum” version, the linearity deviation is less than 0.05 % of the set span
- Long-term drift better than 0.1 % per year or 0.25 % per 5 years
- Process temperatures up to 120 °C as standard
- System pressures up to 420 bar
- Uniform modularity for differential pressure and pressure (Deltabar S, Cerabar S) and all components like sensors, electronics, etc.
- Display module rotatable, with 4-digit digital display, bargraph 4...20 mA and specification of the displayed technical unit
- Simple and safe operation over 4...20 mA, HART, PROFIBUS-PA or Foundation Fieldbus
- Zero and span on site with or without reference pressure
- Function monitoring from sensor to electronics
- Numerous software functions such as characteristics, diagnostic codes, totalizers etc.

Display selection

The Deltabar S is supplied fully set, with a choice of flow, differential pressure or percent display option. You choose the type of display when ordering the primary device (last position of the order code of the orifice plates and Pitot tubes.
Example: DPO 10E-❑❑❑❑❑❑F)

Display option	Version	Characteristic	Inscription	4-digit digital display	Bargraph, 4...20mA current output
			③	①	②
F	Flow values, square root	square root	x 10 l/min	0 ... 1000	0...10,000 l/min
P	Differential pressure values, linear	linear	0...200 mbar	0 ... 200.0	0...200 mbar
S	Adjustment 0...100 %, square root	square root	% (sq.rt, rt. ex.)	0 ... 100,0	0...10,000 l/min
T	Adjustment 0...100 %, linear	linear	% (lin.)	0 ... 100,0	0...200 mbar

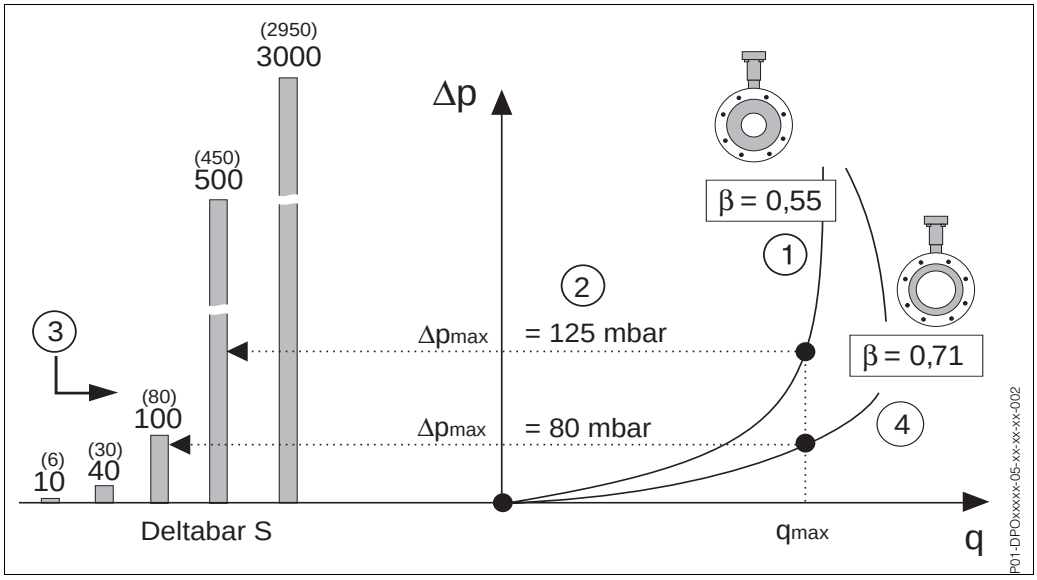
Tab. 11: Display options, numeric example (Columns 5-7) for q = 0...10,000 l/min, Δp_{max} = 200 mbar

Measuring range of the Deltabar sensor

You can obtain good results by choosing the right combination of orifice plate and measuring range. Endress+Hauser optimizes the calculation of the orifice with the selection of the best fitting sensor. The right dynamics should be attained with as little pressure loss as possible (see following chapter).

1. Start with orifice plate characteristic $\beta = 0.55$ (opening ratio)
2. Therefore, at the max. flow q_{max}, there is a max. differential pressure across the orifice plate of e.g. $\Delta p_{max} = 125$ mbar. With the 500 mbar-sensor, this would give an unsuitable combination of measuring cell and orifice plate version.
3. Optimisation: to use the next-smallest sensor, e.g. differential pressure $\Delta p = 80$ mbar for 100 mbar cell
4. Then, the orifice plate characteristic is $\beta = 0.71$

Result: The optimum adjustment of orifice plate calculation and Deltabar sensor minimises the Δp system error and reduces pressure loss.



Ordering the Deltabar S

To optimise Deltatop/Deltaset, order the Deltabar S with the measuring range code (see below). Endress+Hauser does everything else.

Metal cell:

- PMD 235 - ❑❑ 4 8 8 ❑❑❑❑ for stainless steel diaphragm, stat. pressure resistance to 160 bar
- PMD 235 - ❑❑ 5 8 8 ❑❑❑❑ for stainless steel diaphragm, stat. pressure resistance to 420 bar
- PMD 235 - ❑❑ B 8 8 ❑❑❑❑ for Hastelloy-diaphragm, stat. pressure resistance to 160 bar
- PMD 235 - ❑❑ H 8 8 ❑❑❑❑ for Hastelloy-diaphragm, stat. pressure resistance to 420 bar

Ceramic cell:

- PMD 230- ❑❑ 8 8 8 ❑❑❑❑ for ceramic diaphragm, static. pressure resistance to 100 bar

The exact choice of cell nominal operating range (e.g. 100 mbar) is made at the factory on the basis of the Pitot tube calculation or the orifice plate optimisation.

Special case for orifice plate

If you require a particular differential pressure p (e.g. 200 mbar), then order it as follows:

- Metal cell: PMD 235 - ❑❑ x x 9 ❑❑❑❑
- Ceramic cell: PMD 230 - ❑❑ x x 9 ❑❑❑❑

xx stands for the selection of the suitable differential pressure cell, 9 stands for set (lin./rt. ex., from... to..., unit), e.g. set: square root, from 0 to 200 mbar. The orifice plate is then optimised at the factory, so that the required differential pressure is generated at maximum flow.

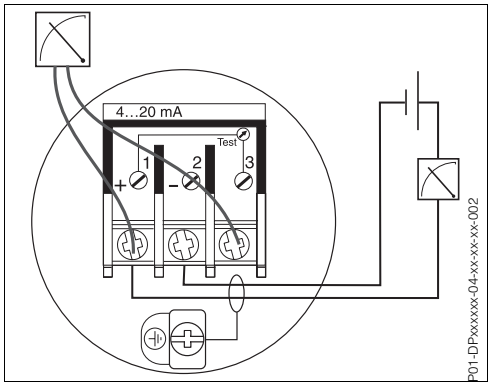
Electrical connection

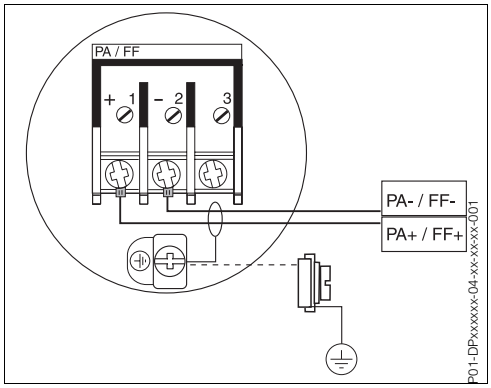
Analogue signal 4...20 mA, HART

For the signal line, use a twisted, screened, two-core cable. The supply voltage in non-hazardous areas is 11.5...45.0 VDC, in hazardous areas 11.5...30VDC.

PROFIBUS-PA or FIELDBUS FOUNDATION

The digital communication signal is transmitted on a bus along a two-core connecting line. The bus line also carries the power supply. For the bus line, use a twisted, screened, two-core cable.





Ambient conditions

- ❏ Ambient temperature: -40...+85 °C
- ❏ Storage temperature: -40...+100 °C
- ❏ Climate class: GPC acc. to DIN 40040
- ❏ Vibration resistance: ±0,1 % (to DIN IEC 68 Part 2-6, relating to sensor span)
- ❏ Ingress protection: IP 65/NEMA 4X
- ❏ Electromagnetic compatibility:
  Interference emission to EN 61326, Equipment Class B;
  Interference immunity to EN 61326, Appendix A (industrial sector), NAMUR-recommendation EMV (NE 21)
  Interference immunity to EN 61000-4-3: 30 V/m

Supplementary Documentation

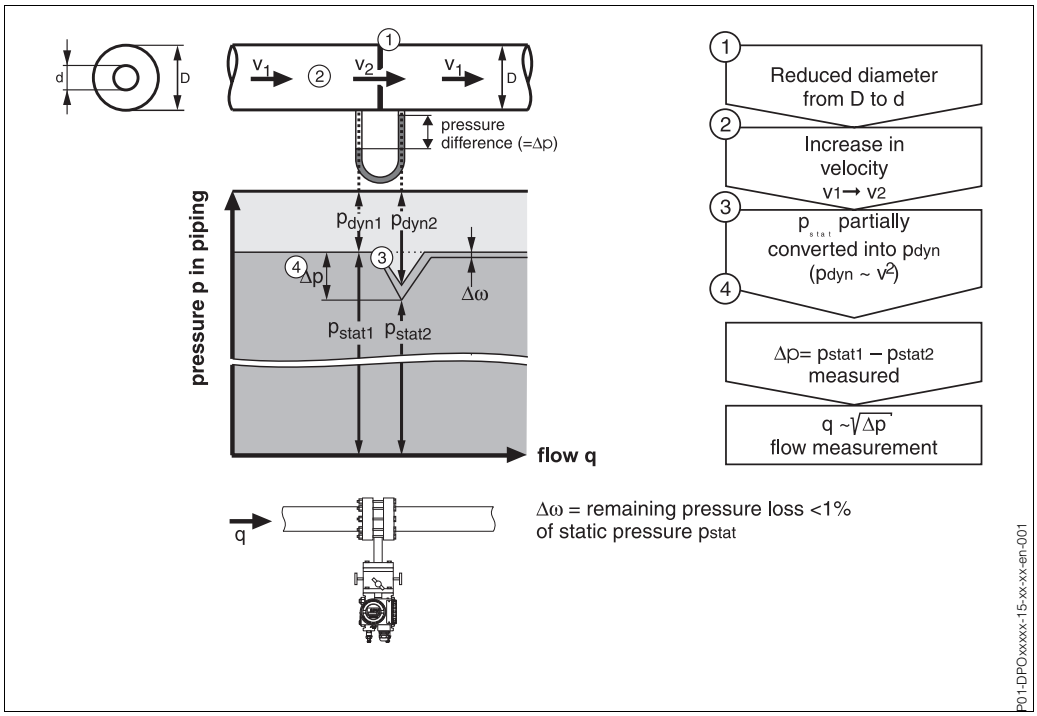
Deltabar S Differential Pressure Transmitter
PMD 230 / 235
Technical Information TI 256P/01/en

Principle and operation

Orifice plate

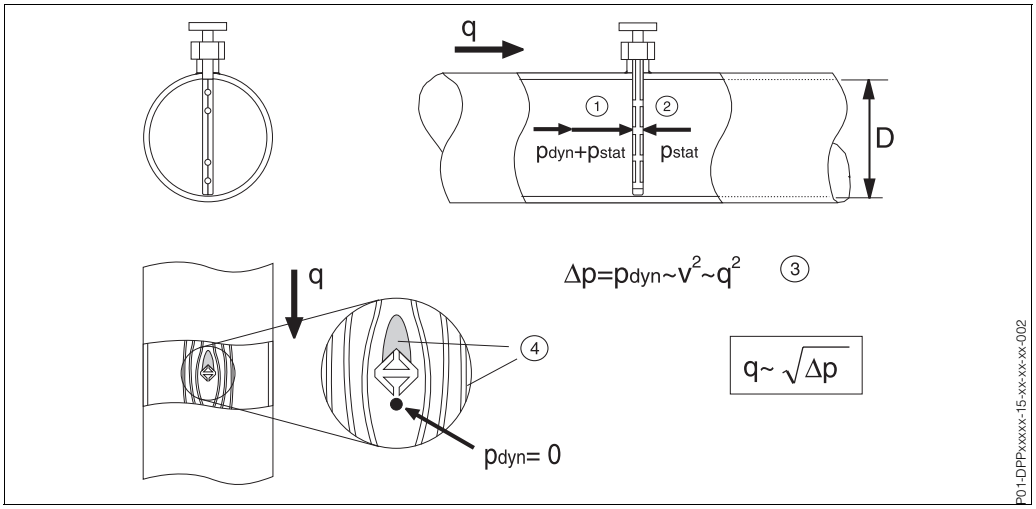
The orifice plate forms a pipe narrowing (diameter d) ①. According to Bernoulli the medium undergoes a velocity increase ② at this point. A small portion of the static pressure p_{stat} is converted into dynamic pressure p_{dyn} ③. This reduction in static pressure is measured using the Deltabar S ④. The differential pressure Δp is proportional to q^2 (q = flow) or. q is proportional to the root of Δp.

Behind the orifice plate, the static pressure reduction (=Δp) is converted back into static pressure. Only a small part (depending on the opening ratio β=d/D) forms a permanent pressure loss Δw. Typically, is Δω is less than 1% of the static pressure p_{stat} in the line.



Pitot tube

The probe is installed in the media line as a pressure sensor. With the flow, the probe records both the static and the dynamic pressure via the probe openings ①. In the minus chamber of the Pitot tube, lying opposite, more or less only the static pressure has any effect, as on this side of the probe the openings are not expose to the dynamic forces of the flow movement ②. The differential pressure corresponds to the dynamic pressure in the pipeline from which the flow can be directly calculated ③. No. ④ shows the path of the flow lines.



Standardisation to ISO 5167-1/A1

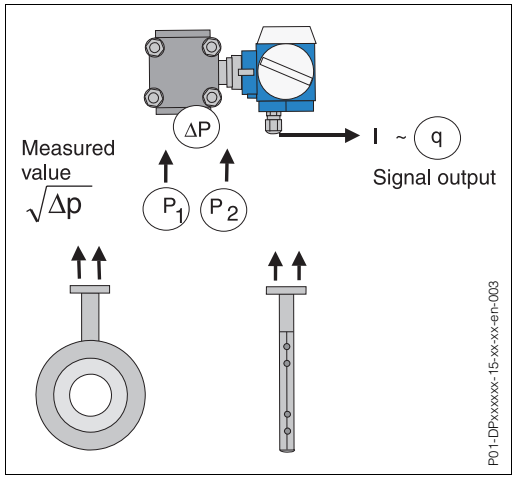
Differential pressure flow measurement is standardised as ISO 5167-1/A1 as the only flow measuring principle in the world. This comprises geometries, arrangements and calculation regulations. The user can therefore rely on a technology used by millions.

The figure on the right shows the main components of a flow rate measuring point. The following are seen as standard:

Orifice plates
DN 50...DN 1000: no orifice plate calibration required (standard values).
DN 4...DN 40: Calibration recommended by standard. With E+H, you can order wet calibration for the orifice plate DPO 15.
Greater than DN 1000: Extrapolation of standard values

Pitot tube
Type calibration. The similarity to valid DIN/ISO standards ensures measurement reliability.

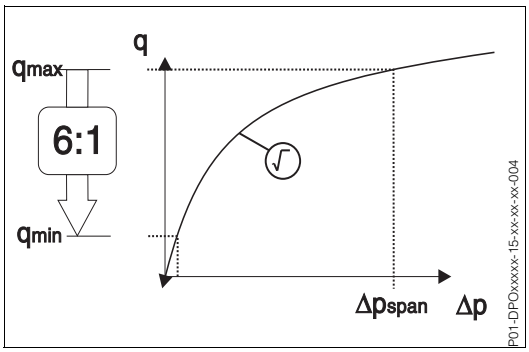
Signal output
The pressure value at the primary device is then turned into a flow-proportional linear current output by a square root characteristic in the transmitter.

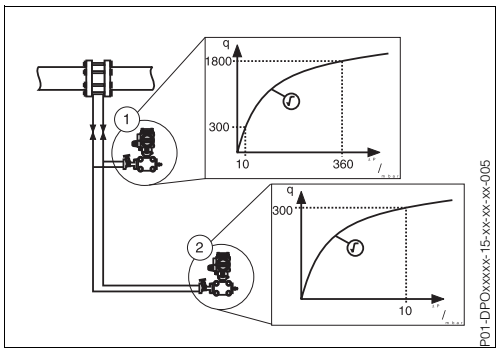


Dynamics

The dynamics provide the ratio of the maximum flow to the minimum flow. By minimum flow, we understand the smallest measurable flow value at the specified accuracy. If a flowmeter has high dynamics, it can accurately record those flows which are considerably smaller than the maximum flow.

Due to the high resolution of the Deltabar S transmitter, Deltatop and Deltaset can achieve dynamics of typically 6:1 to 3:1. The lower limit is considered as the transition of the square root function to the linearised function (see below left). However, even below this mark, there is still very high reproducibility.





If typical dynamics of between 15:1 and 10:1 are required, then a multiple installation is necessary (see above right). For this, e.g. two Deltabar S are used parallel. This low-cost solution is implemented using the Deltaset concept.

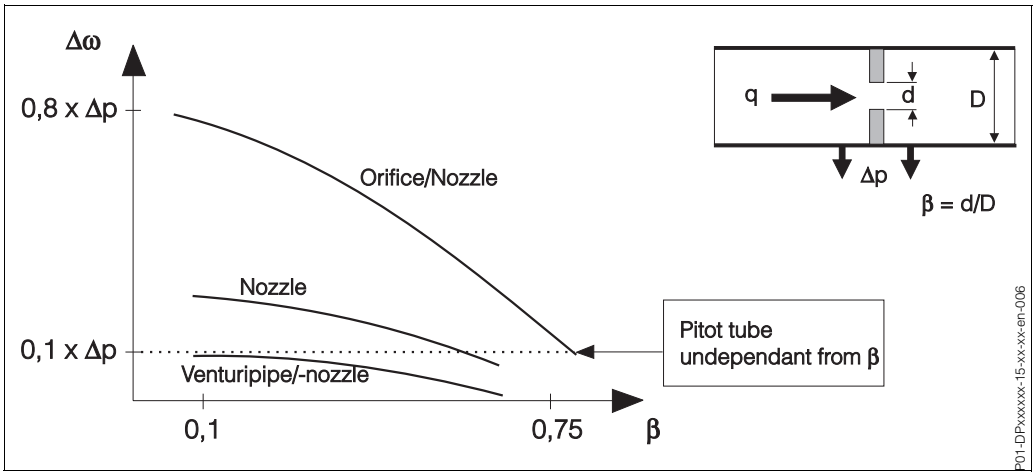
The dynamics are lower under strongly fluctuating process conditions (pressure and temperature). If necessary, we recommend the use of a flow computer (see section on “Compensation”)

Low pressure loss

The remaining pressure loss ($\Delta\omega$) and the dynamics of the orifice plate are dependent on each other. The smaller the orifice plate opening - indicated by the orifice plate ration (β = d/D) - the greater the dynamics of the measuring system and therefore the greater the pressure loss.

With some applications, it is necessary to optimise the maximum dynamics or the minimum pressure loss. This is achieved by selecting the right orifice plate opening during planning. Use the interpret sheet to aid the selection of optimisation criteria. The following optimisation options are possible:

- Standard (optimisation of pressure loss and dynamics)
- Optimisation to minimum pressure loss
- Optimisation to maximum dynamics



Remaining static pressure loss $\Delta\omega$ related to diameter ratio β of the orifice plate

The remaining static pressure loss is less than the differential pressure. Typical static pressures are in the range of 2 bar to 10 bar. Typical differential pressures Δp are between 5 mbar and 200 mbar. Pressure loss is approximately 30 % of the differential pressure Δp. I.e. for small orifice plate opening ratios β the ratio $\Delta\omega/p_{stat}$ is less than 1%. With Pitot tubes, nozzles and Venturi tubes/ nozzles it is much less than 1 %.

The following table shows the remaining pressure losses for typical process pressures for gas, liquids and steam, related to the system pressure.

	typ. static pressure	Orifice plate	Pitot tube
Steam	p_{stat} = 6 bar	Δp = 50 mbar $\Delta\omega$ = 20 mbar = 0.33% von p_{stat}	Δp = 16 mbar $\Delta\omega$ = 6 mbar = 0.10% von p_{stat}
Gas	p_{stat} = 1bar	Δp = 20 mbar $\Delta\omega$ = 5 mbar = 0.50% von p_{stat}	Δp = 7 mbar $\Delta\omega$ = 2 mbar = 0.20% von p_{stat}
Liquid	p_{stat} = 4bar	Δp = 40 mbar $\Delta\omega$ = 18 mbar = 0.45% von p_{stat}	Δp = 25 mbar $\Delta\omega$ = 10 mbar = 0.25% von p_{stat}

Tab. 12: Pressure loss Δp and remaining pressure loss $\Delta\omega$ at typical static pressures (operating pressure)

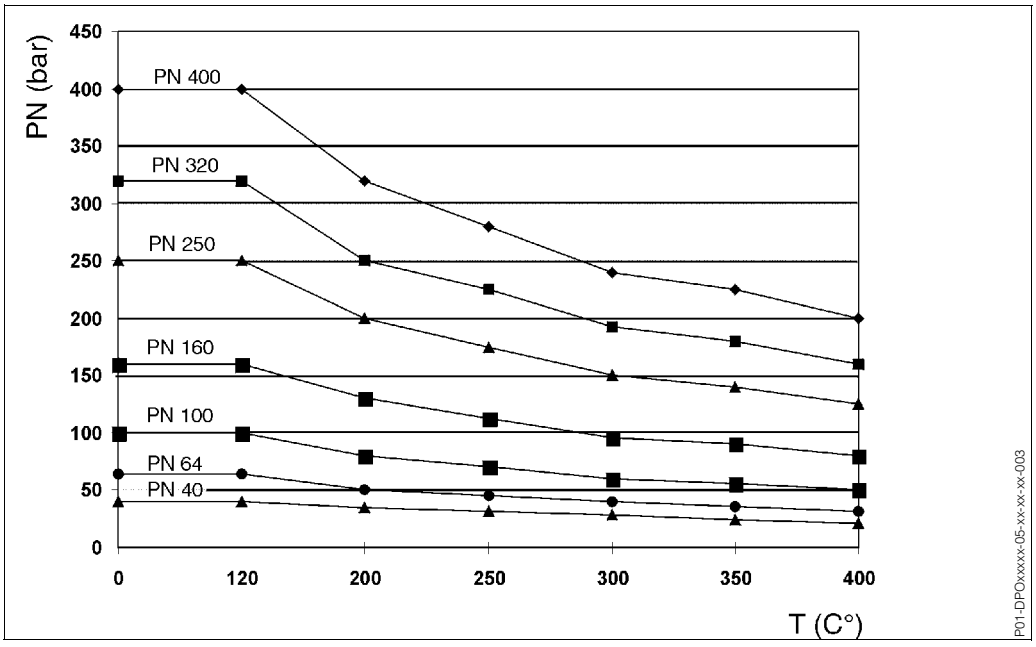
Materials

When selecting the right material for the primary device, alongside corrosion resistance and pressure load capacity, the temperature application limits of the relevant material is of primary importance. The following table shows values for typical materials where the standard materials for Deltatop and Deltaset have a grey background.

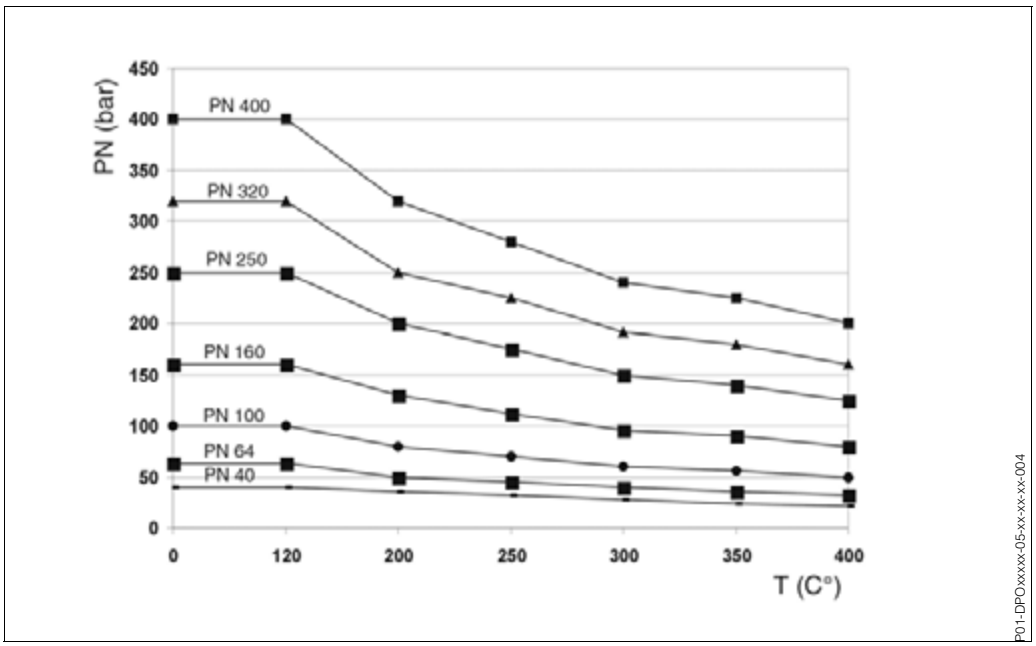
	Name	Material no.	Application temperature
Structural steel	St 37-2	1.0114	to approx. 350 °C
	ST 38.8	1.0305	to approx. 500 °C
	Thick boiler plate H II	1.0425	to approx. 400 °C
	C 22.8	1.0460	to approx. 490 °C
Heat-resistant steel	15 NiCuMoNb5 (WB 36)	1.6368	to approx. 500 °C
	15 Mo 3	1.5415	to approx. 530 °C
	13 CrMo 4 4	1.7335	to approx. 560 °C
	10 CrMo 9 10	1.7380	to approx. 590 °C
	X 20 CrMoV 12 1	1.4922	to approx. 600 °C
Low-temperature steel	TT St 35 N	1.0356	approx. -100...300 °C
	TSt E 355	1.0566	approx. -130...300 °C
Corrosion resistant steel	X 5 CrNi 1810	SS 304	approx. -40...300 °C
	X 6 CrNiTi 1810	SS 321	approx. -190...300 °C
	X 6 CrNiMoTi 17 12 2	SS 316Ti	approx. -60...400 °C
	X 10 Cr 13	SS 410	to approx. 450 °C
Plastic	Polyvenylchlorid	PVC	to approx. 70 °C
	Polypropylene	PP	to approx. 90 °C
	Polyethylene	PE	to approx. 80 °C
	Polyvinylidenefluoride	PVDF	to approx. 130 °C
	Polytetrafluorethylene	PTFE	to approx. 150 °C
Special material	Hastelloy C	2.4610	to approx. 400 °C
	Monel	2.4360	to approx. 400 °C

Tab. 13: Application temperature of some materials

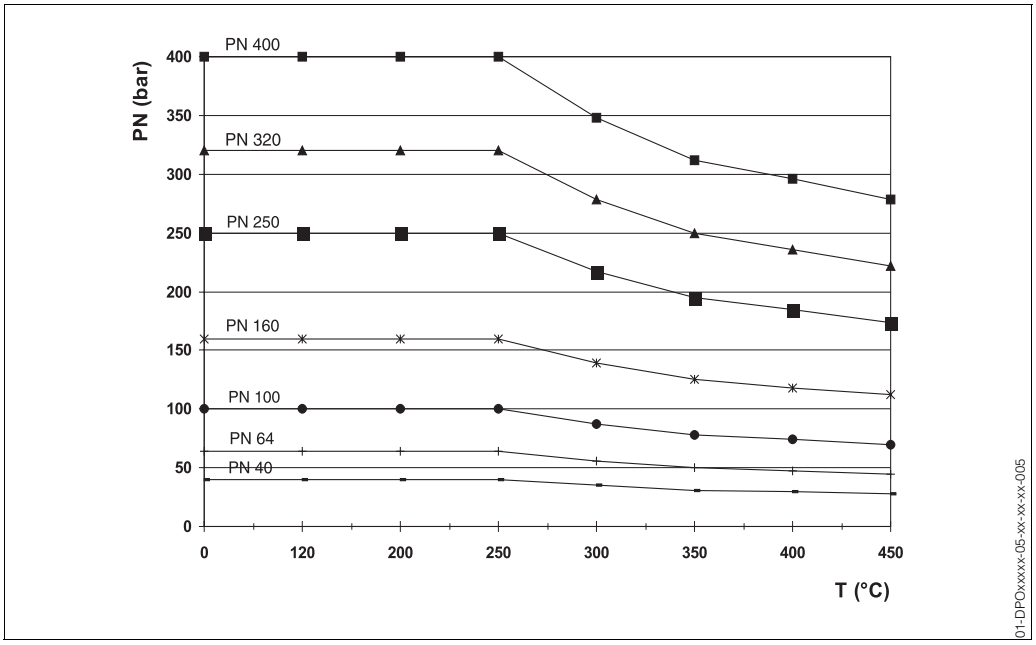
When selecting the right material, alongside the application temperature limit, the pressure load capacity concerning occurring temperatures is of primary importance. You can find an overview of the dependence of a specified pressure rating and the possible application temperature in the pressure/temperature charts below. There, you can see that a high temperature reduces the pressure rating. This is also valid for additional components of the measurement section such as valves, condensat chambers, etc.



Pressure/temperature curve for material C22.8



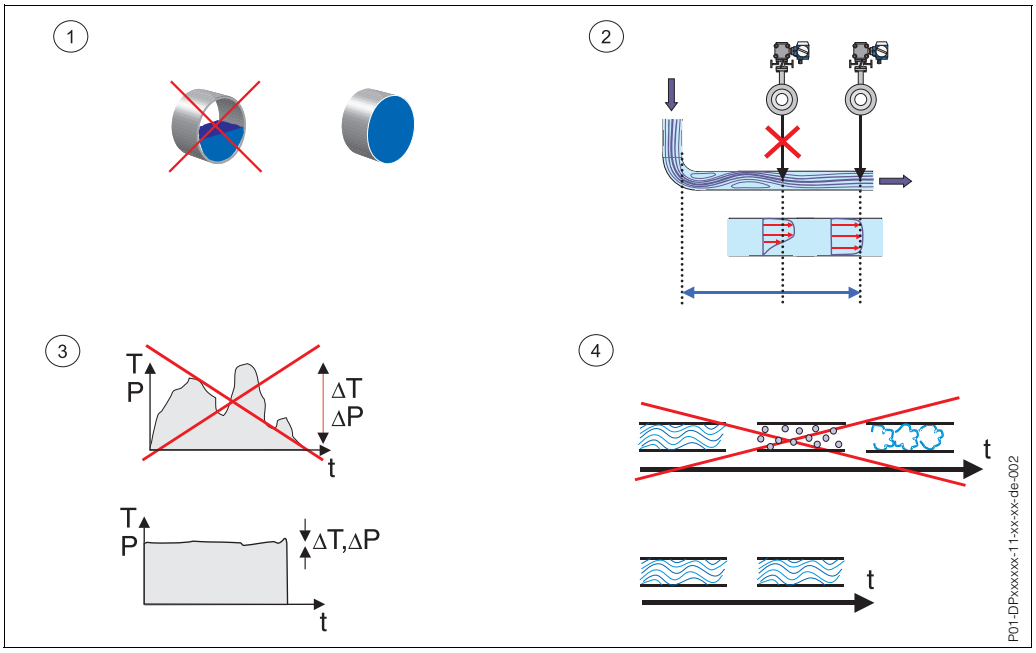
Pressure/temperature curve for material SS 316Ti.



Pressure/temperature curve for material 15Mo3.

Designing the measuring point

Requirements for flow measurement with primery element and differential pressure transmitter



Requirements for accurate flow measurement with primary device and differential pressure transmitter:

① *Completely filled piping*

② *Constant flow profile*
- *Turbulent flow*
- *Sufficient up- and downstream lengths*
- *No build-ups*

③ *Constant process conditions*
- *Temperature*
- *Pressure*

④ *Homogeneous media*
- *No change in the state of aggregation of liquid/gas/steam*

Filled piping
①

With the flow measurement of liquids, completely filled piping is of the highest importance. When planning the primary device, the flow is determined from the flow velocity and the full pipe cross-sectional area.

With gas and steam, the piping is always completely filled by the medium.

Up- and downstream lengths
②

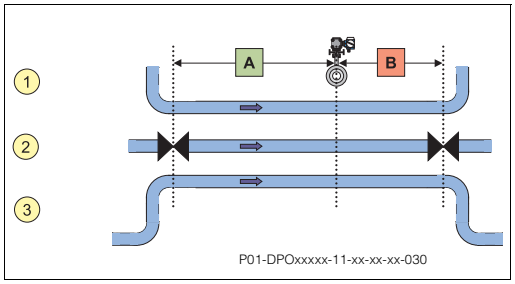
A symmetrical flow profile is the requirement for accurate measurement and is ensured by build-up free piping and sufficiently long up- and downstream lengths.

The flow profile is altered by obstacles in the process line, in the form of narrowings, bends, elbows, etc. The flow settles down again when it passes through a straight section of piping, the inlet run section. The same is true for obstacles after the measuring point: the back-pressure which occurs leads to a change in the flow profile at the pressure tapping point. Therefore, try and keep to straight outlet runs.

The use of flow conditioners allows a reduction in the length of the necessary up- and downstream lengths. The increase in expected errors through reduction without a flow conditioner is shown in the following diagram (see “Reduced upstream length”).

The standard prescribes the up- and downstream lengths to maintain the flow profiles. Use the diagram and the table to determine how large these must be:

A Upstream; B Downstream
① *90° elbow*
② *Valves open*
③ *2x 90° elbows*



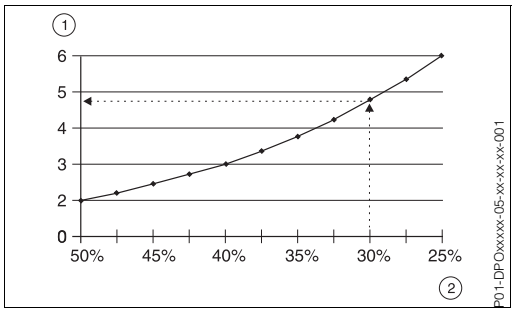
	Orifice plate or nozzle Venturi: use half lengths						Pitot tube	
	Upstream			Downstream			Upstream	Downstream
	β= 0,1	β= 0,5	β= 0,75	β= 0,1	β= 0,5	β= 0,75		
90° elbow	10	14	36	4	6	8	7 x D	3 x D
2x 90° elbow	14	20	42	4	6	8	9 x D	3 x D
3x 90° elbow	34	40	70	4	6	8	18 x D	4 x D
Pipe constriction	5	6	22	4	6	8	7 x D	3 x D
Pipe expander	16	18	38	4	6	8	24 x D	4 x D
Valve, open	18	22	36	4	6	8	30 x D	4 x D

Tab. 14: Up- and downstream lengths
D internal diameter
d Opening diameter
β *d/D Opening ratio*

Reduced upstream lengths

The diagram shows the expected error increase ① related to a reduction in the upstream lengths ②. The factor determined states in which magnitude the accuracy stated on the flow data sheet is reduced.

Example: the typical error of a standard orifice plate in 0.6 %.With an upstream lengths reduced by 30 %, there is therefore an error of 0.6% x factor 4.8 = 2.9 %



Reynolds number

A turbulent flow is required for flow measurement with primary devices. The Reynolds number shows whether it is a laminar or a turbulent flow. It is calculated using the following equation:

$$Re_D = \frac{v \cdot D \cdot \rho}{\nu}$$

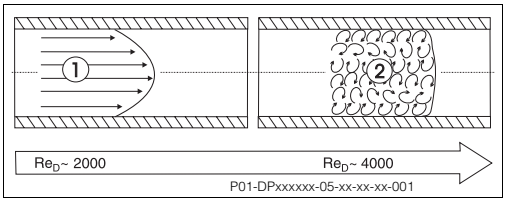
Re_D = Reynolds number, related to pipe diameter D
v = Medium velocity
ρ = Density
ν = Kinematic viscosity

The Reynolds number is a dimensionless parameter which describes the flow related to medium velocity, internal diameter, medium density and its kinematic viscosity.

The diagram on the right shows the relationship between the Reynolds number Re and the type of flow. The Applicator from Endress+Hauser (version 8.01 or higher) calculates the Reynolds number for each application.

The medium viscosity should not fall below the following values:

- ❑ Orifice plate Re = 2.800
- ❑ Pitot tube Re = 4.000
- ❑ Nozzle: Re = 200.000
- ❑ Venturi: Re = 40.000



Type of flow:
① laminar
② turbulent

The kinematic viscosity can be calculated from the dynamic viscosity using the density (kg/m ^{3}):

$$\text{kinematic viskosity } \nu = \frac{\eta}{\rho} = \frac{\text{dyn. viskosity}}{\text{density}} \qquad \left[\frac{m^2}{s}\right] \left[10^6 cSt\right]$$

$$\text{dynamic viskosity } \eta = \nu \cdot \rho \qquad \left[\frac{kg}{m \cdot s}\right] \left[\frac{N \cdot s}{m^2}\right] \left[Pa \cdot s\right] \left[10^{-3} cP\right]$$

The Reynolds number is reversly proportional to the diameter when the flow, density and viscosity are equal.

$$Re \sim \frac{q \cdot \rho}{D \cdot \nu} \Rightarrow Re \sim \frac{1}{D}$$

Reducing the pipe diameter allows the increase of the Reynolds number.
It is generally true: the flows are equal when their Reynolds numbers are equal.

Process conditions
③

Pressure and temperature
The influence of pressure and temperature on flow measurement is only of importance for gases and steam. With high accuracy requirements, pressure and temperature changes must be compensated (see also the chapter “Compensation“).

If you require an adjustment of the display value to changed process data for pressure and temperature, the new operating flow display value is calculated as follows:

$$\text{New operating flow display value } q_{neu} = q \cdot \frac{T \cdot p_{absnew}}{p_{abs} \cdot T_{new}}$$

Example
Previous values: p_{abs} = 2 bar, T = 20 °C = 293.15 K, q = 300 m^3/h
New values: p_{absnew} = 6 bar, T_{new} = 45 °C = 318.15 K

$$\text{New flow display value } q_{neu} = 300\left[\frac{m3}{h}\right] \cdot \frac{293,15[K] \cdot 6[bar]}{2[bar] \cdot 318,15[K]} = 829,28\left[\frac{m3}{h}\right]$$

Medium
④

When interpreting the primary device, you require the process and medium data. The homogenity of the medium, i.e. the composition over time, should not change, as changes lead to measuring errors. The design of the measuring system for different media means that the flow measurement with primary device can be used universally. When the medium is changed, the device need only be set to the changed differential pressure Δp.

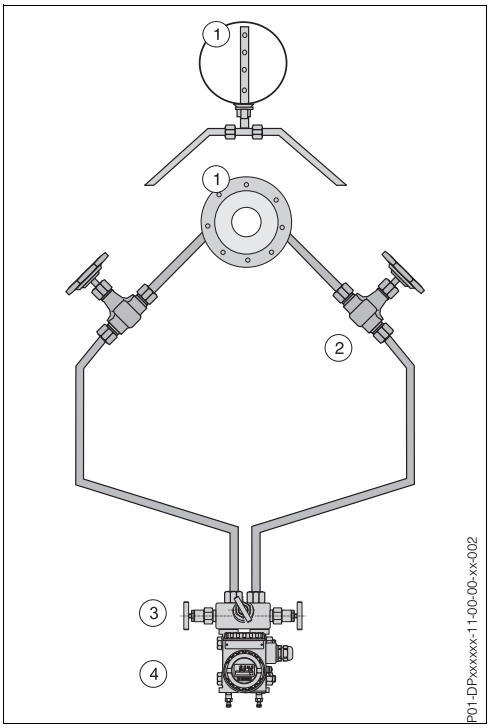
Application examples

Deltaset for liquid

With liquid applications, the transmitter must always be mounted beneath the pipe outlets. This and the 1:15 slope of the piping ensures the increase of air bubbles back to the process pipes.

The following components form a typical liquid application for Deltaset:

1. Orifice plate
   DPO 5❑E(or A)-❑❑❑❑❑❑❑
   or Pitot tube
   DPP 50-❑❑❑❑❑❑❑❑
2. Shut-off valve DPV50-❑❑2
3. manifold DPM50-❑A2❑
4. Deltabar S PMD235-❑❑❑#88❑❑❑❑

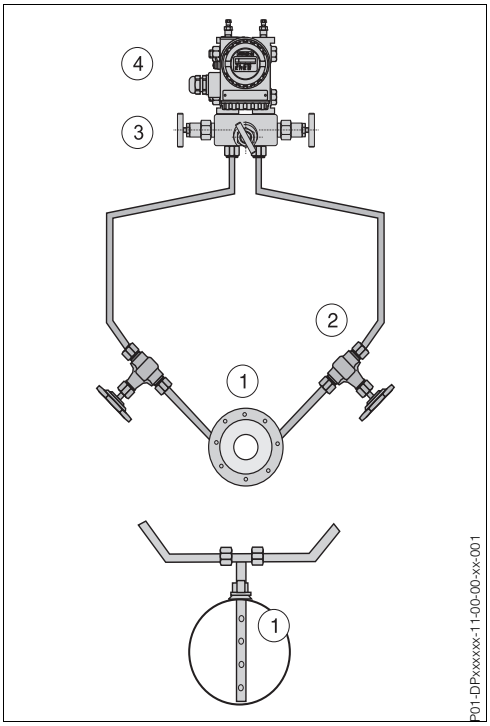


Deltaset for gas

With gas applications, the transmitter must always be mounted above the pipe outlets. Any condensate will flow back into the process pipeline. All horizontal pulse lines must be laid with a gradient of 15:1 to the process connection - coming from the transmitter.

The following components form a typical gas application for Deltaset:

1. Orifice plate
   DPO 5❑E(or A)-❑❑❑❑❑❑❑
   or Pitot tube
   DPP 50-❑❑❑❑❑❑❑❑
2. Shut-off valve DPV50-❑❑2
3. manifold DPM50-❑A2❑
4. Deltabar S PMD235-❑❑❑#88❑❑❑❑



Deltaset for steam

With steam applications, both condensat chambers of the primary device must always be at the same geodesic height and the transmitter must be below the pipe outlets.

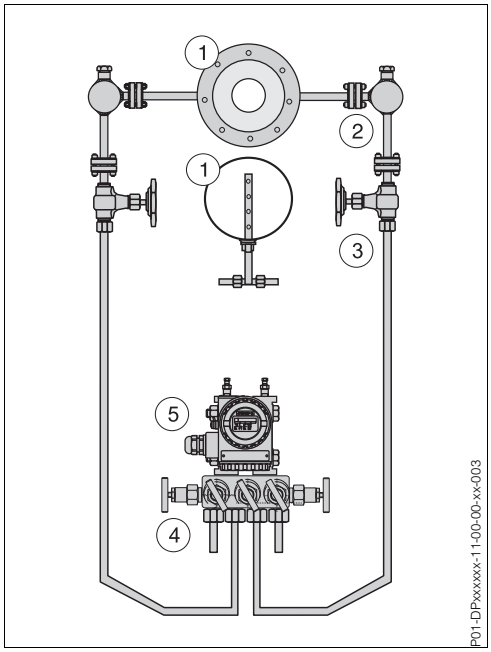
The following components form a typical steam application:

1. Orifice plate
   DPO 5❑E(or A)-❑❑❑❑❑❑❑
   or Pitot tube
   DPP 50-❑❑❑❑❑❑❑❑
2. Condensate trap with flange pairs G1/2"
   DPC50-❑1❑3
3. Shut-off valve DPV50-❑❑3
4. 5-valve manifold DPM50-❑H2❑
5. Deltabar S PMD235-❑❑❑#88❑❑❑❑

The shut-off valves allow the closing of the process taps for the "+" pressure and the "-" pressure of the differential pressure signal of the primary device.

The 5-valve manifold allows simple piping and can be used instead of the T-sections and additional condensate blow-out valves.

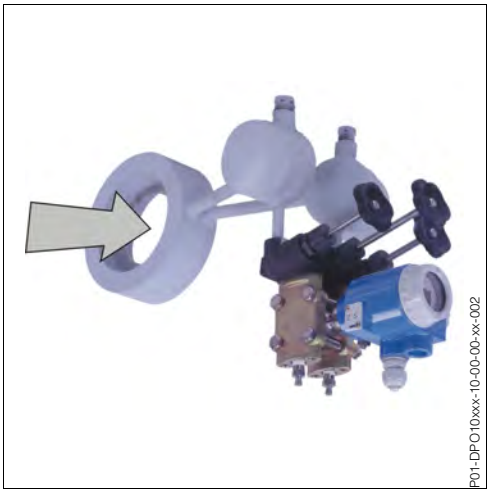
With steam, lay the impulse pipes at a gradient of 15:1 to ensure reliable rising of air injections in the water interface of the transmitter.



Also, we would recommend the use of flange pairs - or preferably welded connections - for steam applications. Behind the condensat chambers, continue piping Ermeto12S.

Deltatop for steam

Arrangement examples for the compact solution with Deltatop.



Compact standard orifice plate
Deltatop DPO 10
Application: steam, horizontal pipe, mounting right



Pitot tube Deltatop DPP 10
Application: steam, vertical pipe upwards

Temperature and pressure compensation

Parameters

Alongside differential pressure Δp, pressure p and temperature T are test variable of flow q. If there are no strong fluctuations in pressure and temperature, then the accuracy of the differential pressure signal is fully sufficient for the majority of measuring points. There is then no need for any compensation

With some applications, particularly in the gas and steam sectors, a special compensation is required. A change in pressure and/or temperature leads to a change in density. If this is not taken into account, total accuracy may be reduced.

The following parameters are required for compensation:

- Gases: compensation of p and T
- Saturated steam: either p or T are compensated
- Superheated steam: compensation of p and T
- Liquids: compensation of T (very rare)

Both on the process side and on the system side, there are two possibilities for implementing compensation (large differences in price and effort).

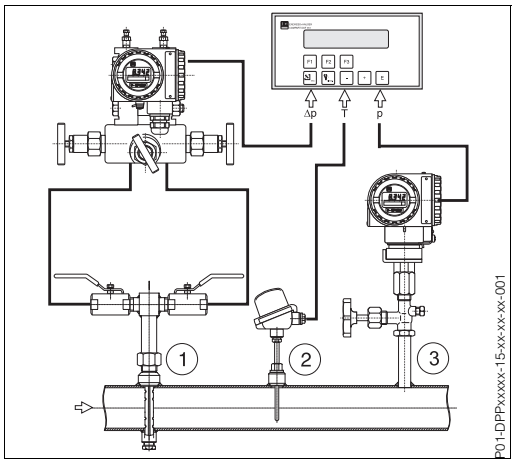
Process side

Version A:

3 special process connections for Δp, T and p, which are evaluated with the flow computer.

- T and p are usually installed separately after the flow measuring point. Recommendation: Temperature transmitter Omnigrad and pressure transmitter Cerabar S.

① Flow q with Pitot tube DPP 50
② Temperature T, e.g. with Omnigrad
③ Process pressure p, e.g. with Cerabar S

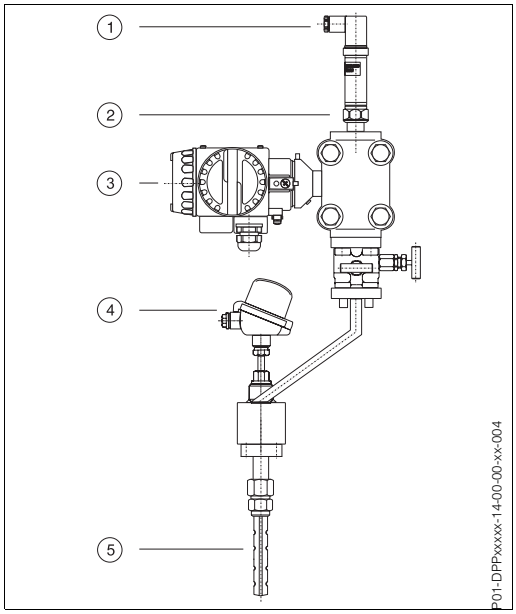


Version B:

Only 1 process connection for Δp, p and T

- Use an adapter to screw a pressure transmitter or a pressure transducer (e.g. Cerabar T, Cerabar M or Cerabar S) into the minus side of the Deltabar S flange. With Pitot tubes, the temperature can be determined using the integrated temperature sensor ④.

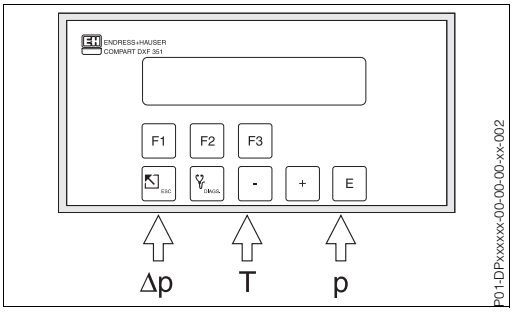
① Process pressure p, e.g. Cerabar T
② NPT adapter 1/4" male, 1/2" female
③ Deltabar S
④ Integrated temperature sensor
⑤ Pitot tube Deltatop DPP 10



System side

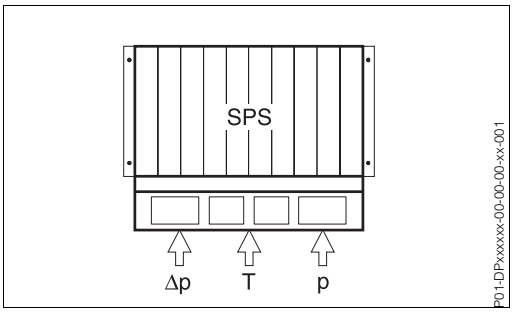
Version 1: flow computer

- The process variables Δp, p and/or T are fed into a flow computer.
  Recommendation: Compart DXF from Endress+Hauser. This provides access to
  - stored flow equations,
  - stored steam and water data
  and other commissioning aids.



Version 2: PLC

- The process variables are fed into the (available) PLC. The flow equations are programmed there. With this solution the investment costs are low, but the commissioning costs are increased.



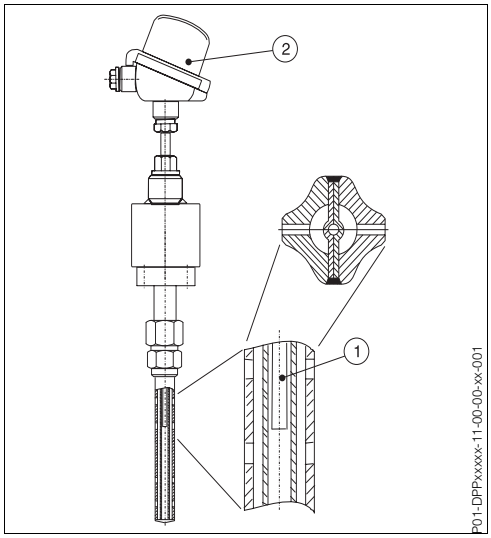
Integrated temperature sensor for Pitot tubes

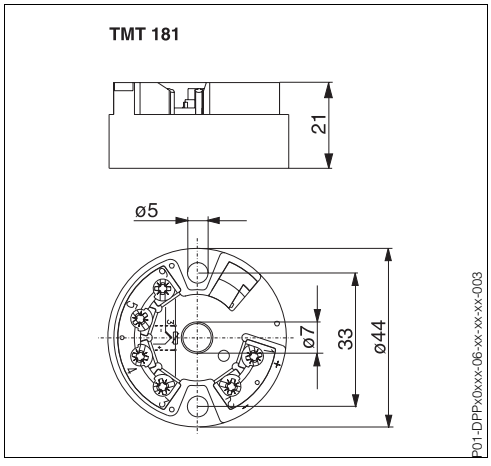
To determine the medium temperature, with Pitot tubes from DN 100 there is optionally an integrated temperature measurement:

❑ With Pt100 temperature sensor
❑ With 4...20 mA temperature transmitter

The benefits of such a temperature measurement:

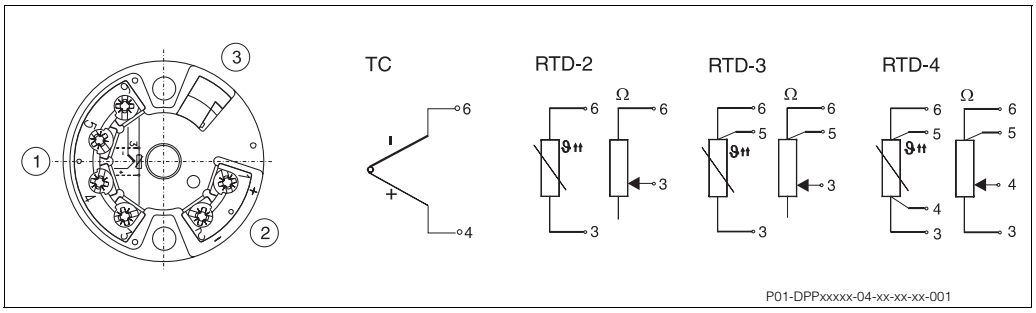
- Resistance thermometer Pt 100 ① is fixed within the probe profile. The protective tube which is formed by the two partition walls between the probe chambers protects it against damage. Also it has no contact with the medium and is not exposed to the operating pressure.
- The rod-shaped resistance thermometer ① made of SS 316TI is particularly robust and resistant to oscillation. The length is dependent on the length of the Pitot tube.
- Rapid installation and removal possible under operating pressure.
- Temperature range between -200 °C and +500°C
- Probe head ② made of aluminium for installing the E+H temperature head transmitter TMT 181 (terminal head to DIN 43729, flat face)





Technical data of the temperature head transmitter iTEMP PCP TMT 181

- ❑ Application
  PC-programmable temperature head transmitter TMT 181 for converting various input signals into scalable4...20 mA analog output signal.
  The TMT 181 is preset to customer specifications according to the specifications in the flow data sheet.
- ❑ Input: Input: resistance thermometer RTD
  PT 100: measuring range limit -200 °C...+850 °C, min. span 10K.
  2, 3 or 4 wire connection
- ❑ Input: Thermocouple TC
  NiCr-Ni: measuring range limit -200 °C...+1372 °C, min. span 50 K
  PtRh10-Pt: measuring range limit 0 °C...+1768 °C, min. span 500 K
- ❑ Output
  Output signal: 4...20 mA
  Max. load: $V_{Power\ Supply}$ - 8 V / 0,022 A
  Digital filter 1rst degree: 0...8 s
  Input current required: ≤ 3,5 mA
  Current limit: ≤ 23 mA
  Switch-on delay: 4 s
  Reply time: 1 s
- ❑ Operating condition
  Ambient temperature: -40...+85 °C (for explosion hazardous areas, see Ex certificatet)
  Storage temperature: -40...+100 °C
  Climate class: to EN 60654-1, Class C
  Electromagnetic compatibility: Interference immunity and interference emission to EN 61326-1 and Namur NE 21
- ❑ Certificates and approvals:
  Ex approval: ATEX II 1 / EEx ia IIC and IIB
  (max. ambient temperature T4 = 85 C, T5 = 70 C, T6 = 55 C)
- ❑ Electric connection
  ① Sensor connection
  ② Supply voltage 8...35 V (with reverse polarity protection) and output signal
  ③ SETUP-Connection
  TC Connection of thermocouples
  RTD Connection of resistance thermometer



- ❑ Supplementary Documentation
  Temperature head transmitter iTEMP PCP
  TMT 181
  Technical Information TI 070R/09/en

Deltatop versions

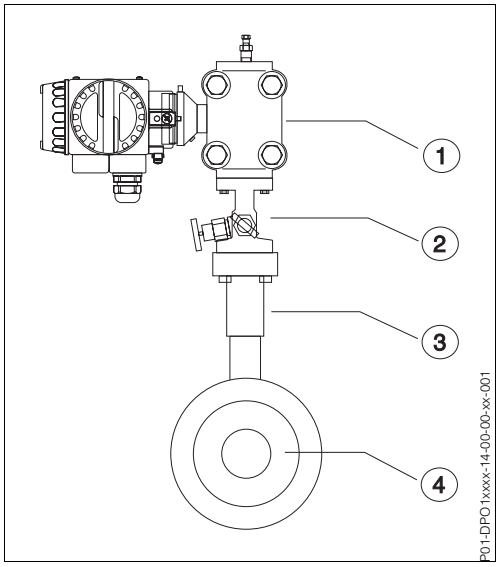
Scope of supply

Deltatop is a compact flowmeter and runs on the basis of differential pressure. All Deltatop versions comprise:

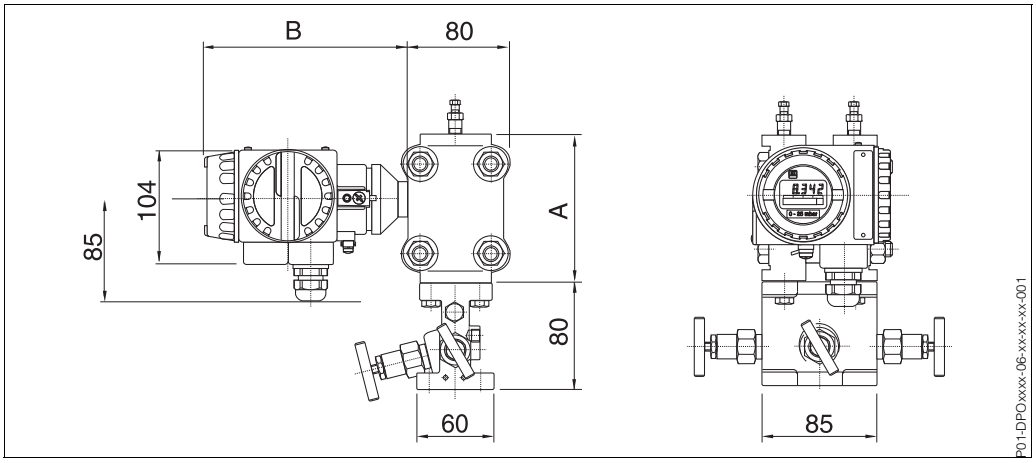
① Deltabar S
② 3- or 5-valve manifold
③ Compact fit
④ Primary device (orifice plate, Pitot tube)

The delivery comes complete with a mounted differential pressure transmitter (which is ordered extra). The Deltabar S is supplied with an optimum differential pressure sensor, so that the customer need not calculate the differential pressure prior to ordering. The differential pressure range and the selected display option (flow, differential pressure or percent value) are preset. A linear signal is made available using the square root characteristic.

The steam version differs from the gas or liquid version in terms of design and dimensions.



Dimensions



Dimensioned drawings for Deltabar S with manifold

① Deltabar S–housing
T4 with display on side of Deltabar — Dimension B = 120 mm
T5 with display on top of Deltabar — Dimension B = 150 mm

② Deltabar S–Process connection
PMD 235 with metallic sensor — Dimension A = 106 mm for 10...40 mbar sensor
Dimension A = 100 mm for 100 mbar...40 bar sensor
PMD 230 with ceramic sensor — Dimension A = 96 mm

③ Manifold for gas/liquid applications

The weight of the housing, process connection and manifold together is approx. 8 kg

Deltatop DPO 10
Compact version
Undivided orifice plate with corner taps

Standard orifice plate with corner tapping to DIN 19205 (B) or ISO 5167. For installation between flanges to DIN 263x. With Deltabar S and 3-valve manifold, ready mounted and set.

For the required Ordering Information - see also pp. 27 and 28:

10 Application
Medium and pipe orientation
Figure: Gas measurement, horizontal piping

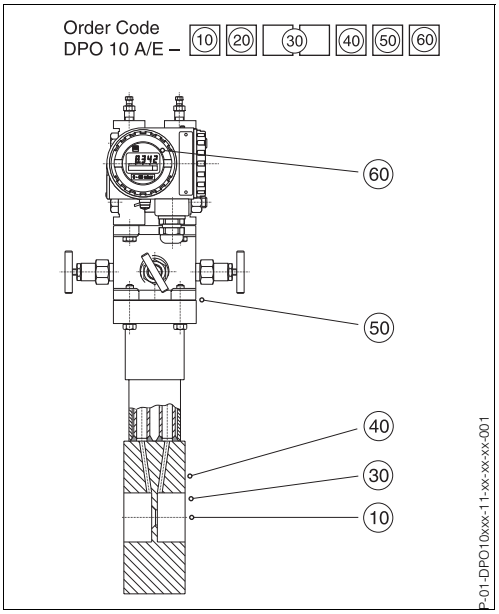
20 Approval
With or without special approvals

30 Nominal diameter pipe, material
Suppliable nominal diameters and material of orifice plate and manifold

40 Pressure rating, facing
Permissible pressure rating and shape of facing

50 Seals
Sealing material on manifold

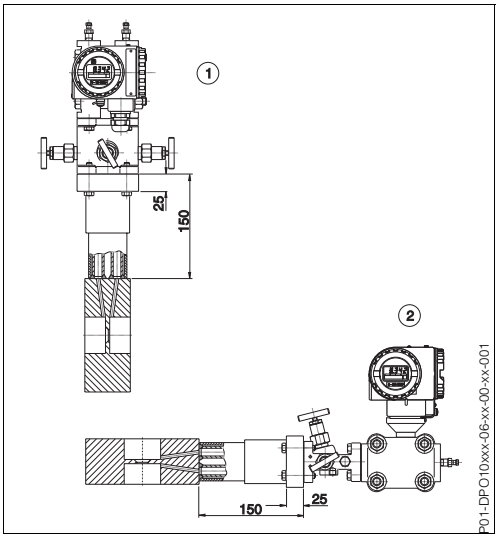
60 Adjustment Deltabar S
Flow, differential pressure or percentage display



Dimensioned drawings (right)

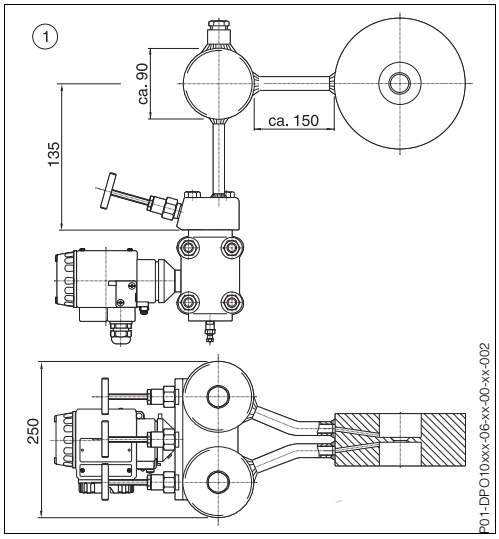
❑ Orifice plates for gases and liquids
① Horizontal piping
② Vertical piping

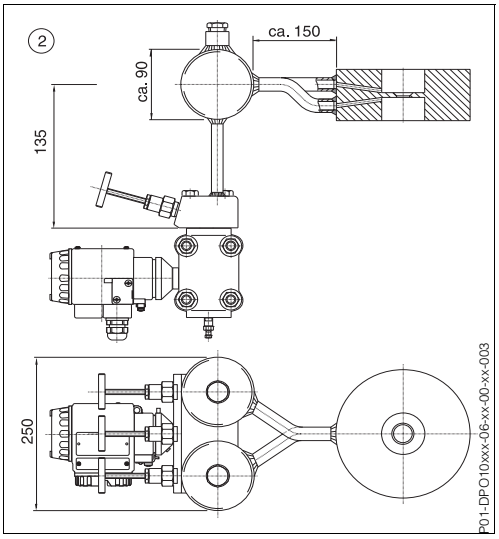
Max. temperature in process tube:
Gases/fluids 200 °C, steam 300 °C



Dimensioned drawings (below)

❑ Orifice plates for steam (mounting left)
(with two condensat chambers):
① for horizontal piping
② for vertical piping





Deltatop DPO 10
Dimension tables

DN (mm)	d_4 (mm)								E (mm)	d_1 (mm)	Weight (approx. kg)
	PN 6	PN 10	PN 16	PN 25	PN 40	PN 64	PN 100	PN 160			
50	96	107		107		112	119		3	D + 1 mm	10
65	116	127		127		137	143		3		10.5
80	132	142		142		147	153		4		12
100	152	162		167		173	180		4		13
125	182	192		193		210	217		4	D + 2 mm	14
150	207	217		223		247	257		5		15
200	262	272	272	283	290	309	324		5		18
250	317	327	328	340	352	364	391	388	5		22
300	372	377	383	400	417	424	458	458	6		27
350	422	437	443	457	474	486	512		6		31
400	472	488	495	514	546	543			6	D + 4 mm	33
500	577	593	617	624	628				8		37
600	678	695	734	731					8		45
700	783	810	804	833					10		57
800	890	917	911	942					10		67
900	990	1017	1011	1042					10		77
1000	1090	1124	1128	1154					10		88

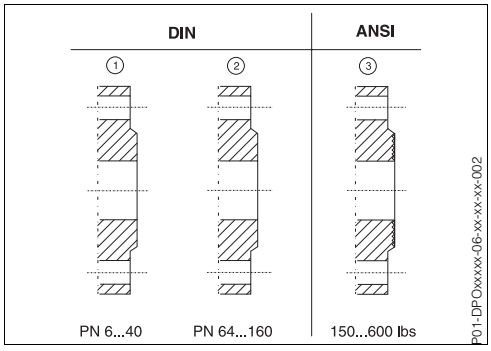
Tab. 15: Dimensions and weight of orifice plate DPO 10E, nominal diameter DN in mm

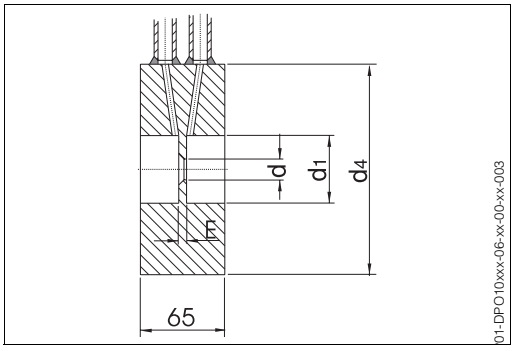
DN (in inches)	d_4						E (mm)	d_1 (mm)	Weight (approx. kg)
	in mm	in inches	in mm	in inches	in mm	in inches			
	150 lbs		300 lbs		600 lbs				
2	104.5	4.1	111	4.4	111	4.4	3	D +1 mm	10
2 1/2	124	4.9	130	5.1	130	5.1	3		10.5
3	136.5	5.4	149.5	5.9	149.5	5.9	4		12
4	174.5	6.9	181	7.1	193.5	7.6	4		13
5	197	7.8	216	8.5	241.5	9.5	4	D +2 mm	14
6	222.5	8.8	251	9.9	266.5	10,5	5		15
8	279.5	11.0	308	12.1	320.5	12.6	5		18
10	339.5	13.3	362	14.2	400	15.7	5		22
12	409.5	16.1	422	16.6	457	18.0	6		27
14	451	17.8	484.4	19.1	492	19.4	6		31
16	514.5	20.3	540	21.3	565	22.2	6	D +4 mm	33
20	606.5	23.9	654	25.7	682.5	26.9	8		37
24	717.5	27.9	774.5	30.5	790.5	31.1	8		45

Tab. 16: Dimensions and weight of orifice plate DPO 10A, nominal diameter DN in inches

Possible facings
① Raised face (Rz=160)
② Shape E (Rz=16)
③ Shape RF (raised face)

Dimensions
d Orifice plate opening
E Orifice plate thickness
d1 Holding ring
d4 Exterior orifice plate
D Pipe internal diameter





Deltatop DPO 10E
Ordering information for standard orifice plate, corner tapping
DIN

10 — Application: pipe orientation

C	Gas flow; horizontal pipe orientation
B	Gas flow; verticals pipe orientation
C	Liquid flow; horizontal pipe orientation
D	Liquid flow; vertical pipe orientation
E	Steam; horizontal pipe, mounting left (version with condensat chambers)
F	Steam; horizontal pipe, mounting right (version with condensat chambers)
G	Steam; vertical pipe, flow upwards (version with condensat chambers)
N	Steam; vertical pipe, flow downwards (version with condensat chambers)
Y	Special version

20 — Approval

1	Without special approvals
2	Material approval to 3.1B, EN 10204
3	Free from oil and grease
4	Confirmed pressure test
5	3.1B application and pressure test
9	Special version

30 — Nominal diameter pipe, material
Letter = nominal diameter / Numeral = material

Example G2: DN 125, Material SS 316Ti

C❑	DN 50	Ring and manifold	1 Material C22.8
D❑	DN 65	Ring and manifold	2 Material SS 316TI
E❑	DN 80	Ring and manifold	
F❑	DN 100	Ring and manifold	
G❑	DN 125	Ring and manifold	
H❑	DN 150	Ring and manifold	
K❑	DN 200	Ring and manifold	
L❑	DN 250	Ring and manifold	
M❑	DN 300	Ring and manifold	
N❑	DN 350	Ring and manifold	
P❑	DN 400	Ring and manifold	
Q❑	DN 500	Ring and manifold	
R❑	DN 600	Ring and manifold	
S❑	DN 700	Ring and manifold	
T❑	DN 800	Ring and manifold	
U❑	DN 900	Ring and manifold	
W❑	DN 1000	Ring and manifold	
Y9	Special version		

40 — Pressure rating, facing

C	PN 6	Facing form C
B	PN 10	Facing form C
C	PN 16	Facing form C
D	PN 25	Facing form C
E	PN 40	Facing form C
F	PN 64	Facing form E
G	PN 100	Facing form E
N	PN 160	Facing form E
Y	Special version	

50 — Seals on manifold

1	Viton seals on manifold
2	PTFE seals on manifold, max. PN 100
9	Special version

60 — Adjustment Deltabar S

F	Flow values, square root
P	Differential pressure values, linear
S	Adjustment 0..100%, square root
T	Adjustment 0..100%, linear
Y	Special version

DPO 10E — **Complete product designation**

Deltatop DPO 10A Ordering information for standard orifice plate, corner tapping ANSI

10 — Application: pipe orientation

C	Gas flow; horizontal pipe orientation
B	Gas flow; verticals pipe orientation
C	Liquid flow; horizontal pipe orientation
D	Liquid flow; vertical pipe orientation
E	Steam; horizontal pipe, mounting left (version with condensat chambers)
F	Steam; horizontal pipe, mounting right (version with condensat chambers)
G	Steam; vertical pipe, flow upwards (version with condensat chambers)
N	Steam; vertical pipe, flow downwards (version with condensat chambers)
Y	Special version

20 — Approval

1	Without special approvals
2	Material approval to 3.1B, EN 10204
3	Free from oil and grease
4	Confirmed pressure test
5	3.1B certificate and pressure test
9	Special version

30 — Nominal diameter pipe, material
Letter = nominal diameter / Numeral = material

Example G2: DN 5", Material SS 316Ti

C❑	DN 2"	Ring and manifold	[1] Material C22.8
D❑	DN 2 1/2"	Ring and manifold	[2] Material SS 316TI
E❑	DN 3"	Ring and manifold	
F❑	DN 4"	Ring and manifold	
G❑	DN 5"	Ring and manifold	
H❑	DN 6"	Ring and manifold	
K❑	DN 8"	Ring and manifold	
L❑	DN 10"	Ring and manifold	
M❑	DN 12"	Ring and manifold	
N❑	DN 14"	Ring and manifold	
P❑	DN 16"	Ring and manifold	
Q❑	DN 20"	Ring and manifold	
R❑	DN 24"	Ring and manifold	
Y9	Special version		

40 — Pressure rating, facing

C	150 lbs	RF
B	300 lbs	RF
C	600 lbs	RF
Y	Special version	

50 — Seals on manifold

1	Viton seals on manifold
2	PTFE seals on manifold, max. PN 100
9	Special version

60 — Adjustment Deltabar S

F	Flow values, square root
P	Differential pressure values, linear
S	Adjustment 0..100%, square root
T	Adjustment 0..100%, linear
Y	Special version

DPO 10A — **Complete product designation**

Deltatop DPO 12
Compact version
Orifice flange

Measuring flange to DIN 19214 (Part 1) or ANSI B 16.36. With Deltabar S and 3x manifold, screws and seals, fully assembled and set.

For the required Ordering Information - see also pp. 31 and 32:

10 Application
Medium and pipe orientation
Figure: Gas measurement, horizontal piping

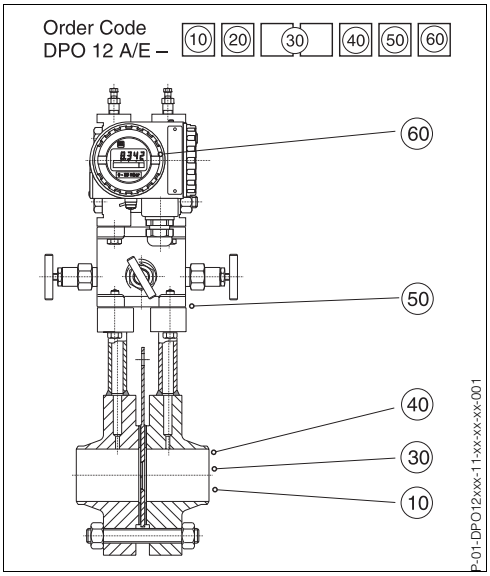
20 Approva
With or without special approvals

30 Nominal diameter pipe, material
Suppliable nominal diameters and material of orifice plate and manifold

40 Pressure rating
Permissible pressure rating and shape of facing

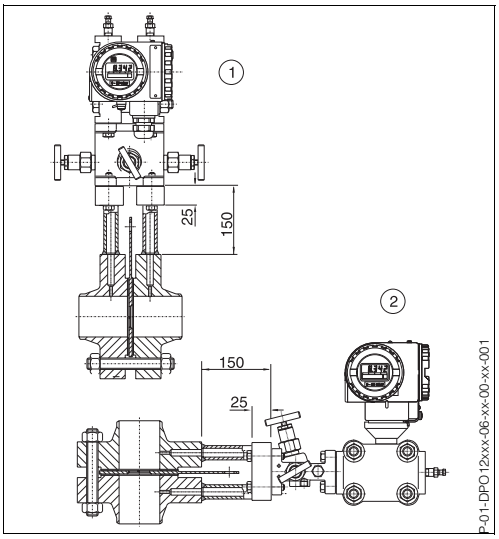
50 Seals on manifold

60 Adjustment Deltabar S
Flow, differential pressure or %-display



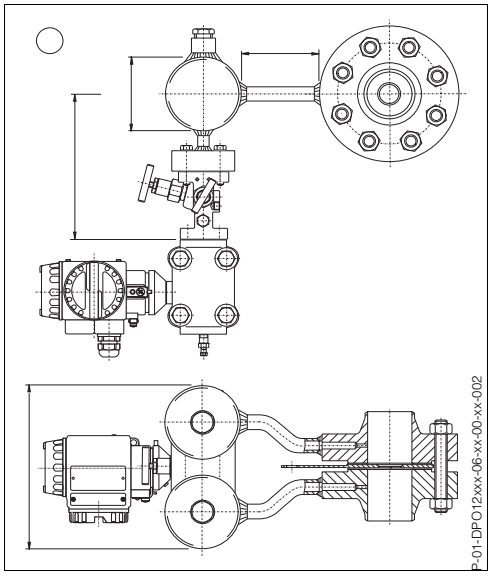
Dimensioned drawings (right):

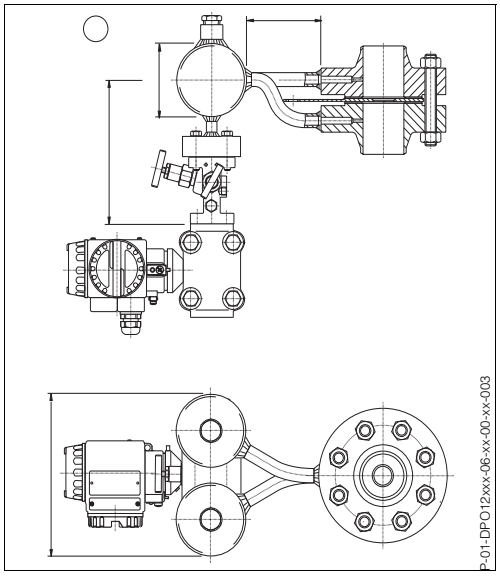
❑ Orifice plates for gases and liquids
① Horizontal piping
② Vertical piping



Dimensioned drawings (below):

❑ Orifice plates for steam
with two condensat chambers:
① Horizontal piping
② Vertical piping





Deltatop DPO 12
Dimension tables

DN (mm)	Length L (mm)						E (mm)	Total weight (approx. kg)
	PN 10	PN 16	PN 25	PN 40	PN 64	PN 100		
50	133	133	135	135	150	159	3	16
65	133	133	139	139	162	170	3	18
80	140	140	148	148	167	170	4	21
100	144	144	162	162	175	191	4	27
125	146	146	164	164	187	222	4	37
150	146	146	174	174	201	242	4	49
200	156	156	180	188	232	272	4	77
250	164	168	192	217	262	326	4	107
300	164	180	196	237	292	352	4	137
350	164	184	257	257	312	390	4	177
400	172	186	277	277	332		4	215
500	176	194	289	289			6	245

Tab. 17: Dimensions and weight of orifice plate DPO 12E in mm

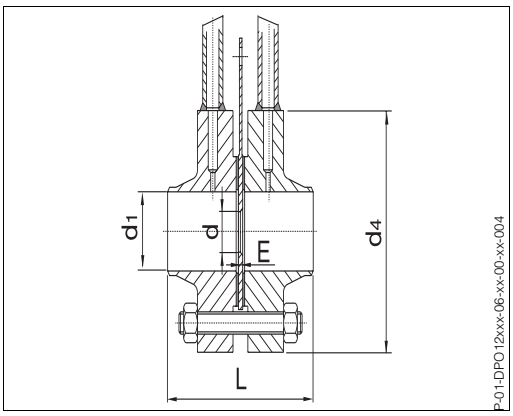
DN (in inches)	Length L (mm)				E (mm)	Total weight (approx. kg)	
	in mm	in inches	in mm	in inches			
	300 lbs		600 lbs			300 lbs	600 lbs
2	179	7.0	179	7.0	3	19	19
2 $^{1}I_{2}$	184	7.2	184	7.2	3	23	23
3	184	7.2	197	7.6	3	31	31
4	190	7.5	222	8.7	3	45	66
5	207	8.1	248	9.8	3	57	102
6	207	8.1	254	10.0	3	67	118
8	228	9.0	286	11.3	3	93	165
10	241	9.5	324	12.8	3	129	265
12	266	10,5	330	13.0	3	192	321
14	292	11.5	350	13.8	6	260	470
16	301	11.8	379	15.0	6	345	638
20	333	13.1	403	15.9	6	510	927
24	345	13.6	429	16.9	6	667	1257

Tab. 18: Dimensions and weight of orifice plate DPO 12A in inches and mm

Dimensions:
d Diameter of orifice plate opening
E Orifice plate thickness
d1 dependent on pipe internal diameter D
L Length

Internal seal between orifice plate disc and measuring flange:
Metallic graphite, smooth facing

- Material of orifice plate: Rust-proof steel SS 316TI
- Angle tapping nozzle 0°



Deltatop DPO 12E Ordering information for orifice flange DIN

10	Application: pipe orientation
C	Gas flow; horizontal pipe orientation
B	Gas flow; verticals pipe orientation
C	Liquid flow; horizontal pipe orientation
D	Liquid flow; vertical pipe orientation
E	Steam; horizontal pipe, mounting left (version with condensat chambers)
F	Steam; horizontal pipe, mounting right (version with condensat chambers)
G	Steam; vertical pipe, flow upwards (version with condensat chambers)
N	Steam; vertical pipe, flow downwards (version with condensat chambers)
Y	Special version

20	Approval
1	Without special approvals
2	Material approval to 3.1B, EN 10204
3	Free from oil and grease
4	Confirmed pressure test
5	3.1B certificate and pressure test
9	Special version

30	Nominal diameter pipe, material		Example G2: DN 125, Material SS 316Ti
C❑	DN 50	Flange and manifold	1 Material C22.8
D❑	DN 65	Flange and manifold	2 Material SS 316TI
E❑	DN 80	Flange and manifold	
F❑	DN 100	Flange and manifold	
G❑	DN 125	Flange and manifold	
H❑	DN 150	Flange and manifold	
K❑	DN 200	Flange and manifold	
L❑	DN 250	Flange and manifold	
M❑	DN 300	Flange and manifold	
N❑	DN 350	Flange and manifold	
P❑	DN 400	Flange and manifold	
Q❑	DN 500	Flange and manifold	
Y9	Special version		

40	Pressure rating	
C	PN1 0	for DN 50 to DN 300
B	PN 10	for DN 350 to DN 500
D	PN 16	for DN 50 to DN 300
E	PN 16	for DN 350 to DN 500
G	PN 25	for DN 50 to DN 300
N	PN 25	for DN 350 to DN 500
L	PN 40	for DN 50 to DN 300
m	PN 40	for DN 350 to DN 500
P	PN 64	for DN 50 to DN 200
R	PN 64	for DN 250 to DN 400
T	PN 100	for DN 50 to DN 150
W	PN 100	for DN 200 to DN 350
Y	Special version	

50	Seals on manifold
1	Viton seals on manifold
2	PTFE seals on manifold, max. PN 100
9	Special version

60	Adjustment Deltabar S
F	Flow values, square root
P	Differential pressure values, linear
S	Adjustment 0..100%, square root
T	Adjustment 0..100%, linear
Y	Special version

DPO 12E	Complete product designation

Deltatop DPO 12A Ordering information for orifice flange ANSI

10	Application: pipe orientation
C	Gas flow; horizontal pipe orientation
B	Gas flow; verticals pipe orientation
C	Liquid flow; horizontal pipe orientation
D	Liquid flow; vertical pipe orientation
E	Steam; horizontal pipe, mounting left (version with condensat chambers)
F	Steam; horizontal pipe, mounting right (version with condensat chambers)
G	Steam; vertical pipe, flow upwards (version with condensat chambers)
N	Steam; vertical pipe, flow downwards (version with condensat chambers)
Y	Special version

20	Approval
1	Without special approvals
2	Material approval to 3.1B, EN 10204
3	Free from oil and grease
4	Confirmed pressure test
5	3.1B certificate and pressure test
9	Special version

30	Nominal diameter pipe, material Letter = nominal diameter / Numeral = material		Example G2: DN 125, Material SS 316Ti
C❑	DN 2"	Flange and manifold	[1] Material C22.8
D❑	DN 2 1/2"	Flange and manifold	[2] Material SS 316TI
E❑	DN 3"	Flange and manifold	
F❑	DN 4"	Flange and manifold	
G❑	DN 5"	Flange and manifold	
H❑	DN 6"	Flange and manifold	
K❑	DN 8"	Flange and manifold	
L❑	DN 10"	Flange and manifold	
M❑	DN 12"	Flange and manifold	
N❑	DN 14"	Flange and manifold	
P❑	DN 16"	Flange and manifold	
Q❑	DN 20"	Flange and manifold	
R❑	DN 24"	Flange and manifold	
Y9	Special version		

40	Pressure rating	
C	300 lbs	for DN 2" to DN 12"
D	300 lbs	for DN 14" to DN 24"
E	600 lbs	for DN 2" to DN 12"
F	600 lbs	for DN 14" to DN 24"
Y	Special version	

50	Seals on manifold
1	Viton seals on manifold
2	PTFE seals on manifold, max. PN 100
9	Special version

60	Adjustment Deltabar S
F	Flow values, square root
P	Differential pressure values, linear
S	Adjustment 0..100%, square root
T	Adjustment 0..100%, linear
Y	Special version

DPO 12A	Complete product designation

Deltatop DPO 15
Compact version
Orifice pipe unit

Orifice pipe unit with up- and downstream lengths. Flange acc. to DIN 263x. With Deltabar S and 3-valve manifold, ready mounted and set.

This version covers the pipe diameter range below DN 50. As the orifice plate standards above this diameter range are valid, the orifice pipe unit can be calibrated by the manufacturer. The integrated up- and downstream lengths and the central orifice plate installation provide high accuracy.

For the required Ordering Information - see also pp. 36 and 37:

10 Application
Medium and pipe orientation
Figure: Gas measurement, horizontal piping

20 Approval
With or without special approvals

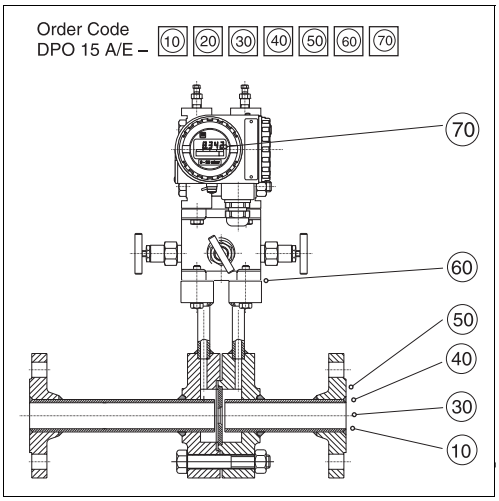
30 DN flange connection, material, length

40 Pressure rating

50 Shape of facing of pipe flange

60 Seals on manifold

70 Adjustment Deltabar S
Flow, differential pressure or %- display

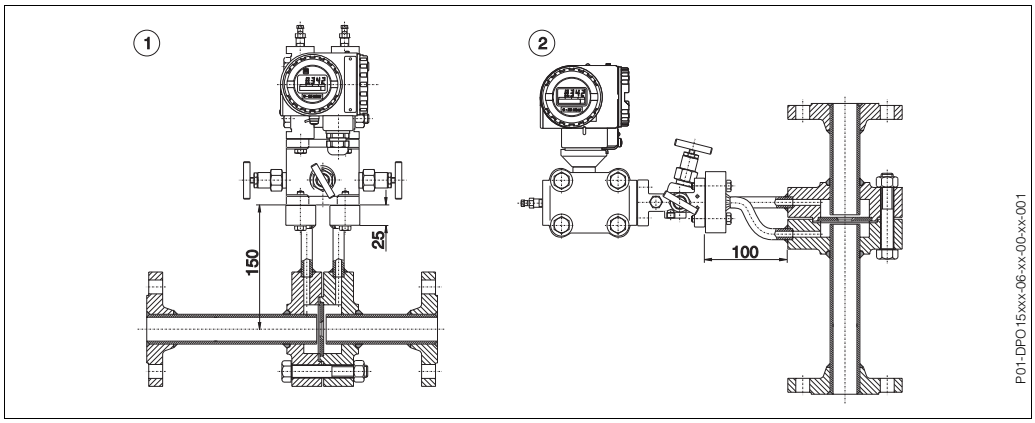


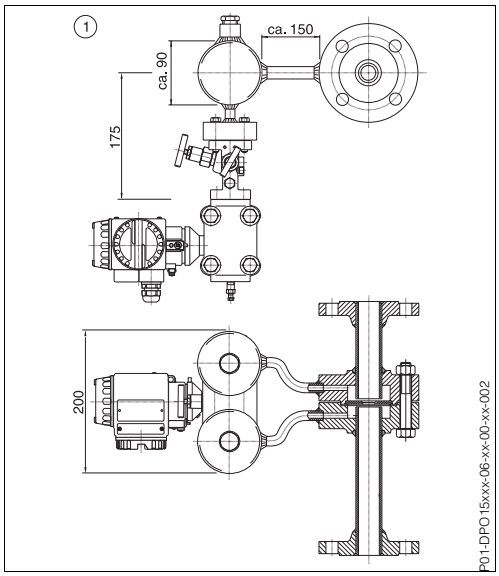
Dimensioned drawings (right):

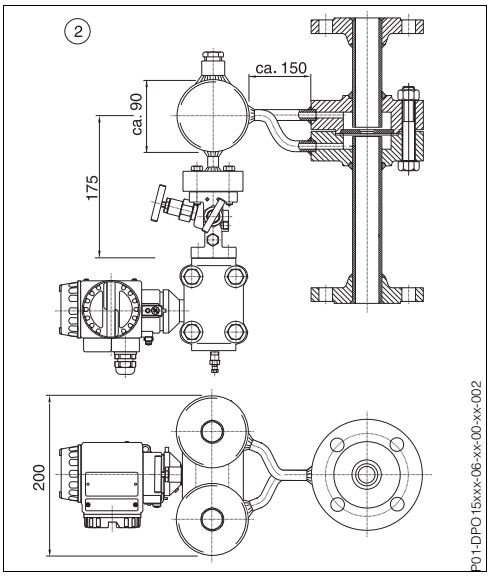
❑ Orifice plates for gases and liquids
① for horizontal piping
② for vertical piping with Deltabar housing T4

Dimensioned drawings (below):

❑ Orifice plates for steam (with two condensat chambers):
① Horizontal piping
② Vertical piping







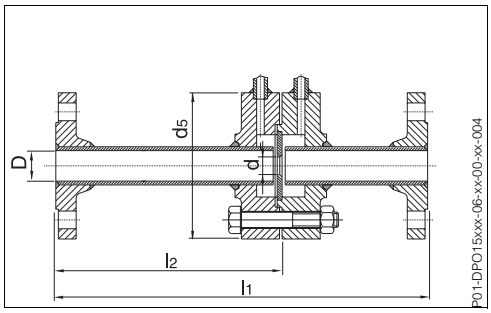
DN	l1 (mm)	l2 (mm)	Total weight (kg, approx.)
DIN			
10	400	230	11
15	550	380	12
20	700	500	16
25	900	650	19
32	1100	800	22
40	1300	1000	25
ANSI			
1/2	550	380	12
3/4	700	500	16
1	900	650	19
1 1/2	1300	1000	25

Tab. 19: Dimensions of DPO 15E and DPO 15A

Material of orifice plate: rust-proof steel SS 316TI
Limit thickness insulation from which the orifice plate must be lengthened: 120 mm
Max. temperature in process tube: gases/fluids 200 °C, steam 300 °C
Angle of tapping nozzle: 0 °

Dimensions:

d Diameter of orifice plate opening
D Pipe internal diameter
d5 See table
l1 Length
l2 Distance from orifice plate to flange



	PN 6	PN 10/16 PN 40	PN 64 PN 100			150 lbs	300 lbs 600 lbs
DN 10	75	90	100		**DN 1/2"**	88,9	95,2
DN 15	80	95	105		**DN 3/4"**	98,6	117,3
DN 20	90	105			**DN 1"**	108,0	124,0
DN 25	100	115	140		**DN 1 1/2"**	127,0	155,4
DN 32	120	140	155				
DN 40	130	150	170				

Tab. 20: Dimensions of d5 for DPO 15E and DPO 15A

Deltatop DPO 15E Ordering information for orifice pipe unit, DIN

10	Application: pipe orientation
C	Gas flow; horizontal pipe orientation
B	Gas flow; verticals pipe orientation
C	Liquid flow; horizontal pipe orientation
D	Liquid flow; vertical pipe orientation
E	Steam; horizontal pipe, mounting left (version with condensat chambers)
F	Steam; horizontal pipe, mounting right (version with condensat chambers)
G	Steam; vertical pipe, flow upwards (version with condensat chambers)
N	Steam; vertical pipe, flow downwards (version with condensat chambers)
Y	Special version

20	Approval
1	Without special approvals
2	Material approval to 3.1B, EN 10204
3	Free from oil and grease
4	Confirmed pressure test
5	3.1B certificate and pressure test
6	Wet calibration with certificate
9	Special version

30	Flange connection, material, length	
C	DN 10	C22.8; length 400
B	DN 10	SS 316TI; length 400
C	DN 15	C22.8; length 550
D	DN 15	SS 316TI; length 550
I	DN 20	C22.8; length 700
J	DN 20	SS 316TI; length 700
E	DN 25	C22.8; length 900
F	DN 25	SS 316TI; length 900
K	DN 32	C22.8; length 1100
L	DN 32	SS 316TI; length 1100
G	DN 40	C22.8; length 1300
N	DN 40	SS 316TI; length 1300
Y	Special version, e.g. DN4	

40	Pressure rating
1	PN 6
2	PN 10
3	PN 16
4	PN 25
5	PN 40
6	PN 64
7	PN 100
9	Special version

50	Facing of pipe flange
C	Facing form C
B	Facing form E
C	Facing: groove
D	Facing: recess
Y	Special version

60	Seals on manifold
1	Viton seals on manifold
2	PTFE seals on manifold, max. PN 100
9	Special version

70	Adjustment Deltabar S
F	Flow values, square root
P	Differential pressure values, linear
S	Adjustment 0..100%, square root
T	Adjustment 0..100%, linear
Y	Special version
DPO 15E	Complete product designation

Deltatop DPO 15A Ordering information for orifice pipe unit, ANSI

10	Application: pipe orientation
	C Gas flow; horizontal pipe orientation
	B Gas flow; verticals pipe orientation
	C Liquid flow; horizontal pipe orientation
	D Liquid flow; vertical pipe orientation
	E Steam; horizontal pipe, mounting left (version with condensat chambers)
	F Steam; horizontal pipe, mounting right (version with condensat chambers)
	G Steam; vertical pipe, flow upwards (version with condensat chambers)
	N Steam; vertical pipe, flow downwards (version with condensat chambers)
	Y Special version

20	Approval
	1 Without special approvals
	2 Material approval to 3.1B, EN 10204
	3 Free from oil and grease
	4 Confirmed pressure test
	5 3.1B certificate and pressure test
	6 Wet calibration with certificate
	9 Special version

30	Flange connection, material, length		
	C	DN 1/2"	C22.8; length 550
	B	DN 1/2"	SS 316TI; length 550
	C	DN 3/4"	C22.8; length 700
	D	DN 3/4"	SS 316TI; length 700
	E	DN 1"	C22.8; length 900
	F	DN 1"	SS 316TI; length 900
	G	DN 1 1/2"	C22.8; length 1300
	N	DN 1 1/2	SS 316TI; length 1300
	Y	Special version, e.g. DN4	

40	Pressure rating
	1 150 lbs
	2 300 lbs
	3 600 lbs
	9 Special version

50	Facing of pipe flange
	C Flange facing: groove
	B Flange facing: recess
	C Flange facing: raised face (RF)
	Y Special version

60	Seals on manifold
	1 Viton seals on manifold
	2 PTFE seals on manifold, max. PN 100
	9 Special version

60	Adjustment Deltabar S
	F Flow values, square root
	P Differential pressure values, linear
	S Adjustment 0..100%, square root
	T Adjustment 0..100%, linear
	Y Special version

DPO 15E	Complete product designation

Deltatop DPP 10
Compact version with Pitot tube

Pitot tube with probe profile made of SS 316TI, metallic graphite seal. With Deltabar S and 3-valve manifold, ready mounted and set.

For the required Ordering Information - see also pp. 41:

10 Application
Medium and pipe orientation
Figure: Gas measurement, horizontal piping

20 Approval
With or without special approvals

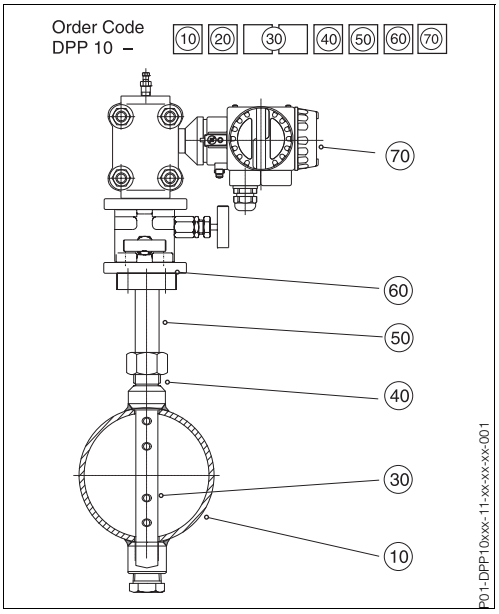
30 Nominal diameter pipe, material
Suppliable nominal diameters and material of welding parts

40 Probe installation
Cutting ring, flange or flow tap

50 Temperature sensor (as option)

60 Seals on manifold

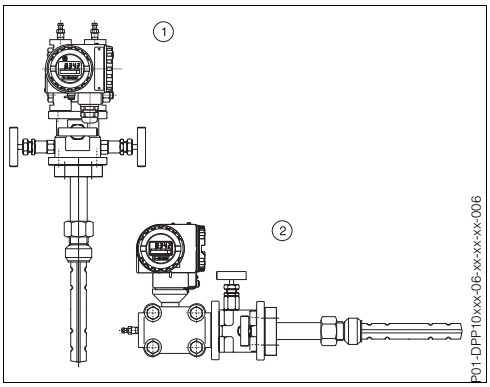
70 Adjustment Deltabar S
Flow, differential pressure or %-display



- With the Pitot tube, flow direction from DN 65 or 2 1/2" is insignificant, as the probe has a symmetrical construction.
- Material of probe profile:: Rust-proof steel SS 316TI

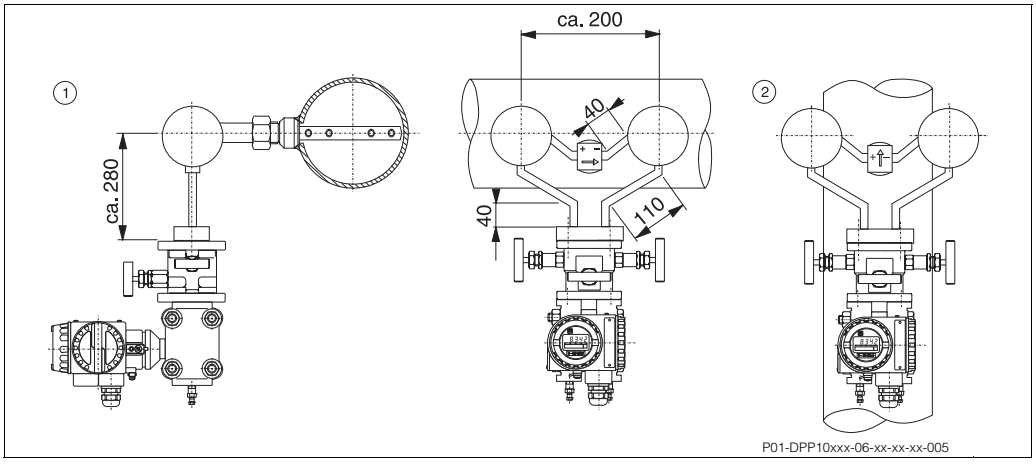
Dimensioned drawings (right):

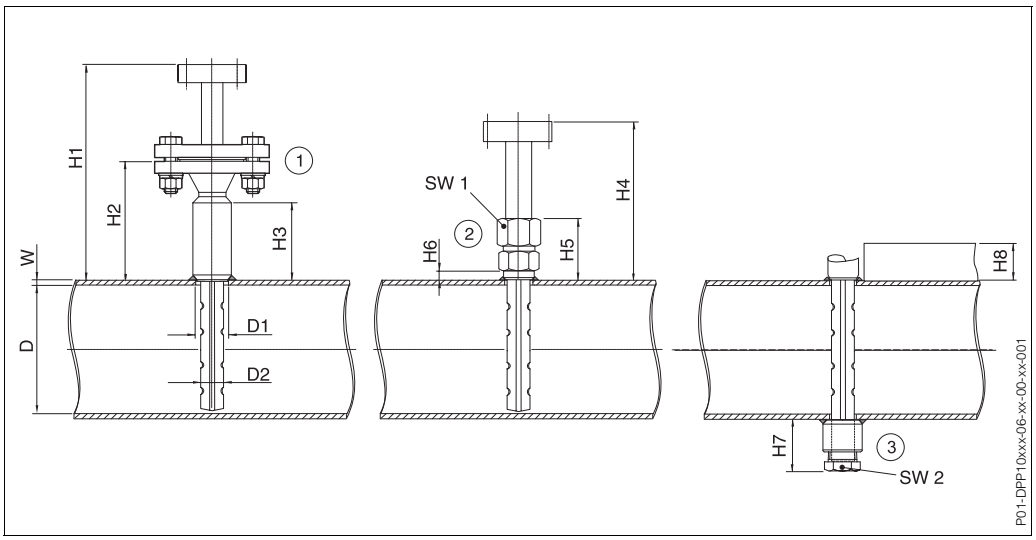
❑ Pitot tubes for gases and fluids:
① for horizontal piping
② for vertical piping with Deltabar housing T4



Dimensioned drawings (below):

❑ Pitot tubes for steam (with two condensat chambers):
① for horizontal piping
② for vertical piping





① *Flange: Max. temperature 200 °C, for steam 300 °C/116 bar*
② *Cutting ring: max. temperature 200 °C, for steam 200 °C/16 bar*
③ *Pitot tubes from DN 700 generally with steady, optionally for smaller nominal diameters (e.g. for large flow velocities)*

D *Pipe inner diameter (acc. to design sheet)*
D1 *Mounting drillhole*
D2 *Probe profile*
H1 *Distance to flange plate*
H2 *Distance to mounting flange*
H3/H6 *With insulated pipes, this minimum dimension must be increase by the insulation thickness H8 (this is also valid for H1/H2 and H4/H5)*
H7 *Height of the steady*
H8 *Hgh insulation (acc. to design sheet, standard 120 mm)*
W *Pipe wall thickness*
AF *Across flats*

	Mounting drill hole	**Probe profile**	**Flange ①**			**Cutting ring ②**				**Steady**	
	D1	**D2**	**H1**	**H2**	**H3**	**H4**	**H5**	**H6**	**SW1**	**H7**	**SW2**
DN 65/DN 80	16	12	180	80	50 *	130	48	10 *	27	40	22
DN ≥ DN 100	35	25	227	127	90 *	148	68	15 *	45	55	36

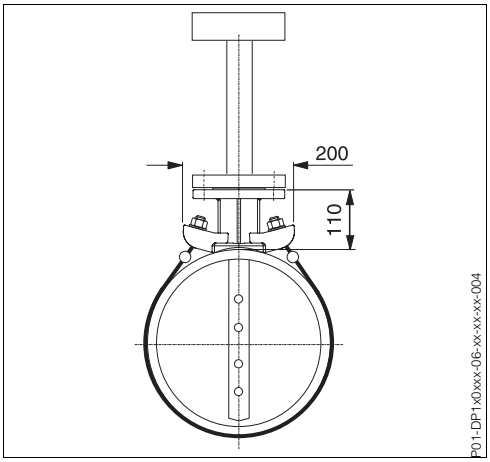
Tab. 21: Dimensions of Pitot tube DPP 10, all dimensions in mm

	Pipe DN 65/DN 80	**Pipe ≥DN 100**
Probe PN 40 bar	Flange DN 25	Flange DN 32
Probe PN 100 bar	Flange DN 25	Flange DN 40
Probe PN 160 bar	Flange DN 25	Flange DN 40
Probe PN 300 lbs	Flange DN 1"	Flange DN 1 1/4"
Probe PN 600 lbs	Flange DN 1"	Flange DN 1 1/4"
Probe PN 1500 lbs	Flange DN 1"	Flange DN 1 1/4"

Tab. 22: Nominal diameter of flanges for Pitot tube DPP 10

Saddle flange
The saddle flange allows the Pitot tube to be mounted on pipes (nominal diameter DN 65...DN 500), upon which it is not possible to weld a cutting ring screw union or a flange (e.g. with cast or concrete pipes).

- Saddle flange
  Material: GGG-40/EWS-coated
  Dimensions: see Fig., 90 mm wide
  Flange loss: DN 40/50, PN 4 for gas, PN 16 for water
  Saddle seal: NBR
  Weight: 5.5 kg
- Holding bracket
  From rust-proof steel, fully-vulcanised, 70 mm wide

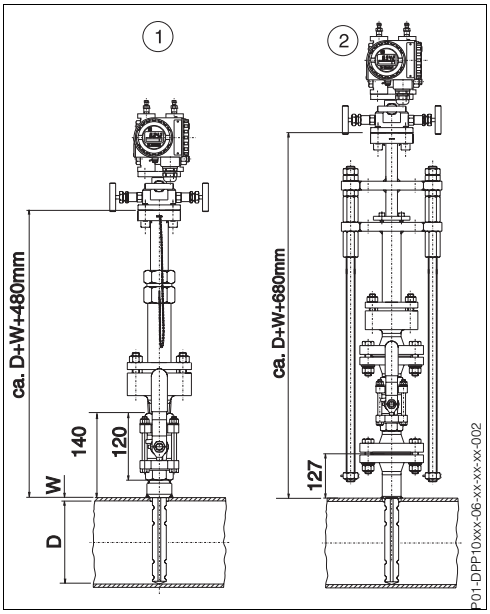


Flow tap
You can use the flow tap solution to repair or replace the Pitot tube during operation.

D Internal diameter of piping
W Wall thickness of pipe;
From DN 700 with steady 1NPT, Depth 51 mm
Max. temperature 300 °C, C, for steam 350 °C

① Flow tap with fixing chain
Distance from pipe - manifold (if probe in pipe): D + W + 480 mm
Distance from pipe - manifold (if probe removed from pipe): 2D + 2W + 480 mm

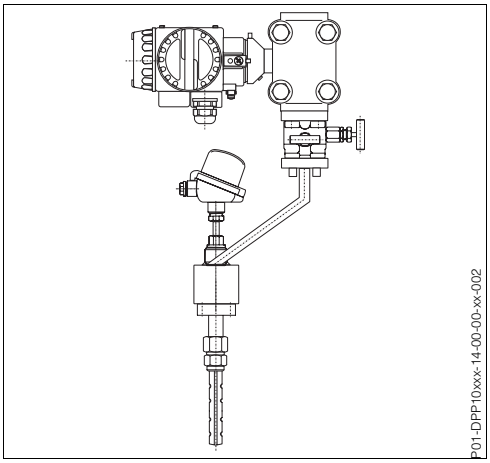
② Flow tap with spindle
Distance from pipe - manifold (if probe in pipe): D + W + 680 mm
Distance from pipe - manifold (if probe removed from pipe): 2D + 2W + 680 mm



Temperature sensor
To determine the medium temperature, with Pitot tubes from DN 100 there is optionally an integrated temperature measurement:

❏ With Pt100 temperature sensor
❏ With 4...20 mA temperature sensor

You can find additional information on the temperature sensor on page 23.



Deltatop DPP 10 Ordering Information for Pitot tube

10 Application: pipe orientation

C	Gas flow; horizontal pipe orientation
B	Gas flow; verticals pipe orientation
C	Liquid flow; horizontal pipe orientation
D	Liquid flow; vertical pipe orientation
K	Steam; horizontal pipe, mounting left (version with condensat chambers)
P	Steam; horizontal pipe, mounting right (version with condensat chambers)
L	Steam; vertical pipe, flow upwards (version with condensat chambers)
Q	Steam; vertical pipe, flow downwards (version with condensat chambers)

20 Approval

1	Without special approvals
2	Material approval to 3.1B, EN 10204
3	Free from oil and grease
4	Confirmed pressure test
5	3.1B certificate and pressure test
9	Special version)

30 Nominal diameter pipe, material
Letter = nominal diameter / Numeral = material

Example G2: DN 125, Material SS 316Ti
1 Material C22.8
2 Material SS 316TI

D❑	DN 65	2 1/2"		
E❑	DN 80	3"		
F❑	DN 100	4"		
G❑	DN 125	5"		
H❑	DN 150	6"		
K❑	DN 200	8"		
L❑	DN 250	10"		
M❑	DN 300	12"		
N❑	DN 350	14"		
P❑	DN 400	16"		
Q❑	DN 500	20"		
R❑	DN 600	24"		
S❑	DN 700	28"		with end support
T❑	DN 800	32"		with end support
U❑	DN 900	36"		with end support
V❑	DN 1000	40"		with end support
W❑	DN 1200	48"		with end support
W3	DN 1500	60"	C 22.8	with end support
W4	DN 1500	60"	SS 316Ti	with end support
X❑	DN 1800	72"		with end support
X3	DN 2000	80"	C 22.8	with end support
X4	DN 2000	80"	SS 316Ti	with end support
Y	Special version			

40 Pitot tube installation

C	Cutting ring	PN 40
B	Flange DIN 2527	PN 40
C	Flange DIN 2527	PN 100
D	Flange DIN 2527	PN 160
E	Flange ANSI B16.5	300 lbs
F	Flange ANSI B16.5	600 lbs
G	Flange ANSI B16.5	1500 lbs
N	Flow tap with spindle	
I	Flow tap with fixing chain	
L	Saddle flange for non-weldable pipes	
Y	Special version	

50 Integrated temperature sensor

1	Without temperature sensor
2	With integrated Pt100 temperature sensor
3	With integrated 4...20 mA temperature sensor
9	Special version

60 Seals on manifold

1	Viton seals on manifold
2	PTFE seals on manifold, max. PN 100
Y	Special version)

70 Adjustment Deltabar S

F	Flow values, square root
P	Differential pressure values, linear
S	Adjustment 0..100%, square root
T	Adjustment 0..100%, linear
Y	Special version

DPP 10 — **Complete product designation**

Deltaset versions

Scope of supply

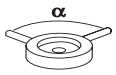
Deltaset is a modular flowmeter system based on Differential pressure values. It complements Deltatop during installations with impulse pipes, e.g.

- at process temperatures above 300°C (impulse pipes as cooling section),
- to be able to install the transmitter despite impeded access to the piping,
- if available impulse pipes are to be used.

In the individual ordering positions, select the primary device (orifice plate or Pitot tube), 2 shut-off valves, 2 condensat chambers and the manifold. The delivery comes complete with enclosed Deltabar S differential pressure transmitter (which is ordered extra). The primary device, 2 shut-off valves (and 2 condensat chambers for steam applications) are premounted. The impulse pipes can be mounted by the customer between the shut-off valves and the manifold.

The Deltabar S is supplied with an optimum differential pressure sensor, so that the customer need not calculate the primary device prior to ordering. The differential pressure is preset, as is the square root or linear characteristic and the selected display option (flow, differential pressure or percentage value).

Angle α of tapping nozzle

	**One-part orifice plate with corner tapping DPO 50**		**Two-part orifice plate with corner tapping (annular chamber) DPO 51**		**Measuring flange orifice plate DPO 52**	
	Liquid, Gas	Steam	Liquid, Gas	Steam	Liquid, Gas	Steam
Piping horizontal	0 °	0 °	0° No. 2 *	0° No. 2 *	α to DIN 19205 No. 10 *	180° No. 2 *
Piping vertical bottom –> top	0 °	90 °	0° No. 12 *	90° No. 4 *	90° No. 13 *	90° No. 6 *
Piping vertical top –> bottom	0 °	90 °	0° No. 12 *	90° No. 5 *	90° No. 13 *	90° No. 7 *

Tab. 23: Angle α for tapping nozzle
*The numbers with * are related to the appropriate arrangement acc. to DIN 19205 (Part 1) listed in Table 7. This standard specifies the standard tapping angles.*

Connection selection

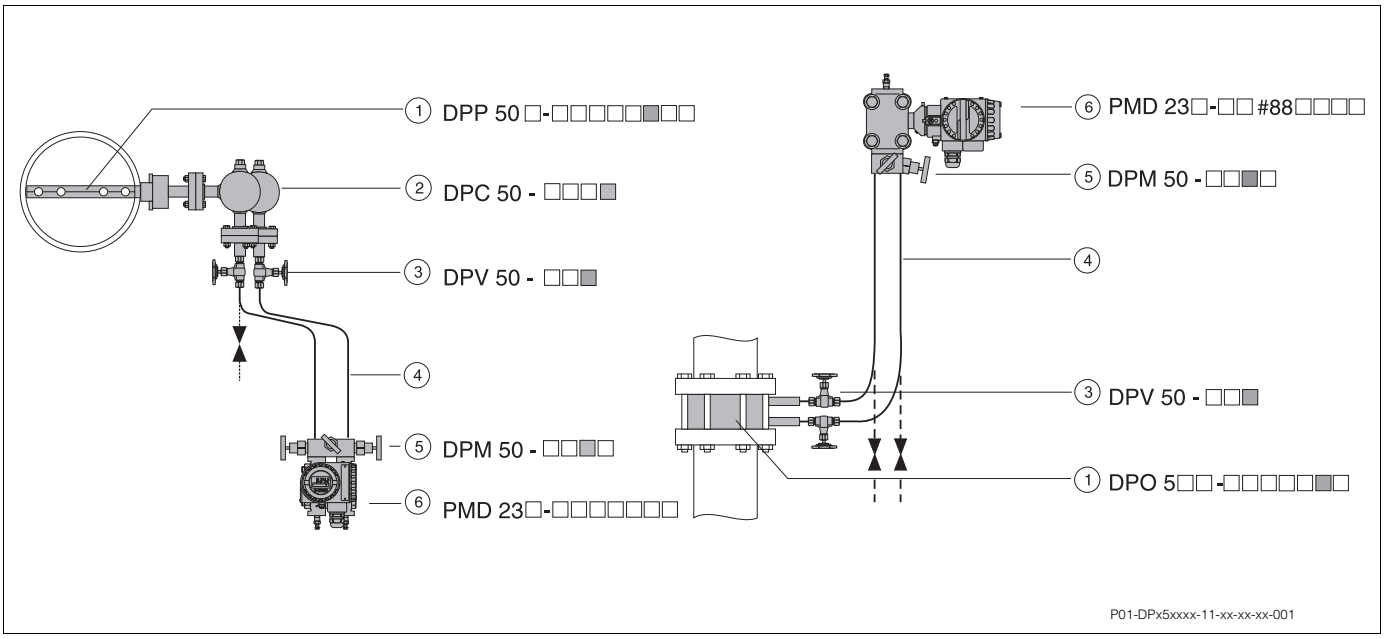
The following figure gives an example of the components forming a Deltaset measuring point:

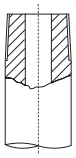
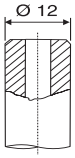
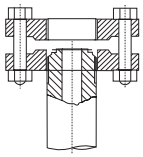
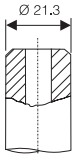
- Pitot tube for steam (left)
- Orifice plate for gas (right)

□ This position in the order code sets the connections of the individual components

The table shows with which pressure taps the components can be ordered - you can find additional information with the appropriate ordering information.

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	Pressure taps	Thread 1/2 NPT	Pipe for cutting ring	G 1/2 with flange pair	Pipe for welded connection	
						
				Use with steam		
		Use with gases and liquids				
①	**Primary device** DPO 50/51/52/53, DPP50	DPO 5❑❑-❑❑❑❑❑1❑ DPP 50-❑❑❑❑❑1❑ 1/2 NPT male	DPO 5❑❑-❑❑❑❑❑2❑ DPP 50-❑❑❑❑❑2❑ Pipe 12 mm for cutting ring	DPO 5❑❑-❑❑❑❑❑3❑ DPP 50-❑❑❑❑❑3❑ G 1/2	DPO 5❑❑-❑❑❑❑❑4❑ DPP 50-❑❑❑❑❑4❑ Welded connection 21.3	
②	**2 condensat chambers** DPC 50 (for steam)			DPC 50-❑❑❑3 G1/2 with flange pair DIN 19207 / G 1/2 /	DPC 50-❑❑❑4 Welded connection 21.3 / Welded connection 21.3	
③	**2 shut-off valves** DPV 50 Input/output	DPV 50-❑❑1 1/2 NPT female / 1/2 NPT female	DPV 50-❑❑2 Cutting ring / Cutting ring	DPV 50-❑❑3 G1/2 with flange pair DIN 19207 / Cutting ring	DPV 50-❑❑4 Welded connection 21.3 / Cutting ring	DPV 50-❑❑5 Welded connection 21.3 / Welded connection 14 x 2.5
④	**2 x pressure piping**	Not in scope of supply	Not in scope of supply	Not in scope of supply	Not in scope of supply	Not in scope of supply
⑤	**manifold** DPM 50	DPM 50-❑❑1❑ 1/2 NPT female	DPM 50-❑❑2❑ Cutting ring	DPM 50-❑❑❑❑	DPM 50-❑❑❑❑	DPM 50-❑❑5❑ Welded connection 14 x 2.5

Tab. 24: This table shows which pressure taps are possible with the components of Deltaset.

Deltaset DPO 50
Undivided orifice plate with corner tapping

Primary device acc. to DIN 19205 (B) bzw. ISO 5167. For installation between flanges to DIN 263x.
The (specially ordered) shut-off valves DPV 50 or condensat chambers DPC 50 are supplied premounted, the 3-valve manifold DPM 50 is also supplied. The Deltabar S differential pressure transmitter is optimised and set.

For the required Ordering Information - see also pp. 46 and 47:

10 Application
Medium and pipe orientation
Figure: Gas measurement, horizontal piping

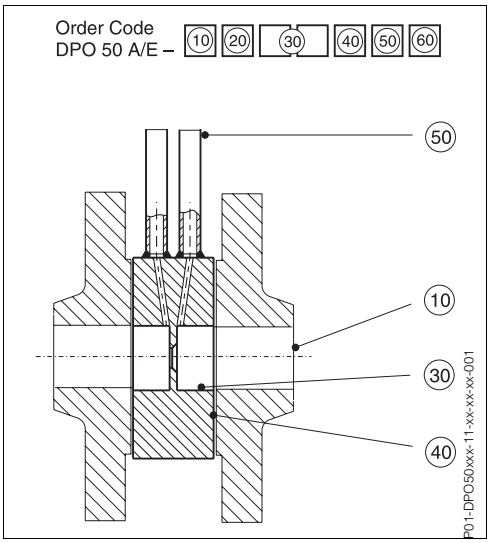
20 Approval
With or without special approvals

30 Nominal diameter pipe, material

40 Pressure rating, facing

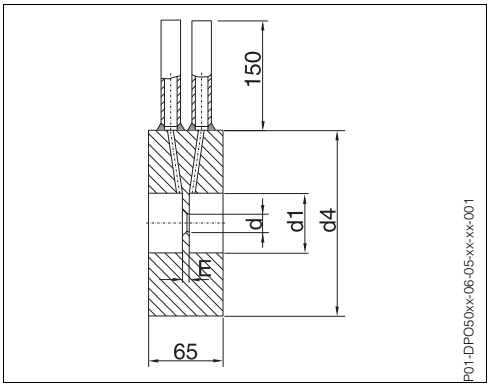
50 Connection of tapping nozzle
See table on page 42

60 Adjustment Deltabar S
Flow, differential pressure or percentage display



Dimensioned drawings (right)

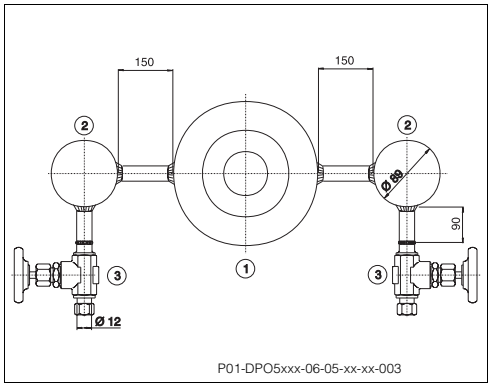
❑ Orifice plates for gases and liquids
For dimensions table, see page 44

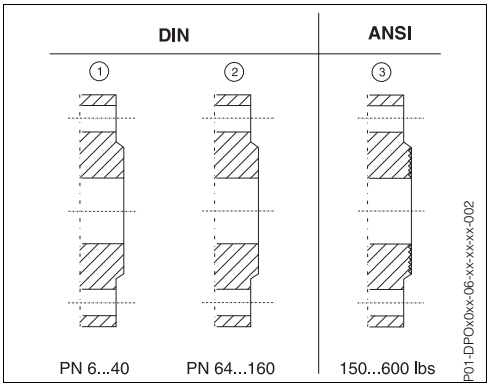


Dimensioned drawings (below)

❑ Orifice plates for steam
(arrangement example)
① Orifice plate
② Condensate trap
③ Shut-off valve

❑ Possible facings
① Raised face (Rz=160)
② Shape E (Rz=16)
③ Shape RF (raised face)





Dimensions for orifice plates
DIN flange
DPO 50E
DPO 51E
DPO 53E

DN (mm)	d_4 (mm)								E (mm)	d_1 (mm)	Weight (approx. kg)
	PN 6	PN 10	PN 16	PN 25	PN 40	PN 64	PN 100	PN 160			
50	96	107		107		112	119		3	D + 1 mm	10
65	116	127		127		137	143		3		10.5
80	132	142		142		147	153		4		12
100	152	162		167		173	180		4		13
125	182	192		193		210	217		4	D + 2 mm	14
150	207	217		223		247	257		5		15
200	262	272	272	283	290	309	324		5		18
250	317	327	328	340	352	364	391	388	5		22
300	372	377	383	400	417	424	458	458	6		27
350	422	437	443	457	474	486	512		6		31
400	472	488	495	514	546	543			6		33
500	577	593	617	624	628				8		37
600	678	695	734	731					8		45
700	783	810	804	833					10		57
800	890	917	911	942					10		67
900	990	1017	1011	1042					10		77
1000	1090	1124	1128	1154					10		88

Tab. 25: Dimensions and weight of orifice plate DPO 50E, nominal diameter DN in mm

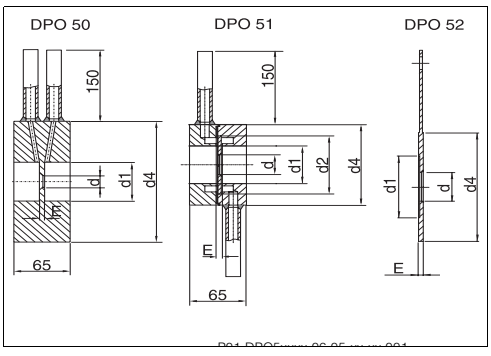
Dimensions for orifice plates
ANSI flange
DPO 50E
DPO 51A
DPO 53A

DN (in inches)	d_4						E (mm)	d_1 (mm)	Weight (approx. kg)
	in mm	in inches	in mm	in inches	in mm	in inches			
	150 lbs		300 lbs		600 lbs				
2	104.5	4.1	111	4.4	111	4.4	3	D +1 mm	10
2 1/2	124	4.9	130	5.1	130	5.1	3		10.5
3	136.5	5.4	149.5	5.9	149.5	5.9	4		12
4	174.5	6.9	181	7.1	193.5	7.6	4		13
5	197	7.8	216	8.5	241.5	9.5	4	D +2 mm	14
6	222.5	8.8	251	9.9	266.5	10,5	5		15
8	279.5	11.0	308	12.1	320.5	12.6	5		18
10	339.5	13.3	362	14.2	400	15.7	5		22
12	409.5	16.1	422	16.6	457	18.0	6		27
14	451	17.8	484.4	19.1	492	19.4	6		31
16	514.5	20.3	540	21.3	565	22.2	6		33
20	606.5	23.9	654	25.7	682.5	26.9	8	D +4 mm	37
24	717.5	27.9	774.5	30.5	790.5	31.1	8		45

Tab. 26: Dimensions and weight of orifice plate DPO 50A, nominal diameter DN in inches

Dimensions:
d Diameter of orifice plate opening (determined in design)
E Orifice plate thickness
d1 Internal diameter of holding ring
d4 Exterior orifice plate diameter
D Pipe internal diameter

Limit thickness of insulation from which the orifice plate neck must be lengthened: 120 mm



Deltaset DPO 50E
Ordering information for corner tapping
DIN

10	**Application: pipe orientation**								
	C	Gas flow; horizontal pipe orientation							
	B	Gas flow; verticals pipe orientation							
	C	Liquid flow; horizontal pipe orientation							
	D	Liquid flow; vertical pipe orientation							
	E	Steam; horizontal pipe,							
	G	Steam; vertical pipe, flow upwards							
	N	Steam; vertical pipe, flow downwards							
	Y	Special version							
20		**Approval**							
		1	Without special approvals						
		2	Material approval to 3.1B, EN 10204						
		3	Free from oil and grease						
		4	Material approval to 3.1A, EN 10204						
		9	Special version						
30			**Nominal diameter pipe, material** Letter = nominal diameter / Numeral = material						Example G2: DN 125, Material SS 316Ti
			C❑	DN 50	Ring and nozzle				1 Material C22.8
			D❑	DN 65	Ring and nozzle				2 Material SS 316TI
			E❑	DN 80	Ring and nozzle				3 Material 15Mo3
			F❑	DN 100	Ring and nozzle				
			G❑	DN 125	Ring and nozzle				
			H❑	DN 150	Ring and nozzle				
			K❑	DN 200	Ring and nozzle				
			L❑	DN 250	Ring and nozzle				
			M❑	DN 300	Ring and nozzle				
			N❑	DN 350	Ring and nozzle				
			P❑	DN 400	Ring and nozzle				
			Q❑	DN 500	Ring and nozzle				
			R❑	DN 600	Ring and nozzle				
			S❑	DN 700	Ring and nozzle				
			T❑	DN 800	Ring and nozzle				
			U❑	DN 900	Ring and nozzle				
			W❑	DN 1000	Ring and nozzle				
			Y9	Special version					
40				**Pressure rating, facing**					
				C	PN 6	Facing form C			
				B	PN 10	Facing form C			
				C	PN 16	Facing form C			
				D	PN 25	Facing form C			
				E	PN 40	Facing form C			
				F	PN 64	Facing form E			
				G	PN 100	Facing form E			
				N	PN 160	Facing form E			
				Y	Special version				
50					**Connection of pressure taps**				
					1	1/2 NPT male, not with steam			
					2	Pipe without thread, diameter 12 mm, not with steam			
					3	G 1/2, shape V to DIN ISO 19207			
					4	Welded connection 21.3 x 6.3			
					9	Special version			
60						**Adjustment Deltabar S**			
						F	Flow values, square root		
						P	Differential pressure values, linear		
						S	Adjustment 0..100%, square root		
						T	Adjustment 0..100%, linear		
						Y	Special version		
DPO 50E							**Complete product designation**		

Deltaset DPO 50A Ordering information for Corner tapping, ANSI

10								**Application: pipe orientation**		
								C	Gas flow; horizontal pipe orientation	
								B	Gas flow; verticals pipe orientation	
								C	Liquid flow; horizontal pipe orientation	
								D	Liquid flow; vertical pipe orientation	
								E	Steam; horizontal pipe, mounting left	
								G	Steam; vertical pipe, flow upwards	
								N	Steam; vertical pipe, flow downwards	
								Y	Special version	
20							**Approval**			
							1	Without special approvals		
							2	Material approval to 3.1B, EN 10204		
							3	Free from oil and grease		
							4	Material approval to 3.1A, EN 10204		
							9	Special version		
30				**Nominal diameter pipe, material** Letter = nominal diameter / Numeral = material						Beispiel G2: DN 5", Material 1.4571
				C❑	DN 2"	Ring and nozzle				1 Material C22.8
				D❑	DN 2 1/2"	Ring and nozzle				2 Material SS 316TI
				E❑	DN 3"	Ring and nozzle				3 Material 15Mo3
				F❑	DN 4"	Ring and nozzle				
				G❑	DN 5"	Ring and nozzle				
				H❑	DN 6"	Ring and nozzle				
				K❑	DN 8"	Ring and nozzle				
				L❑	DN 10"	Ring and nozzle				
				M❑	DN 12"	Ring and nozzle				
				N❑	DN 14"	Ring and nozzle				
				P❑	DN 16"	Ring and nozzle				
				Q❑	DN 20"	Ring and nozzle				
				R❑	DN 24"	Ring and nozzle				
				Y9	Special version					
40							**Pressure rating, facing**			
							C	150 lbs	RF (roughened facing)	
							B	300 lbs	RF (roughened facing)	
							C	600 lbs	RF (roughened facing)	
							Y	Special version		
50								**Connection of pressure taps**		
								1	1/2 NPT male (not with steam)	
								2	Pipe without thread, diameter 12 mm (not with steam)	
								3	G 1/2", shape V to DIN ISO 19207	
								4	Welded connection 21.3 x 6.3	
								9	Special version	
60									**Adjustment Deltabar S**	
									F	Flow values, square root
									P	Difference, linear
									S	Adjustment 0..100%, square root
									T	Adjustment 0..100%, linear
									Y	Special version
DPO 50A										**Complete product designation**

Deltaset DPO 51
Annular chamber orifice

Primary device acc. to DIN 19205 (A) or ISO 5167, orifice plate made of SS 316Ti, for mounting between flanges to DIN 263x with flat seal.
The (specially ordered) shut-off valves DPV 50 or condensat chambers DPC 50 are supplied premounted, the 3-valve manifold DPM 50 is also supplied. The Deltabar S differential pressure transmitter is optimised and set.

For the required Ordering Information - see also pp. 49 and 50:

10 Application
Medium and pipe orientation
Figure: Gas measurement, horizontal piping

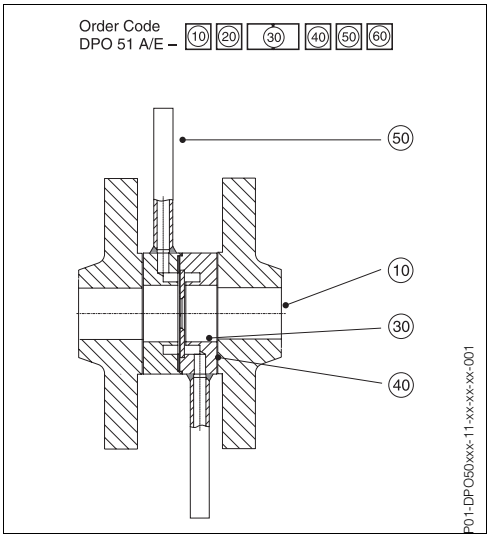
20 Approval
With or without special approvals

30 Nominal diameter pipe, material

40 Pressure rating, facing

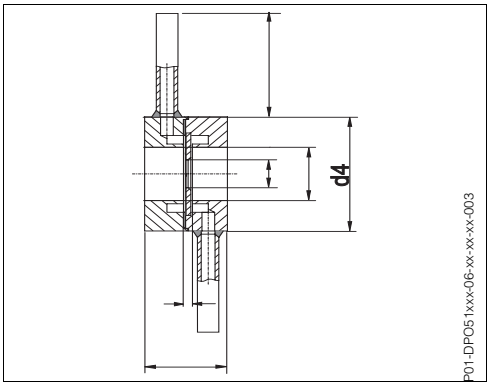
50 Connection of tapping nozzle
See table on page 43

60 Adjustment Deltabar S
Flow, differential pressure or percentage display



Dimensioned drawing (right)

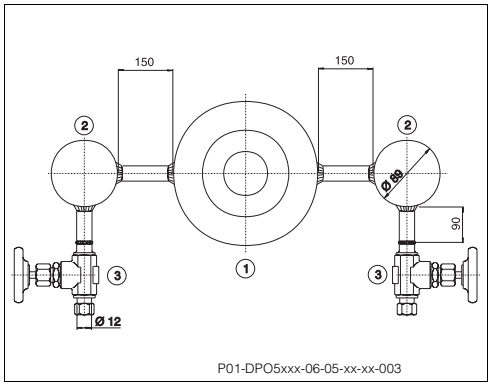
❑ Orifice plates for gases and Liquids
For dimensions table, see page 45

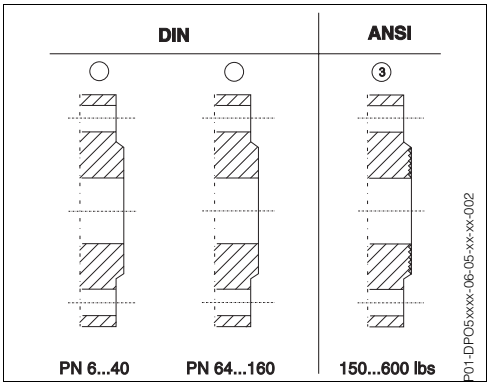


Dimensioned drawings (below)

❑ Orifice plates for steam
(arrangement example)
① Orifice plate
② Condensate trap
③ Shut-off valve

❑ Possible facings
① Raised face (Rz=160) ② Shape E (Rz=16)
③ Shape RF (raised face)





Deltaset DPO 51 E Ordering Information for annular chamber orifice DIN

10	Application: pipe orientation
C	Gas flow; horizontal pipe orientation
B	Gas flow; verticals pipe orientation
C	Liquid flow; horizontal pipe orientation
D	Liquid flow; vertical pipe orientation
E	Steam; horizontal pipe, mounting left
F	Steam; horizontal pipe, mounting right
G	Steam; vertical pipe, flow upwards
N	Steam; vertical pipe, flow downwards
Y	Special version

20	Approval
1	Without special approvals
2	Material approval to 3.1B, EN 10204
3	Free from oil and grease
9	Special version

30	Nominal diameter pipe, material Letter = nominal diameter / Numeral = material		Example G2: DN 125, Material SS 316Ti
C❑	DN 50	Ring and nozzle	1 Material C22.8
D❑	DN 65	Ring and nozzle	2 Material SS 316TI
E❑	DN 80	Ring and nozzle	
F❑	DN 100	Ring and nozzle	
G❑	DN 125	Ring and nozzle	
H❑	DN 150	Ring and nozzle	
K❑	DN 200	Ring and nozzle	
L❑	DN 250	Ring and nozzle	
M❑	DN 300	Ring and nozzle	
N❑	DN 350	Ring and nozzle	
P❑	DN 400	Ring and nozzle	
Q❑	DN 500	Ring and nozzle	
R❑	DN 600	Ring and nozzle	
S❑	DN 700	Ring and nozzle	
T❑	DN 800	Ring and nozzle	
U❑	DN 900	Ring and nozzle	
W❑	DN 1000	Ring and nozzle	
Y9	Special version		

40	Pressure rating, facing	
C	PN 6	Facing form C
B	PN 10	Facing form C
C	PN 16	Facing form C
D	PN 25	Facing form C
E	PN 40	Facing form C
F	PN 64	Facing form E
G	PN 100	Facing form E
Y	Special version	

50	Connection of pressure taps
1	1/2 NPT male (not with steam)
2	Pipe without thread, diameter 12 mm (not with steam)
3	G 1/2, shape V to DIN ISO 19207 (without flange pair)
4	Welded connection 21.3 x 6.3
9	Special version

60	Adjustment Deltabar S
F	Flow values, square root
P	Differential pressure values, linear
S	Adjustment 0..100%, square root
T	Adjustment 0..100%, linear
Y	Special version

DPO 51E	Complete product designation

Deltaset DPO 51 A Ordering Information for annular chamber orifice ANSI

10	**Application: pipe orientation**									
	C	Gas flow; horizontal pipe orientation								
	B	Gas flow; verticals pipe orientation								
	C	Liquid flow; horizontal pipe orientation								
	D	Liquid flow; vertical pipe orientation								
	E	Steam; horizontal pipe, mounting left								
	F	Steam; horizontal pipe, mounting right								
	G	Steam; vertical pipe, flow upwards								
	N	Steam; vertical pipe, flow downwards								
	Y	Special version								
20		**Approval**								
		1	Without special approvals							
		2	Material approval to 3.1B, EN 10204							
		3	Free from oil and grease							
		9	Special version							
30			**Nominal diameter pipe, material** Letter = nominal diameter / Numeral = material							Example G2: DN 125, Material SS 316Ti 1 Material C22.8 2 Material SS 316TI
			C❑	DN 2"	Ring and nozzle					
			D❑	DN 2 1/2"	Ring and nozzle					
			E❑	DN 3"	Ring and nozzle					
			F❑	DN 4"	Ring and nozzle					
			G❑	DN 5"	Ring and nozzle					
			H❑	DN 6"	Ring and nozzle					
			K❑	DN 8"	Ring and nozzle					
			L❑	DN 10"	Ring and nozzle					
			M❑	DN 12"	Ring and nozzle					
			N❑	DN 14"	Ring and nozzle					
			P❑	DN 16"	Ring and nozzle					
			Q❑	DN 20"	Ring and nozzle					
			R❑	DN 24"	Ring and nozzle					
			Y9	Special version						
40					**Pressure rating, facing**					
				C	150 lbs	RF (roughened facing)				
				B	300 lbs	RF (roughened facing)				
				C	600 lbs	RF (roughened facing)				
				Y	Special version					
50						**Connection of pressure taps**				
					1	1/2 NPT male (not with steam)				
					2	Pipe without thread, diameter 12 mm (not with steam)				
					3	G 1/2", shape V to DIN ISO 19207 (without flange pair)				
					4	Welded connection 21.3 x 6.3				
					9	Special version				
60							**Adjustment Deltabar S**			
						F	Flow values, square root			
						P	Differential pressure values, linear			
						S	Adjustment 0..100%, square root			
						T	Adjustment 0..100%, linear			
						Y	Special version			
DPO 51A							**Complete product designation**			

Deltaset DPO 52
Orifice flange

Primary device acc. to DIN 19214 or ANSI B16.36. orfice plate with screws and seals.
The (specially ordered) shut-off valves DPV 50 or condensat chambers DPC 50 are supplied premounted, the 3-valve manifold DPM 50 is also supplied. The Deltabar S differential pressure transmitter is optimised and set.

For the required Ordering Information - see also pp. 53 and 54:

10 Application
Medium and pipe orientation
Figure: Gas measurement, horizontal piping

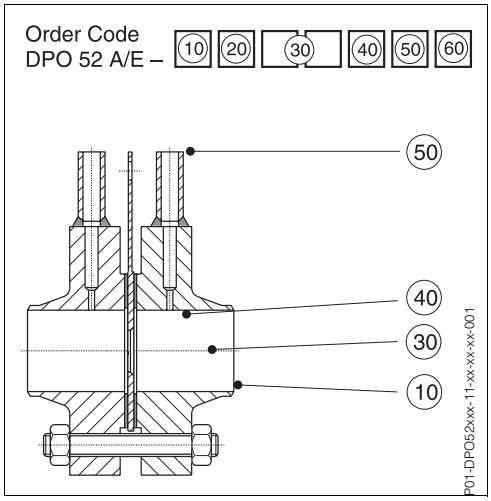
20 Approval
With or without special approvals

30 Nominal diameter pipe, material

40 Pressure rating

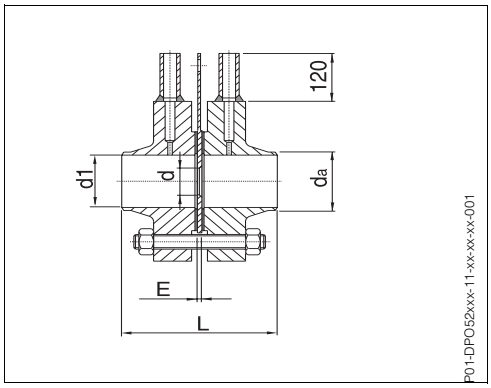
50 Connection of tapping nozzle
See table on page 43

60Adjustment Deltabar S
Flow, differential pressure or percentage display



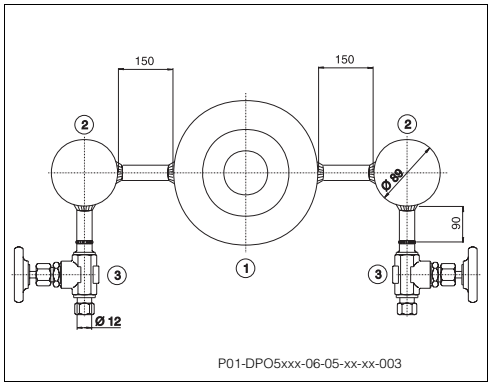
Dimensioned drawing

❑ Orifice plates for gases and liquids
See dimensions table on next page



Dimensioned drawings

❑ Orifice plates for steam
(arrangement example)
① Orifice plate
② Condensate trap
③ Shut-off valve



DN (mm)	da (mm)	Length L (mm)						E (mm)	Weight (approx. kg)
		PN 10	PN 16	PN 25	PN 40	PN 64	PN 100		
50	60.3	133	133	135	135	150	159	3	9
65	76.1	133	133	139	139	162	170	3	11
80	88,9	140	140	148	148	167	170	4	14
100	114.3	144	144	162	162	175	191	4	20
125	139.7	146	146	164	164	187	222	4	30
150	168.3	146	146	174	174	201	242	4	42
200	219.1	156	156	180	188	232	272	4	70
250	272	164	168	192	217	262	326	4	100
300	323.9	164	180	196	237	292	352	4	130
350	355.6	164	184	257	257	312	390	4	170
400	406.4	172	186	277	277	332		4	208
500	508	176	194	289	289			6	238

Tab. 27: Dimensions and weight of orifice plate DPO 52E, nominal diameter DN in mm

DN	da	Length L				E	Weight
(inches)	in mm	in mm	in inches	in mm	in inches	in mm	300 lbs(600 lbs) approx. kg
		300 lbs		600 lbs			
2	60.3	179	70.5	179	70.5	3	12 (12)
2 1/2	73.0	184	72.4	184	72.4	3	16 (16)
3	88,9	184	72.4	197	77.6	3	24 (24)
4	114.3	190	74.8	222	87.4	3	38 (59)
5	141.3	207	81.5	248	97.6	3	50 (95)
6	168.3	207	81.5	254	100.0	3	60 (111)
8	219.1	228	89.8	286	112.6	3	86 (158)
10	273.0	241	94.9	324	127.6	3	122 (258)
12	323.8	266	104.7	330	129.9	3	185 (314)
14	355.6	292	115.0	350	137.8	6	253 (463)
16	406.4	301	118.5	379	149.2	6	338 (631)
20	508.0	333	131.1	403	158.7	6	503 (920)
24	609.6	345	135.8	429	168.9	6	660 (1250)

Tab. 28: Dimensions and weight of orifice plate DPO 52A, nominal diameter DN in inches

Deltaset DPO 52E Ordering information for orifice flange DIN

10 — Application: pipe orientation

C	Gas flow; horizontal pipe orientation
B	Gas flow; verticals pipe orientation
C	Liquid flow; horizontal pipe orientation
D	Liquid flow; vertical pipe orientation
E	Steam; horizontal pipe, mounting left
F	Steam; horizontal pipe, mounting right
G	Steam; vertical pipe, flow upwards
N	Steam; vertical pipe, flow downwards
Y	Special version

20 — Approval

1	Without special approvals
2	Material approval to 3.1B, EN 10204
3	Free from oil and grease
9	Special version

30 — Nominal diameter pipe, material
Letter = nominal diameter / Numeral = material

Example G2: DN 125, Material SS 316Ti
1 Material C22.8
2 Material SS 316TI

C❑	DN 50	Flange and nozzle
D❑	DN 65	Flange and nozzle
E❑	DN 80	Flange and nozzle
F❑	DN 100	Flange and nozzle
G❑	DN 125	Flange and nozzle
H❑	DN 150	Flange and nozzle
K❑	DN 200	Flange and nozzle
L❑	DN 250	Flange and nozzle
M❑	DN 300	Flange and nozzle
N❑	DN 350	Flange and nozzle
P❑	DN 400	Flange and nozzle
Q❑	DN 500	Flange and nozzle
Y9	Special version	

40 — Pressure rating

C	PN 10	(for DN 50...DN 300)
B	PN 10	(for DN 350...DN 500)
D	PN 16	(for DN 50...DN 300)
E	PN 16	(for DN 350...DN 500)
G	PN 25	(for DN 50...DN 300)
N	PN 25	(for DN 350...DN 500)
L	PN 40	(for DN 50...DN 300)
m	PN 40	(for DN 350...DN 500)
P	PN 64	(for DN 50...DN 300)
R	PN 64	(for DN 350...DN 500)
Y	Special version	

50 — Connection of pressure taps

1	1/2 NPT male (not with steam)
2	Pipe without thread, diameter 12 mm (not with steam)
3	G 1/2, shape V to DIN ISO 19207 (without flange pair)
4	Welded connection 21.3 x 6.3
9	Special version

60 — Adjustment Deltabar S

F	Flow values, square root
P	Differential pressure values, linear
S	Adjustment 0..100%, square root
T	Adjustment 0..100%, linear
Y	Special version

DPO 52E — **Complete product designation**

Deltaset DPO 52A
Odering information for orifice flange
ANSI

10	**Application: pipe orientation**									
	C	Gas flow; horizontal pipe orientation								
	B	Gas flow; verticals pipe orientation								
	C	Liquid flow; horizontal pipe orientation								
	D	Liquid flow; vertical pipe orientation								
	E	Steam; horizontal pipe, mounting left								
	F	Steam; horizontal pipe, mounting right								
	G	Steam; vertical pipe, flow upwards								
	N	Steam; vertical pipe, flow downwards								
	Y	Special version								
20		**Approval**								
		1	Without special approvals							
		2	Material approval to 3.1B, EN 10204							
		3	Free from oil and grease							
		9	Special version							
30			**Nominal diameter pipe, material** Letter = nominal diameter / Numeral = material							Example G2: DN 125, Material SS 316Ti 1 Material C22.8 2 Material SS 316TI
			C❑	DN 2"	Flange and nozzle					
			D❑	DN 2 1/2"	Flange and nozzle					
			E❑	DN 3"	Flange and nozzle					
			F❑	DN 4"	Flange and nozzle					
			G❑	DN 5"	Flange and nozzle					
			H❑	DN 6"	Flange and nozzle					
			K❑	DN 8"	Flange and nozzle					
			L❑	DN 10"	Flange and nozzle					
			M❑	DN 12"	Flange and nozzle					
			N❑	DN 14"	Flange and nozzle					
			P❑	DN 16"	Flange and nozzle					
			Q❑	DN 20"	Flange and nozzle					
			R❑	DN 24"	Flange and nozzle					
			Y9	Special version						
40					**Pressure rating**					
				C	300 lbs	(for DN 2"...DN 12")				
				D	300 lbs	(for DN 14"...DN 24")				
				E	600 lbs	(for DN 2"...DN 12")				
				F	600 lbs	(for DN 14"...DN 24")				
				Y	Special version					
50						**Connection of pressure taps**				
					1	1/2 NPT male (not with steam)				
					2	Pipe without thread, diameter 12 mm (not with steam)				
					3	G 1/2", shape V to DIN ISO 19207 (without flange pair)				
					4	Welded connection 21.3 x 6.3				
					9	Special version				
60							**Adjustment Deltabar S**			
						F	Flow values, square root			
						P	Differential pressure values, linear			
						S	Adjustment 0..100%, square root			
						T	Adjustment 0..100%, linear			
						Y	Special version			
DPO 52A								**Complete product designation**		

Deltaset DPO 53
Orifice plate

Primary device to DIN 19206. Orifice plate made of SS 316TI. For D-D/2 pressure tapping or flange tapping. The Deltabar S differential pressure transmitter is ordered separately and comes optimised and set.

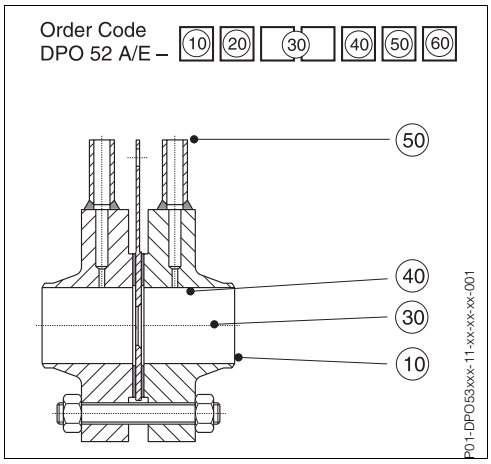
For the required Ordering Information - see also pp. 56:

10 Approval
With or without special approvals

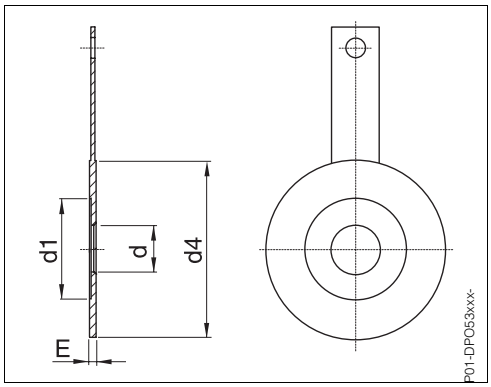
20 DN nominal diameter

30 Pressure rating

40 Adjustment Deltabar S
Flow, differential pressure or percentage display



Dimensioned drawing
For dimensions table, see page 45



Deltaset DPO 53E Ordering information for orifice plate DIN

10		**Approval**
	1	Without special approvals
	2	Material approval to 3.1B, EN 10204
	3	Free from oil and grease
	9	Special version

20			**Nominal diameter DN**
	C	DN 50	L DN 350
	B	DN 65	m DN 400
	C	DN 80	N DN 500
	D	DN 100	P DN 600
	E	DN 125	Q DN 700
	F	DN 150	R DN 800
	G	DN 200	S DN 900
	N	DN 250	T DN 1000
	K	DN 300	
	Y	Special version	

30		**Pressure rating**
	C	PN 10
	B	PN 16
	C	PN 25
	D	PN 40
	E	PN 64
	F	PN 100
	G	PN 160
	Y	Special version

40		**Adjustment Deltabar S**
	F	Flow values, square root
	P	Differential pressure values, linear
	S	Adjustment 0..100%, square root
	T	Adjustment 0..100%, linear
	Y	Special version

DPO 53E	**Complete product designation**

Deltaset DPO 53A, Ordering information for orifice plate ANSI

10		**Approval**
	1	Without special approvals
	2	Material approval to 3.1B, EN 10204
	3	Free from oil and grease
	9	Special version

20			**Nominal diameter DN**
	C	DN 2"	L DN 14"
	B	DN 2 1/2"	m DN 16"
	C	DN 3"	N DN 20"
	D	DN 4"	P DN 24"
	E	DN 5"	Q DN28"
	F	DN 6"	R DN 32"
	G	DN 8"	S DN 36"
	N	DN 10"	T DN 40"
	K	DN 12"	
	Y	Special version	

30		**Pressure rating**
	C	150 lbs
	B	300 lbs
	C	600 lbs
	Y	Special version

40		**Adjustment Deltabar S**
	F	Flow values, square root
	P	Differential pressure values, linear
	S	Adjustment 0..100%, square root
	T	Adjustment 0..100%, linear
	Y	Special version

DPO 53A	**Complete product designation**

Deltaset DPP 50
Pitot tube

The specially ordered shut-off valves DPV 50 or or condensat chambers DPC 50 are supplied premounted. The Deltabar S differential pressure transmitter is optimised and set.

For the required Ordering Information - see also page 60:

10 Applikation, medium and pipe orientation
Horizontal or vertical

20 Approval
With or without special approvals

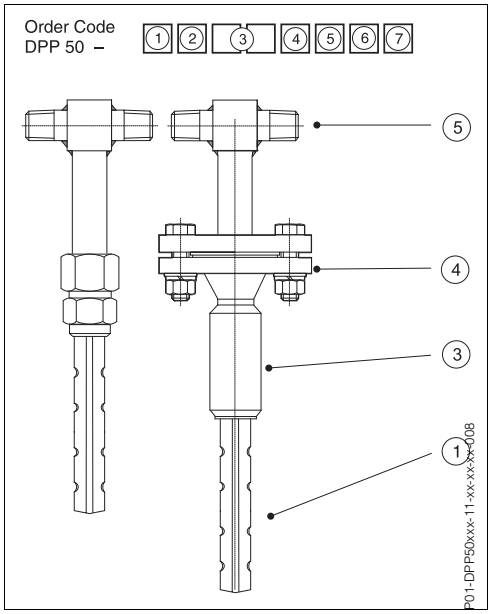
30 Nominal diameter DN and material of the welding socket

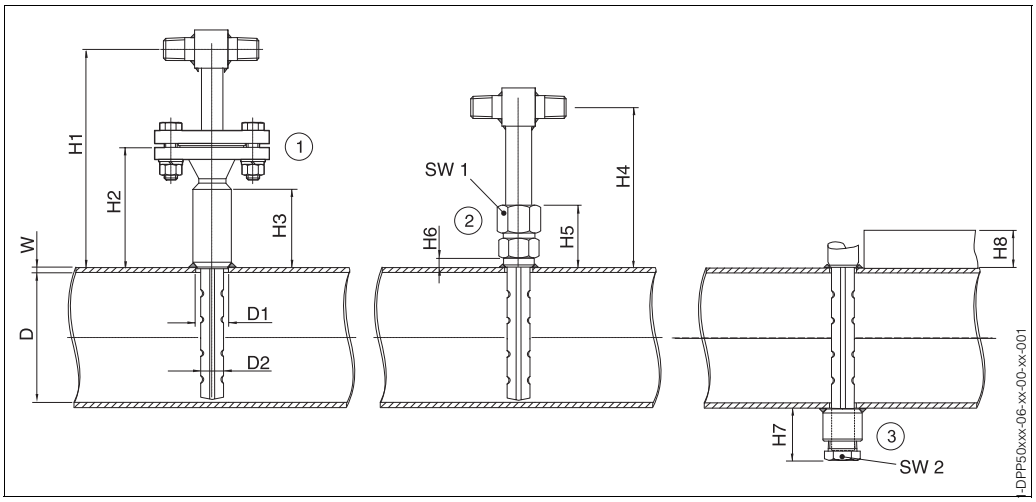
40 Probe installation

50 Connection of pressure taps

60 Integrated temperature sensor (as option)

70 Adjustment Deltabar S
Flow, differential pressure or percentage display





① *Flange*
② *Cutting ring: max. temperature 200 °C, for steam 200 °C/16 bar*
③ *Pitot tubes from DN 700 generally with steady, optionally for smaller nominal diameters (e.g. for large flow velocities)*
D *Pipe inner diameter*
D1 *Mounting drillhole* *D2* *Probe profile*
H1 *Distance to tapping nozzle* *H2* *Distance to mounting flange*
H3/H6 *With insulated pipes, this minimum dimension must be increase by the insulation thickness H8 (this is also valid for H1/H2 and H4/H5)*
H7 *Height of the steady* *H8* *High insulation*
W *Pipe wall thickness* *SW* *Across flats*

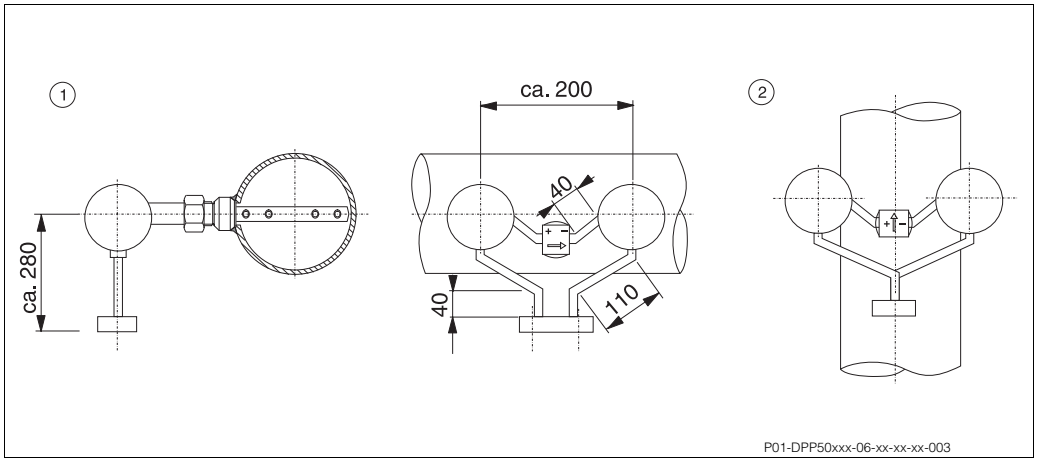
	Mounting drill hoe	Probe profile	Flange ①			Cutting ring ②				Steady	
	D1	D2	H1	H2	H3	H4	H5	H6	SW1	H7	SW2
DN 65/DN 80	16	12	180	80	50 *	130	48	10 *	27	40	22
DN ≥ DN 100	35	25	227	127	90 *	148	68	15 *	45	55	36

Tab. 29: Dimensions of Pitot tube DPP 50, all dimensions in mm

- With the Pitot tube, the flow direction from DN 50 is insignificant, as the probe has a symmetrical construction.
- Material of probe profile: rust-proof steel SS 316TI

	Pipe DN 65/DN 80	**Pipe ≥ DN 100**
Flange PN 40	Flange DN 25	Flange DN 32
Flange PN 100	Flange DN 25	Flange DN 40
Flange PN 160	Flange DN 25	Flange DN 40
Flange PN 300 lbs	Flansch DN 1"	Flansch DN 1 1/4"
Flange PN 600 lbs	Flansch DN 1"	Flansch DN 1 1/4"
Flange PN 1500 lbs	Flansch DN 1"	Flansch DN 1 1/4"

Tab. 30: Nominal diameter of flanges for Pitot tube DPP 50 (see ① at figure above)

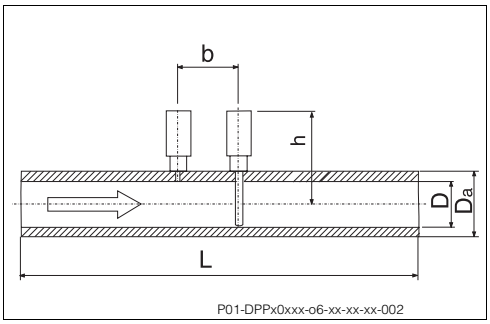


Dimensioned drawings:
Pitot tubes for steam (with two condensat chambers)
① Horizontal piping
② Vertical piping

Pipe installation

Special version for small pipe diameters

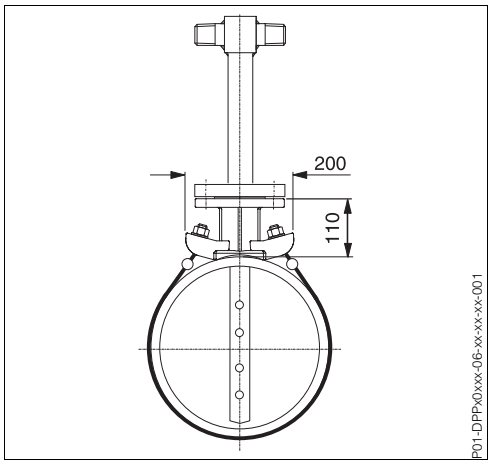
DN 25...DN 50
Welded connection
Max. temperature 200 °C, for steam 300 °C



	Pipe length L	**Height or tapping nozzle h**	**Spacing of tapping nozzle b**	**Internal diameter D**	**External diameter Da**
DN 25	250	33	54	29.7	33.7
DN 40	400	26	54	43.1	48.2
DN 50	500	30	54	54.5	60.3

Saddle flange
The saddle flange allows the Pitot tube to be mounted on pipes (nominal diameter DN 65...DN 500), upon which it is not possible to weld a cutting ring screw union or a flange (e.g. with cast or concrete pipes).

- Saddle flange
  Material: GGG-40/EWS coated
  Dimensions: see Fig., 90 mm wide
  Flange loss: DN 40/50, PN 4 for gas, PN 16 for water
  Saddle seal: NBR
  Weight: 5.5 kg
- Holding bracketFrom rust-proof steel, fully-vulcanised,
  70 mm wide



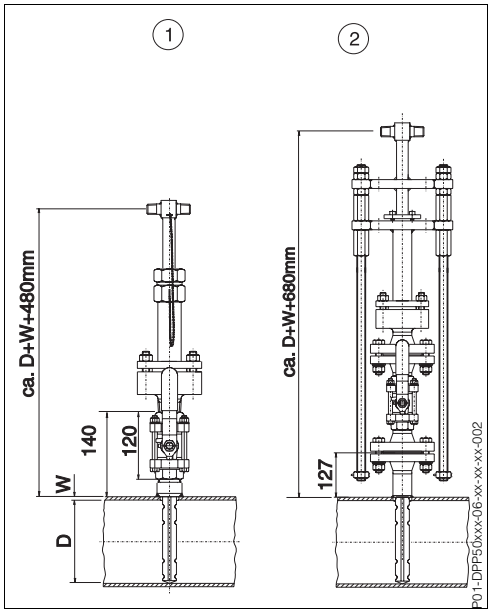
Flow tap
The Pitot tube can be replaced during operation.

D Internal diameter of piping
W Wall thickness of pipe;
From DN 700 with steady 1NPT,
Depth 51 mm

Max. temperature 300 °C, for steam 350 °C

① Flow tap with fixing chain
Distance from pipe - manifold (if probe removed from pipe): D + W + 480 mm
Distance from pipe - manifold (if probe removed from pipe): 2D + 2W + 480 mm

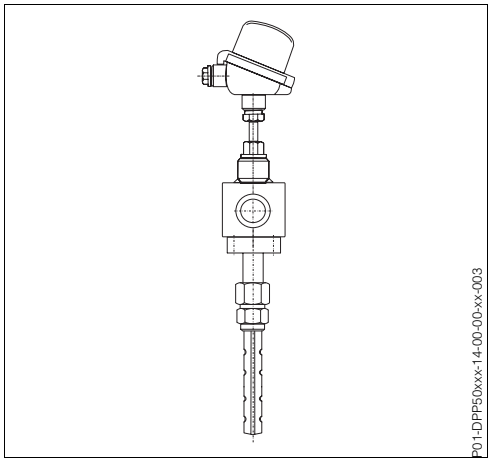
② Flow tap with spindle
Distance from pipe - manifold (if probe in pipe): D + W + 680 mm
Distance from pipe - manifold (if probe removed from pipe): 2D + 2W + 680 mm



Temperature sensor
To determine the medium temperature, with Pitot tubes from DN 100 there is optionally an integrated temperature measurement:

❑ With Pt100 temperature sensor
❑ With 4...20 mA temperature sensor

You can find additional information on the temperature sensor on page 23.



Deltaset DPP 50 Ordering Information for Pitot tube

10 — Application: Pipe orientation

C	Gas flow; horizontal pipe orientation
B	Gas flow; verticals pipe orientation
C	Liquid flow; horizontal pipe orientation
D	Liquid flow; vertical pipe orientation
K	Steam flow; horizontal pipe (version with condensat chambers)
L	Steam flow; vertical pipe, flow upwards (version with condensat chambers)
Q	Steam flow; vertical pipe, flow downwards (version with condensat chambers)
m	Flue gas flow, horizontal pipe with rinse connection
N	Flue gas flow, vertical pipe with rinse connection (Y = special version)

20 — Approval

1	Without special approvals
2	Material approval to 3.1B, EN 10204
3	Free from oil and grease (9 = special version)

30 — Nominal diameter pipe, material of welding socket (flange) Example G2: DN 125, Material SS 316Ti

Letter = nominal diameter / Numeral = material

A❑	DN 25	1"		with pipe (250 mm)	1 Material C22.8
B❑	DN 40	1 1/2"		with pipe (400 mm)	2 Material SS 316TI
C❑	DN 50	2"		with pipe (500 mm)	
D❑	DN 65	2 1/2"			
E❑	DN 80	3"			
F❑	DN 100	4"			
G❑	DN 125	5"			
H❑	DN 150	6"			
K❑	DN 200	8"			
L❑	DN 250	10"			
M❑	DN 300	12"			
N❑	DN 350	14"			
P❑	DN 400	16"			
Q❑	DN 500	20"			
R❑	DN 600	24"			
S❑	DN 700	28"		with end support	
T❑	DN 800	32"		with end support	
U❑	DN 900	36"		with end support	
V❑	DN 1000	40"		with end support	
W❑	DN 1200	48"		with end support	
W3	DN 1500	60"	C 22.8	with end support	
W4	DN 1500	60"	SS 316Ti	with end support	
X❑	DN 1800	72"		with end support	
X3	DN 2000	80"	C 22.8	with end support	
X4	DN 2000	80"	SS 316Ti	with end support	(Y = Special version)9

40 — Pizot tube installation

C	Cutting ring	PN 40
B	Flange DIN 2527	PN 40
C	Flange DIN 2527	PN 100
D	Flange DIN 2527	PN 160
E	Flange ANSI B16.5	300 lbs
F	Flange ANSI B16.5	600 lbs
G	Flange ANSI B16.5	1500 lbs
N	Flow tap with spindle	
I	Flow tap with fixing chain	
K	Pipe installation with welded connection, PN 100	
L	Saddle flange for non-weldable pipes	
Y	Special version	

50 — Connection of pressure taps

1	1/2 NPT male (not with steam)
2	Pipe without thread, diameter 12 mm (not with steam)
3	G 1/2", shape V to DIN ISO 19207 (without flange pair)
4	Welded connection 21.3 x 6.3 (9 = special version)

60 — Integrated temperature sensor

1	Without temperature sensor
2	With integrated Pt100 temperature sensor
3	With integrated 4...20 mA temperature sensor (Y = Special version)

70 — Adjustment Deltabar S

F	Flow values, square root
P	Differential pressure values, linear
S	Adjustment 0..100%, square root
T	Adjustment 0..100%, linear (Y = Special version)

DPP 50- **Complete product designation**

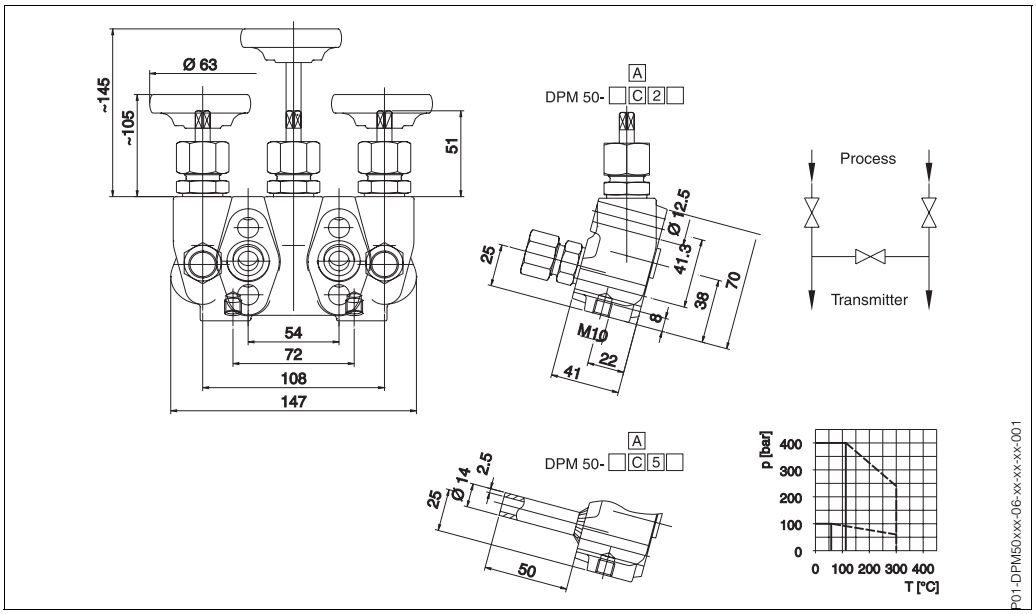
Components

Manifold
Deltaset DPM 50

The manifold is primarily used to connect the impulse pipes to the differential pressure transmitter Deltabar S. If both of the main taps are closed, the differential pressure transmitter can be removed from the measuring device.
With a three route manifold, there is a third manifold available for zero point adjustment between the impulse pipes.
The five route manifold offers the additional possibility of ventilating or emptying the impulse pipes without the need to remove the measuring device. Two additional shut-off or vent manifolds at the differential pressure transmitter can serve the same purpose. If being used with steam, it is preferably that you use a 5-valve manifold.

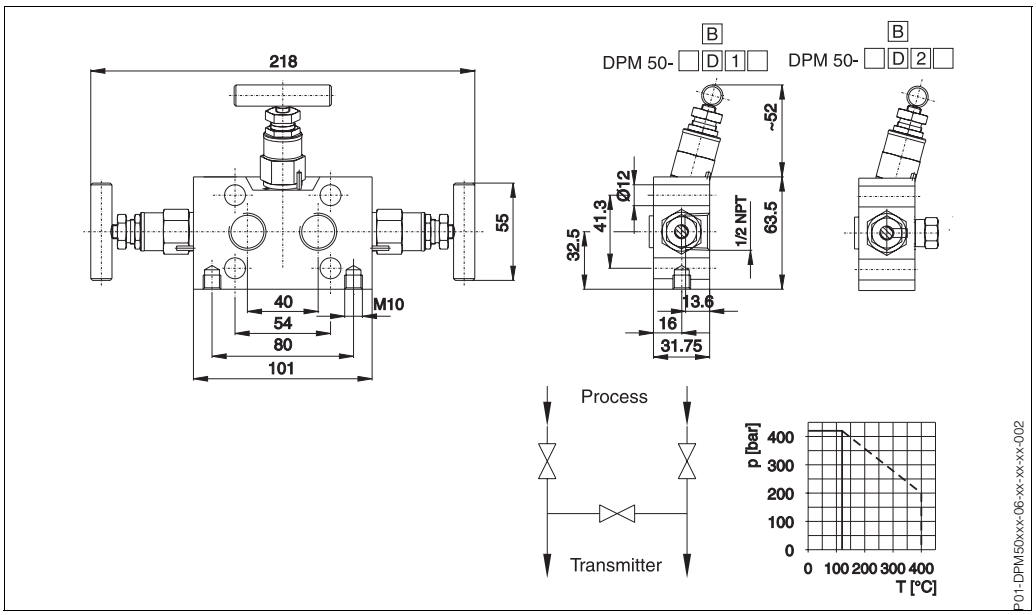
3-valve manifold, forged part with handwheel

PN 100/PN 400, manifold directly flangeable to DIN IEC65B/333/CDV
Variants: see ordering information on page 63

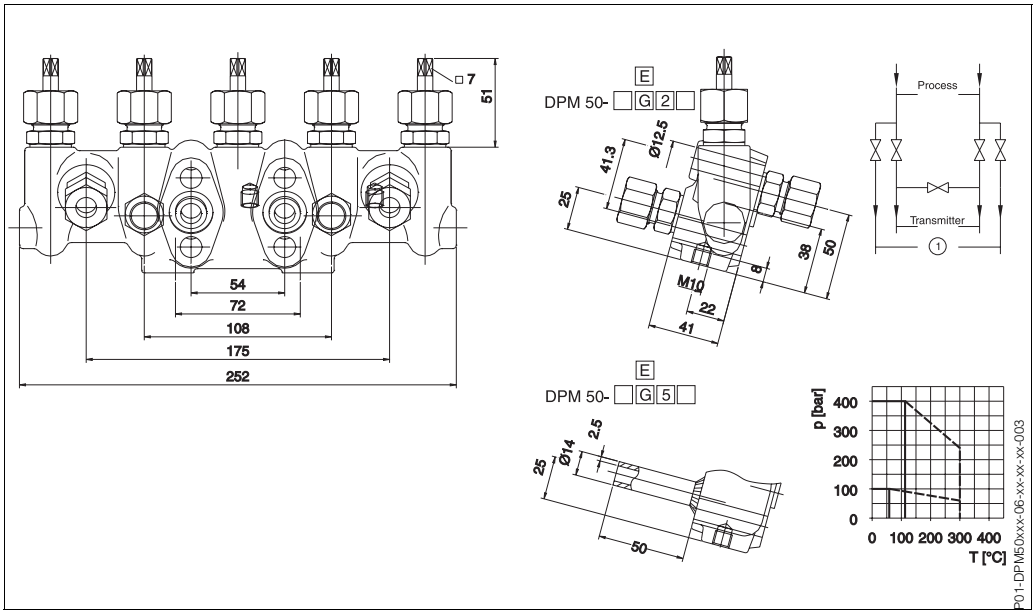


3-valve manifold, milled with hand knob

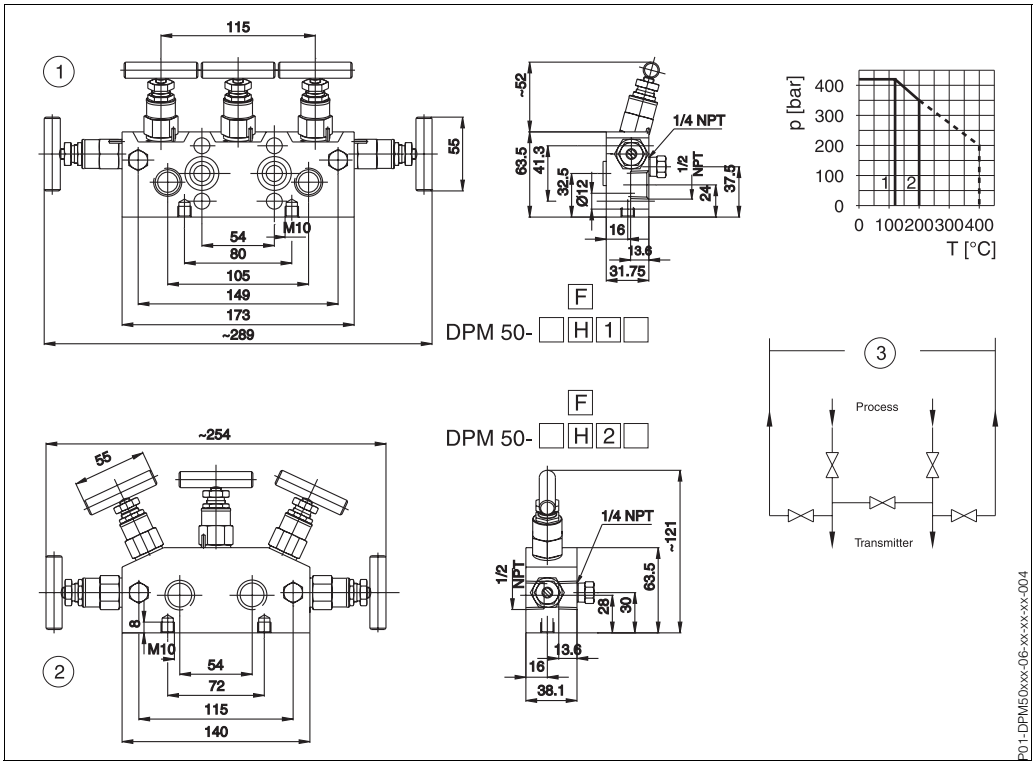
PN 420, manifold directly flangeable to DIN IEC65B/333/CDV
Variants: see ordering information on page 63



5-valve manifold
Forged part with square
PN 100/PN 400
Manifold directly flangeable to DIN IEC65B/333/CDV
Versions: see ordering information on page 63
① Blow-out (wiring scheme)



5-valve manifold
milled with hand knob
PN 100/PN 400
Versions: see ordering information on page 63
① Installation in the impulse pipes
② Directly flangeable to DIN IEC65B/333/CDV
③ Venting/Testing (wiring scheme)



Deltaset DPM 50 Ordering Information for manifold

10		**Approval**						
		1	Without special approvals					
		2	Material approval to 3.1B, EN 10204					
		3	Free from oil and grease (only for stainless steel version)					
		9	Special version					
20		**Manifold type, material**						
		C	3-valve	C 22.8	Forging, with hand wheel key			
		B	3-valve	C 22.8	Milled with hand lever			
		C	3-valve	SS 316Ti	Forging, with with hand wheel key			
		D	3-valve	SS 316Ti	Milled with hand lever			
		E	5-valve	C 22.8	Forging, with square			
		F	5-valve	C 22.8	Milled with hand lever			
		G	5-valve	SS 316Ti	Forging, with square			
		N	5-valve	SS 316Ti	Milled with hand lever			
		Y	Special version					
30			**Connection to process (impuls pipe connection)**					
			1	Connection 1/2" NPT female (only manifolds of type B, D, F, H)				
			2	Connection cutting ring Ermeto 12S				
			5	Welded connection 14 x 2.5 (only manifolds of type A, E, C, G)				
			9	Special version				
40				**Manifold seals/screws**				
				3	Viton seal/screws M10, max. PN 160			
				4	Viton seal/screws M12, max. PN 400			
				5	Viton seal/screws 7/6 UNF, max. PN 400			
				6	PTFE seal/screws M10, max. PN 100			
				7	PTFE seal/screws 7/6 UNF, max. PN 100			
				9	Special version			
DPM 50-					**Complete product designation**			

Shut-off valves Deltaset DPV 50

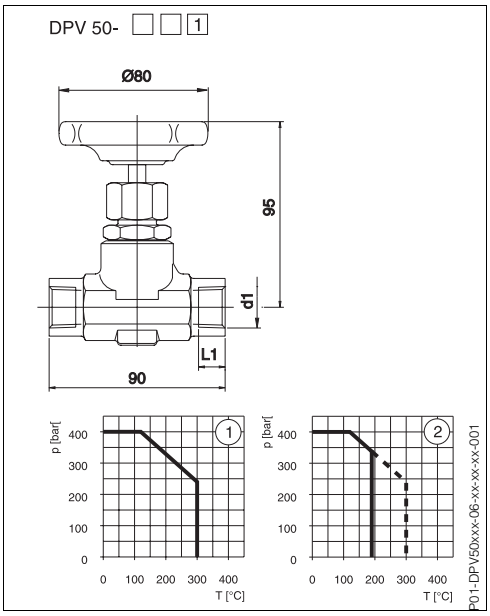
As two (or four) shut-off valves are required for a Deltaset measuring point, DPV 50 always comprises a pair comprising two shut-off valves.

Closing the shut-off valves isolates the impulse pipes including the manifold and transmitter from the process for cleaning and repair purposes.

Basically with primary devices, two shut-off valves are required for process isolation. With certain applications it is recommended that you install two additional shut-off valves in the impulse pipes. They allow venting of ingressed gas or the blowing-out of collected condensate without the need to interrupt measurement or even production. The alternative to this is a 5 route manifold.

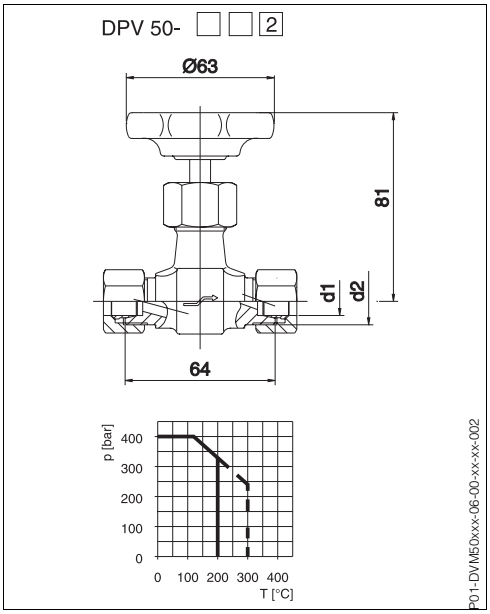
Shut-off valve sleeve/sleeve PN 400, DN 10
Input: 1/2 NPT innen
Output: 1/2 NPT female

d1: 1/2 NPT
L1: 13,6 mm
①: Steel, pure graphite packingt
②: Stainless steel, PTFE packing



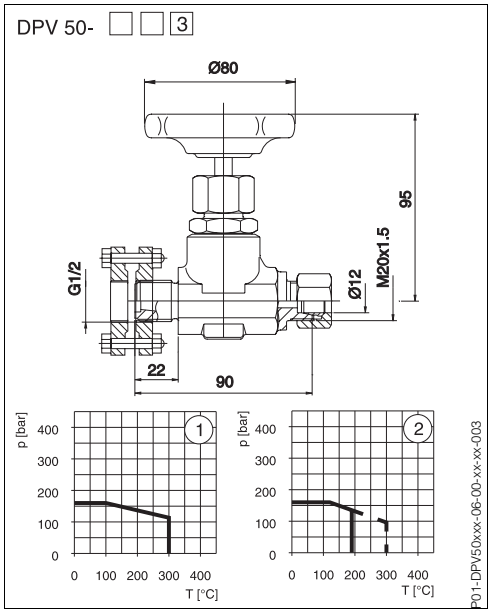
Shut-off valve cutting ring PN 400
Input: Cutting ring screw union
Output: cutting ring screw union

d1: 12 mm Ermeto 12S)
d2: Connection thread M 20x 1.5



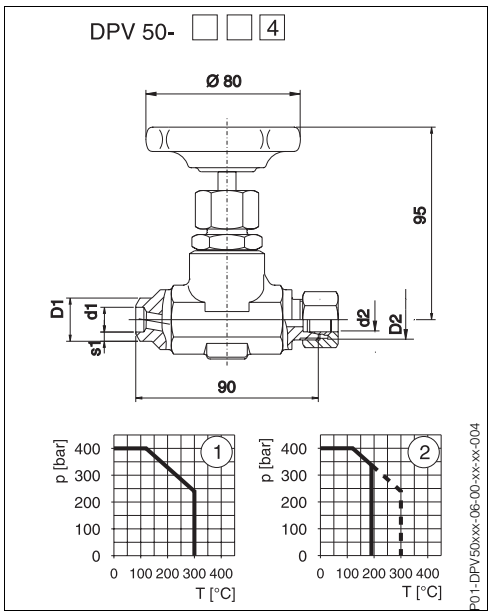
Shut-off valve flange/cutting ring
PN 160, DN 8, DIN 19208
Input: flange
Output: cutting ring screw union

①: Steel, pure graphite packing
②: Stainless steel, PTFE packing



Shut-off valve welded connection/cutting ring
PN 400, DN 8
Input: welded connection
Output: cutting ring screw union

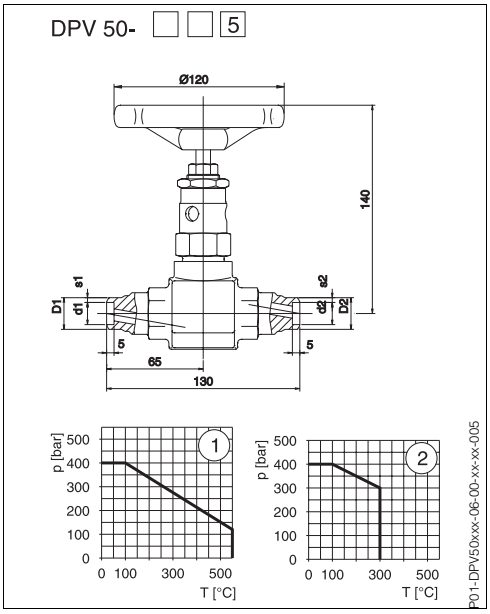
D1: 21.3 mm
d1: 12.2 mm
D2: M 20 x 1.5
d2: 12 mm
s1: 7.1 mm
①: Steel, pure graphite packing
②: Stainless steel, PTFE packing



Shut-off valve welded connection/welded connection
PN 320...PN 500, DN 8
Input: welded connection
Output: welded connection

D1: 21.3 mmS
1: 3.2 mmD
2: 14.0 mmS
2: 2.5 mm

①: 15Mo3 (1.5415), pure graphite packing
②: Stainless steel, PTFE packing

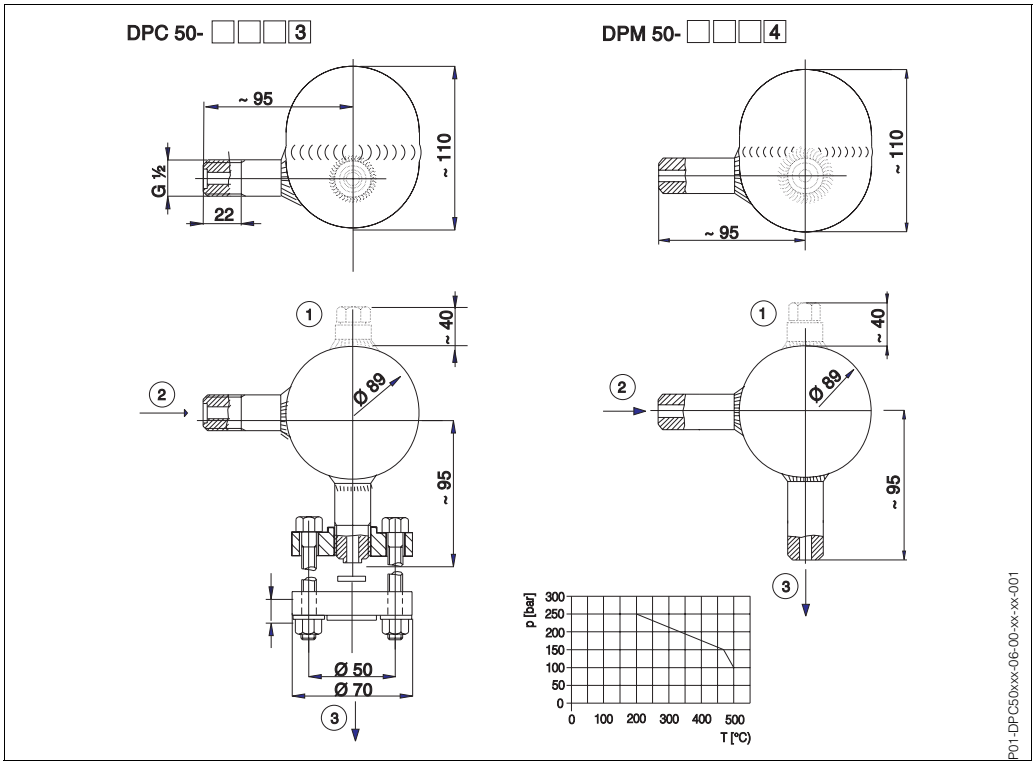


Deltaset DPV 50 Ordering Information for 2 valves

10						**Approval**
					1	Without special approvals
					2	Material approval to 3.1B, EN 10204
					3	Free from oil and grease (only for stainless steel version)
					4	Material approval to 3.1A, EN 10204
					9	Special version
20						**Valve material**
					1	C22.8 (for connection types 1,2,3)
					2	SS 316TI (for connection types 1...4)
					3	15Mo3/1.5415 (for connection type 5)
					Y	Special version
30						**Connection process side/Connection Deltabar side**
					1	Connection 1/2" NPT female, PN 400, input + output
					2	Connection of cutting ring Ermeto 12S, PN 400, input + output
					3	G 1/2" with flange pair, output of cutting ring Ermeto 12S, PN 160
					4	Welded connection 21.3 x 6.3; output of cutting ring Ermeto 12S, PN 400; SS 316TI
					5	Welded connection 21.3 x 6.3; output of welded connection 14 x 2.5; 1.5415
					9	Special version
DPV 50-						**Complete product designation**

Condensat chambers Deltaset DPC 50

As two condensat chambers are required for a Deltaset measuring point with steam applications, DPC 50 always comprises a pair comprising two condensat chambers.



① *Filling nozzle, 1/2" NPT (optional)*
② *From differential pressure transducer*
③ *To differential pressure transmitter*

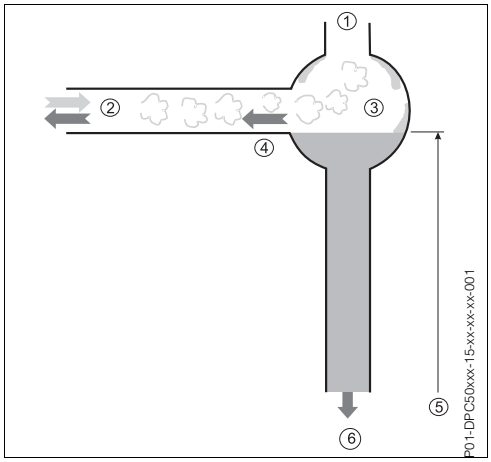
DPC 50-❑❑❑3
Condensate trap with connection G 1/2 (DIN 19207, shape V for ③ or shape R for ②) and one flange pair (DIN 19207 with sealing ring and four screws M10x45)

DPC 50-❑❑❑4
Condensate vessel with welded connection 21.3 x 6.3

Functioning principle of the condensat chambers:

Mount both condensat chambers at the same height to obtain the same distance to the differential pressure.

① Fill the water column using the filling nozzle and then close the nozzle
② Steam enters
③ Condensate runs into water column
④ Condensate flows back
⑤ Constant water column to Δp transmitter
⑥ To manifold and Deltabar S



Deltaset DPC 50 Ordering Information for 2 condensate chambers

10		**Approval**				
		C	Without special approvals			
		B	Material approval to 3.1B, EN 10204			
		C	Free from oil and grease (only for stainless steel version)			
		D	Material approval to 3.1A, EN 10204			
		Y	Special version			
20			**Filling cap**			
			1	With filling nozzle		
			2	Without filling nozzle		
			Y	Special version		
30				**Material, filling volume, PN**		
				C	Material HII/C22.8; 300 cm^3; PN 100	
				B	Material SS 316TI; 300 cm^3; PN 100	
				C	Material 15M03; 300 cm^3; PN 250	
				Y	Special version	
40					**Connection** (inlet = outlet)	
					3	Connection G 1/2", one flange pair
					4	Welded connection 21.3 x 6.3
					9	Special version
DPC 50-						**Complete product designation**

Supplementary documentation

System information	Deltatop / DeltasetSI 039P/00/en
Technical Information	Deltabar S differential pressure transmitter PMD 230 / 235 TI 256P/01/en Temperature head transmitter iTEMP PCP TMT 181 TI 070R/09/en Flow computer Compart DXF TI 032D/06/en
Operating instructions	Deltabar S differential pressure transmitter BA 174P/01/en

Flow data specification

Instructions of completion For ordering purposes, it is necessary to specify your operating data, as they are the basis for the customer-specific and optimised design of the measuring device.

Process data	Description of specification	Example
Primary device	Type of primary device, orifice plate or Pitot tube.	Orifice with corner taps DPO 10
Medium	Type of medium, with chemical formula if known. For mixtures with mixture ratio.	Air
Flow + unit	Maximum flow value with flow unit	3000 m^3/h
Pressure + unit + pressure type	Specification of operating pressure for calculation of primary device. Maximum value important for checking of application limits of the selected device, but not absolutely essential. Unit of operating pressure, absolute or relative pressure values.	2 bar abs.
Temperature + unit	Specification of operating temperature for calculation of primary device. The selected material and design type of Deltatop and Deltaset limit the maximum possible temperature. Temperature unit.	20 °C
Standard/ operating density + unit	Density specification on required for special media (for the calculation of primary device), as data available for media listed in Applicator of version 8.02 or higher. Always state density with unit.	1.293 kg/m^3
Viscosity	State viscosity under operating conditions. This is particularly important when calculating the primary device for oils. Each primary device has application limits relating to viscosity. Specify in µPas or in m^2/s.	$100x10^3$ µPas
Pipe: dimensions	*Pipe internal diameter:* Specifying the nominal pipe diameter (DN) is insufficient as the pipe internal diameter can vary strongly depending on the wall thickness, for DN 50 e.g. between 48 ... 52 mm. The internal diameter is decisive for the correct calculation of the differential pressure transmitter. *Wall thickness:* Specification only required for Pitot tubes. *Insulation thickness:* This defines the length of the differential pressure transducer neck piece (standard 120 mm).	51 mm 3 mm 150 mm
Pipe: material	Specification of pipe material for estimation of flow behaviour (friction, thermal expansion coefficient) and weldability.	SS 316Ti
Additional gas data	*Isentropic exponent:* Specify for special gases; it is typically between 1.2 ...1.4. *Compressibility factor:* Used to calculate the change in density of gases (relating to their change between operating and standard conditions). The dimensionless compressibility lies typically between 0.95 ... 1.01. *Relative humidity:* Also required for the adjustment of density to the operating values. Need only be taken into account at higher relative humidities (greater than 70%).	None
Optimisation criteria	With orifice plate systems, Endress + Hauser offers the optimisation of the flow rate measuring system. It can be optimised to minimum pressure loss, max. dynamics or standard calculation (optimisation to both criteria). The measuring sensor ideally suitable to the differential pressure calculation is selected (and in so doing also the ideal transmitter measuring range).	Standard

Tab. 31: Ordering specifications for the design of Deltatop and Deltaset

Flow data sheet

The data in bold type are particularly necessary for the design of the measurement section.

Please complete the fields carefully to make sure that Deltatop or Deltaset exactly fulfils the requirements of your process.

Flow Data

When ordering DELTATOP or DELTASET

All information asked for in bold type is required for designing the measurement section!

Customer . . . . . .

Reference No. . . . . . *Measuring point No.* . . . . . .

Primary device . . . . . .

Medium	. . . . . **Gas**	. . . . . **Steam**	. . . . . **Liquid**	
Flow + Unit	. . . . . *Minimum*	. . . . . **Maximum = Full scale value**	. . . . . **Unit**	
Pressure + Unit	. . . . . **Operating**	. . . . . *Maximum*	. . . . . **Unit**	☐ **rel.** ☐ **abs.**
Temperature + Unit	. . . . . **Operating**	. . . . . *Maximum*	. . . . . **Unit**	
Standard/Operating density + unit		. . . . .	. . . . . *Unit*	
Viscosity	. . . . . *µPas*	*or*	. . . . . *m²/s*	

Pipe Dimensions	. . . . . *Internal diameter*	. . . . . *Wall thickness*	. . . . . *Insulation thickness*	. . . . . *Unit*
Pipe Material	. . . . .			

For gas mixtures only

Other gas specifications	. . . . . *Isentropic index*	. . . . . *Compressibility factor*
Relative humidity	. . . . . *% r.h.*	

Optimisation criterium (optional, for orifice plates only) (cross one box only)

☐ *Minimum pressure loss and high dP accuracy (standard)*

☐ *Maximum dynamics (low β)*

☐ *Lowest remaining pressure loss (high β)*

Specify measuring range for the optional temperature transmitter

.....°C 4 mA *..... °C 20 mA*

P01-DPxxxxxx-16-xx-xx-en-001

Endress+Hauser
GmbH+Co.
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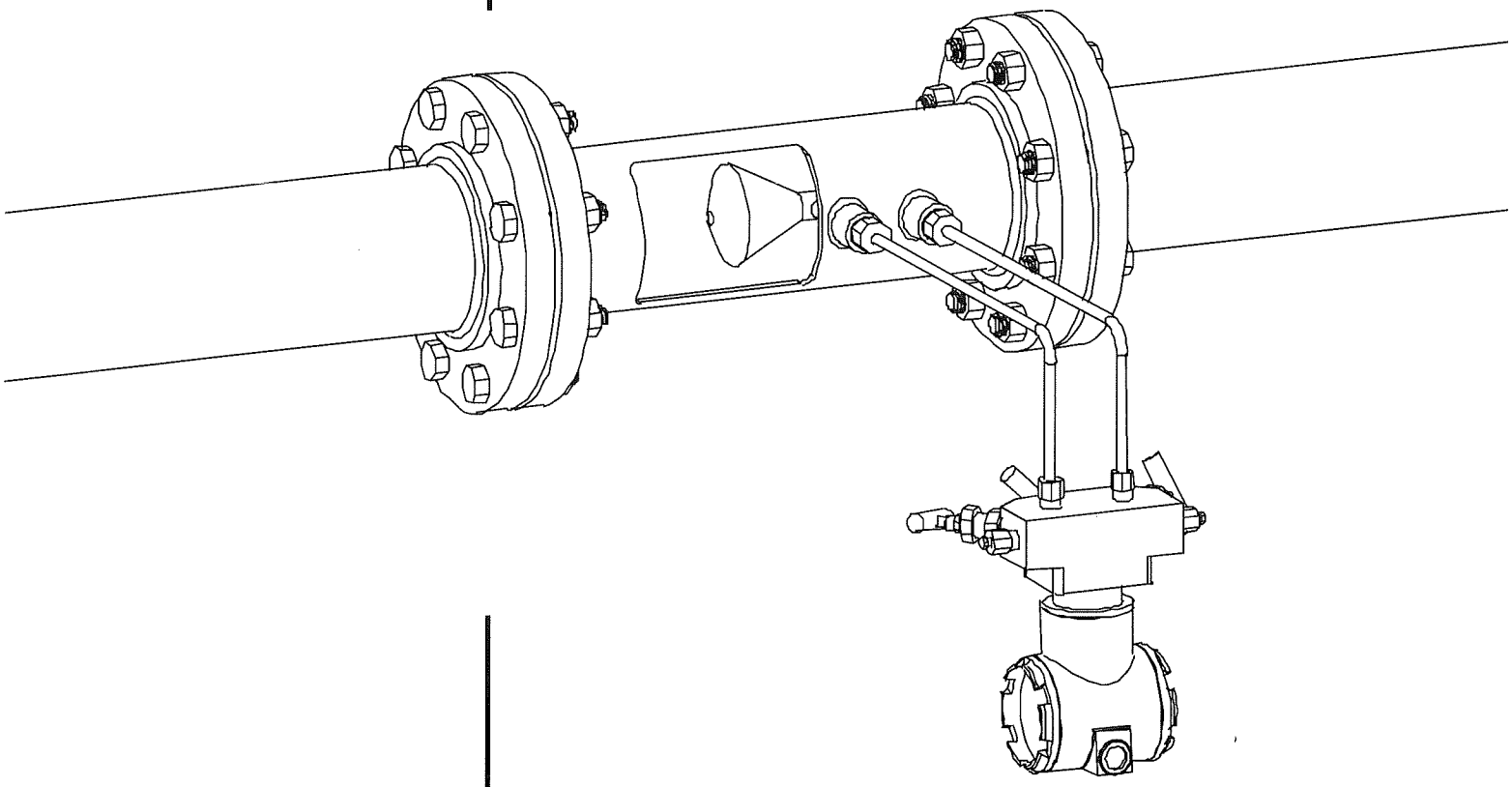


Appendix I

McCROMETER

Advanced
Differential
Pressure
Flowmeter
Technology

VCONE®



INSTALLATION OPERATION & MAINTENANCE MANUAL

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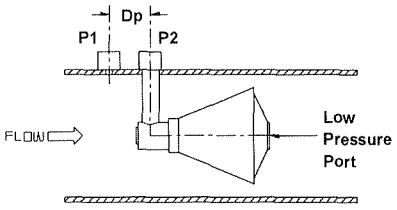
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1.0 General

1.1 Introduction

The McCrometer V-Cone Flowmeter is a patented technology that accurately measures flow over a wide range of Reynolds numbers, under all kinds of conditions and for a variety of fluids. It operates on the same physical principle as other differential pressure-type flowmeters, using the theorem of conservation of energy in fluid flow through a pipe. The V-Cone's remarkable performance characteristics, however, are the result of its unique design. It features a centrally-located cone inside the tube. The cone interacts with the fluid flow, reshaping the fluid's velocity profile and creating a region of lower pressure immediately downstream of itself. The pressure difference, exhibited between the static line pressure and the low pressure created downstream of the cone, can be measured via two pressure sensing taps. One tap is placed slightly upstream of the cone, the other is located in the downstream face of the cone itself. The pressure difference can then be incorporated into a derivation of the Bernoulli equation to determine the fluid flow rate. The cone's central position in the line optimizes the velocity profile of the flow at the point of measurement, assuring highly accurate, reliable flow measurement regardless of the condition of the flow upstream of the meter.

1.2 Principles of Operation



High and Low Ports
Figure 1

The V-Cone is a differential pressure type flowmeter. Basic theories behind differential pressure type flowmeters have existed for over a century. The principal theory among these is Bernoulli's theorem for the conservation of energy in a closed pipe. This states that for a constant flow, the pressure in a pipe is inversely proportional to the square of the velocity in the pipe. Simply, the pressure decreases as the velocity increases. For instance, as the fluid approaches the V-Cone meter, it will have a pressure of P_1. As the fluid velocity increases at the constricted area of the V-Cone, the pressure drops to P_2, as shown in Figure 1. Both P_1 and P_2 are measured at the V-Cone's taps using a variety of differential pressure transducers. The Dp created by a V-Cone will increase and decrease exponentially with the flow velocity. As the constriction takes up more of the pipe cross-sectional area, more differential pressure will be created at the same flowrates. The beta ratio equals the flow area at the largest cross section of the cone (converted to an equivalent diameter) divided by the meter's inside diameter (see 3.2.3).

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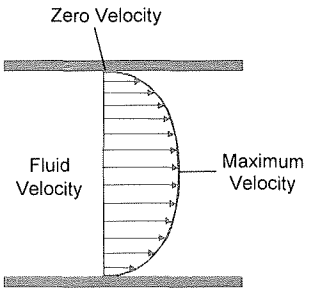
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1.3 Reshaping the Velocity Profile

The V-Cone is similar to other differential pressure (Dp) meters in the equations of flow that it uses. V-Cone geometry, however, is quite different from traditional Dp meters. The V-Cone constricts the flow by positioning a cone in the center of the pipe.

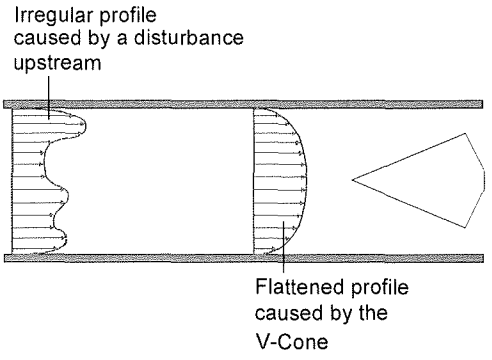
This forces the flow in the center of the pipe to flow around the cone. This geometry presents many advantages over the traditional concentric Dp meter. The actual shape of the cone has been continuously evaluated and tested for over ten years to provide the best performance under differing circumstances.

One must understand the idea of a flow profile in a pipe to understand the performance of the V-Cone. If the flow in a long pipe is not subject to any obstructions or disturbances, it is well-developed flow. If a line passes across the diameter of this well-developed flow, the velocity at each point on that line would be different. The velocity would be zero at the wall of the pipe, maximum at the center of the pipe, and zero again at the opposite wall. This is due to friction at the pipe walls that slows the fluid as it passes. Since the cone is suspended in the center of the pipe, it interacts directly with the "high velocity core" of the flow. The cone forces the high velocity core to mix with the lower velocity flows closer to the pipe walls. Other Dp meters have centrally located openings and do not interact with this high velocity core. This is an important advantage to the V-Cone at lower flowrates. As the flowrate decreases, the V-Cone continues to interact with the highest velocity in the pipe. Other Dp meters may lose their useful Dp signal at flows where the V-Cone can still produce one.



Velocity Profile
Figure 2

The pipe flow profile in actual installations is rarely ideal. There are many installations where a flowmeter exists in flow that is not well developed. Practically any changes to the piping, such as elbows, valves, reductions, expansions, pumps, and tees can disturb well-developed flow. Trying to measure disturbed flow can create substantial errors for other flowmeter technologies. The V-Cone overcomes this by reshaping the velocity profile upstream of the cone. This is a benefit derived from the cone's contoured shape and position in the line. As the flow approaches the cone, the flow profile "flattens" toward the shape of a well-developed profile.



Flattened Velocity Profile
Figure 3

The V-Cone can flatten the flow profile under extreme conditions, such as a single elbow or double elbows out-of-plane, positioned closely upstream of the meter. This means that as different flow profiles approach the cone, there will always be a predictable flow profile at the cone. This ensures accurate measurement even in non-ideal conditions.

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2.0 Features

2.1 High Accuracy

The V-Cone primary element can be accurate to ±0.5% of reading and the Wafer-Cone can be accurate to ±1.0%. The level of accuracy is dependent to a degree on application parameters and secondary instrumentation.

2.2 Repeatability

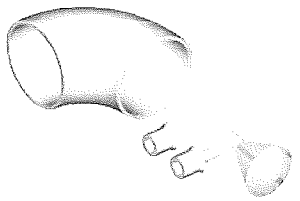
The V-Cone and the Wafer-Cone primary element exhibits excellent repeatability of ±0.1% or better.

2.3 Turndown

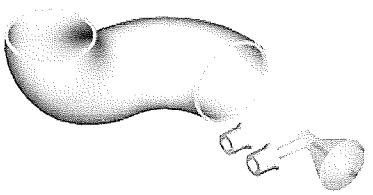
The turndown of the V-Cone can reach far beyond traditional Dp meters. A typical turndown for a V-Cone is 10 to 1. Greater turndowns are attainable. Flows with Reynolds numbers as low as 8000 will produce a linear signal. Lower Reynolds number ranges are measurable and are repeatable by applying a curve fit to the measured Dp, derived from calibration over a specific Reynolds number range.

2.4 Installation Requirements

Since the V-Cone can flatten the velocity profile, it can function much closer to upstream disturbances than other Dp meters. The recommended installation for the V-Cone is zero to three diameters of straight run upstream and zero to one diameters downstream. This can be a major benefit to users with larger, more expensive line sizes or users which have small run lengths. McCrometer conducted performance tests of the V-Cone downstream of a single 90° elbow and two close coupled 90° elbows out of plane. These tests show that the V-Cone can be installed adjacent to either single elbows or two elbows out of plane without sacrificing accuracy.



Single Elbow and V-Cone
Figure 4



Double Elbow and V-Cone
Figure 5

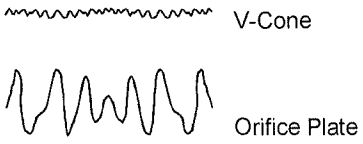
2.5 Long Term Performance

The contoured shape of the cone constricts the flow without impacting the flow against an abrupt surface. A boundary layer forms along the cone and directs the fluid away from the beta edge. This means the beta edge will not be as subject to the usual wear by unclean fluids, as is the case with an orifice plate. The beta ratio will then remain unchanged and the calibration of the meter will be accurate for a much longer time.

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2.6 Signal Stability



Signal Stability
Figure 6

Every Dp meter has a "signal bounce". This means that even in steady flow, the signal generated by the primary element will fluctuate a certain amount. On a typical orifice plate, the vortices that form just after the plate are long. These long vortices create a high amplitude, low frequency signal from the orifice plate. This could disturb the Dp readings from the meter. The V-Cone forms very short vortices as the flow passes the cone. These short vortices create a low amplitude, high frequency signal. This translates into a signal with high stability from the V-Cone. Representative signals from a V-Cone and from a typical orifice plate are shown in figure 6.

2.7 Low Permanent Pressure Loss

Without the impact of an abrupt surface, the permanent pressure loss is lower than a typical orifice plate meter. Also, the signal stability of the V-Cone allows the recommended full scale Dp signal to be lower for the V-Cone than other Dp meters. This will lower the permanent pressure loss.

2.8 Sizing

The unique geometry of the V-Cone allows for a wide range of beta ratios. Standard beta ratios range from 0.45, 0.55, 0.65, 0.75, and 0.80.

2.9 No Areas of Stagnation

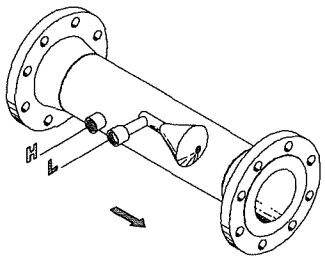
The "swept through" design of the cone does not allow for areas of stagnation where debris, condensation or particles from the fluid could accumulate.

2.10 Mixing

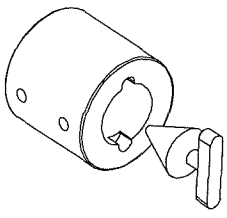
The short vortices described in section 2.6 mix the fluid thoroughly just downstream of the cone. The V-Cone is currently used in many applications as a static mixer where instant and complete mixing are necessary.

2.11 V-Cone Models

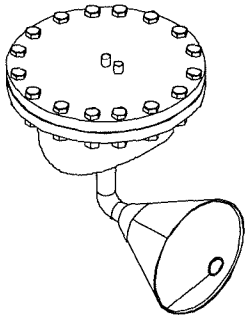
McCrometer offers three types of V-Cone primary elements: the precision tube V-Cone, the Wafer-Cone and the insertion top-plate V-Cone. Precision tube V-Cones range in line sizes from ½" to 72" and larger; Wafer-Cones range from 1/2" to 6"; and insertion top-plate V-Cones range in line size from 6" to 72" and larger.



Precision Tube V-Cone
Figure 7



Wafer-Cone®
Figure 8



Insertion Top-plate V-Cone
Figure 9

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3.0

The V-Cone Flow Meas. System

3.1 Application Data

The customer must provide application parameters so that the appropriate V-Cone flowmeter may be selected. McCrometer has an extensive meter performance database of fluid properties which can be utilized for sizing purposes.

3.2 General Calculations

Nomenclature:

ΔP	differential pressure (Dp)	inWC
D	inside diameter	inch
d	cone diameter	inch
β	beta ratio	.
k	isentropic exponent	.
k_1	flow constant	.
k_4	flow constant – without C_D	.
G_C	grav. constant (32.174)	
C_D	flowmeter coefficient	f/s^2
Y	gas expansion factor	.
ρ	flowing density (rho)	.
α	material thermal expansion α or α_{cone}, α_{pipe} (alpha)	.

P	operating pressure	psia
T	operating temperature	Rankine
Z	gas compressibility	.
S_F	operating specific gravity	.
S_{STP}	specific grav. @ 60°F, 14.696 Psia	.
ρ_{water}	water density (62.3663)	lb/ft^3
P_b	base pressure	psia
T_b	base temperature	Rankine
Z_b	base gas compressibility	.
μ	viscosity	cP
Re	Reynolds Number	.
v	Velocity	fps

3.2.1	Differential Pressure	$\Delta P = P_H - P_L$	ΔP units are in WC
3.2.2	Flowmeter Coefficient	Derived from calibration or from historical data.	Located on sizing and calibration reports.
3.2.3	V-Cone beta ratio	$\beta = \frac{\sqrt{D^2 - d^2}}{D}$	β from sizing report
3.2.4	Flow Constant	$k_1 = \frac{\pi}{576}\sqrt{2G_c}\frac{D^2\beta^2}{\sqrt{1-\beta^4}}C_D$	k_1 from sizing report See note 2.
3.2.5	Material Thermal Expansion Factor	$F_a = 1 + 2\alpha(T - 528)$	See note 1.
3.2.6	Material Thermal Expansion Factor If cone and main line pipe are made of different materials.	See note 1. $F_a = \frac{D^2 - d^2}{((1-\alpha_{pipe}\cdot(T-528))\cdot D)^2 - ((1-\alpha_{cone}\cdot(T-528))\cdot d)^2}$	

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3.2 General Calculations (continued)

3.2.7	Pipeline Velocity	$v = \frac{576\ ACFS}{\pi\ D^2}$	
3.2.8	Reynolds Number	$Re = 123.9\frac{v\ D\ \rho}{\mu}$	Dimensionless number which can be used to correlate meter calibrations in different fluids.
3.2.9	Flow Constant Used when C_D is not constant.	$k_4 = \frac{\pi}{576}\sqrt{2G_c}\frac{D^2\beta^2}{\sqrt{1-\beta^4}}$	This equation can be used in substitute of 3.2.4 when the C_D flow coefficient is not constant. See note 2.

3.3 Calculations for Liquids

3.3.1	Density	$\rho = \rho_{water}\ S_F$	
3.3.2	Flowrate Conversion	$GPM = 448.83\ ACFS$	
3.3.3	Flowrate	$ACFS = F_a\ k_1\sqrt{\frac{5.197\ \Delta P}{\rho}}$	
3.3.4	Flowrate When C_D is not constant.	$ACFS = F_a\ k_4\sqrt{\frac{5.197\ \Delta P}{\rho}}\ C_D$	

Notes:

1. Material Thermal Expansion - The thermal expansion equations correct for dimensional changes which occur as the operating temperature deviates from the base temperature of 70° F (see 3.2.5 and 3.2.6 on page 5).

   The F_a factor can be excluded from the flow equation if the operating temperature is:

   < 100° Fahrenheit , < 560° Rankine, < 38° Celsius

   If the F_a factor is significant and the operating temperature is stable then a constant F_a value may be used. If the F_a factor is significant and the temperature varies then an F_a factor should be calculated prior to every flow calculation.

2. Discharge Coefficient - Discharge coefficients can be implemented in the flow equations via several different methods. Following are typical methods: *average C_D* or *C_D look up table.*
If a C_D look up table or fitted data is utilized additional calculations must be made based on the Reynolds number (see example processes 3d and 4b).

3. Liquids - Typical Calculation Processes:
   - 3a. given: D, β, ρ, C_D, and input of ΔP — Calculate: 3.2.4, 3.3.3
   - 3b. given: D, β, ρ, C_D, and input of ΔP, T — Calculate: 3.2.4, 3.2.5 or 3.2.6 if req., 3.3.3
   - 3c. given: D, β, S_F, C_D, and input of ΔP, T — Calculate: 3.2.4, 3.2.5 or 3.2.6 if req., 3.3.1, 3.3.3
   - 3d. given: D, β, μ, ρ, C_D look up, and input of ΔP

     Calculate: initially set C_D = 0.8, 3.2.9, 3.2.5 or 3.2.6 if required,

     → 3.2.7, 3.2.8, look up C_D , 3.3.4 — Iterate until flowrate is < 0.01% different from last calculation.

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3.4 Calculations for Compressible Fluids (gases and vapors)

3.4.1	V-Cone Gas Expansion Factor rev. May. 2001	$Y = 1 - (0.649 + 0.696\beta^4)\frac{0.03613\,\Delta P}{k \cdot P}$	k - Isentropic Exponent note: 0.03613 converts ΔP (inWC at 4°C) to same units as P (Psia)
3.4.2	Wafer-Cone Gas Expansion Factor rev. Oct. 2001	$Y = 1 - (0.755 + 6.787\beta^8)\frac{0.03613\,\Delta P}{k \cdot P}$	
3.4.3	Gas Density	$\rho\,(lb/ft^3) = 2.6988\frac{S_{STP}\,P}{Z\,T}$	
3.4.4	Flowrate Actual Cubic Feet Per Second	$ACFS = F_a\,k_1\,Y\sqrt{\frac{5.197\,\Delta P}{\rho}}$	
3.4.5	Flowrate Actual Cubic Feet Per Second When C_D is not constant.	$ACFS = F_a\,k_4\,Y\sqrt{\frac{5.197\,\Delta P}{\rho}}\,C_D$	
3.4.6	Flowrate Standard Cubic Feet Per Second	$SCFS = ACFS\left(\frac{P\,T_b\,Z_b}{P_b\,T\,Z}\right)$	converts actual flow to standard flow at base conditions

Notes (continued from page 6):

4. Gases and Steam - Typical Calculation Processes:

4a. given: D, β, μ, S_F, Z, k, C_D, and inputs of ΔP, P, T

Calculate: 3.2.4, 3.2.5 or 3.2.6 if needed, 3.4.1 or 3.4.2, 3.4.3, 3.4.4

4b. given: D, β, μ, S_F, Z, k, C_D look up, and inputs of ΔP, P, T

Calculate: initially set C_D = 0.8, 3.2.4, 3.2.5 or 3.2.6 if needed, 3.4.1 or 3.4.2, 3.4.3, 3.4.4,

→ 3.2.7, 3.2.8, look up C_D , 3.4.4 —

Iterate until flowrate is < 0.01% different from last calculation.

5. Fluid properties - Fluid properties such as viscosity, compressibility and isentropic exponent vary with temperature and to some extent pressure. The viscosity in the calculations above could effect the selected C_D value, the compressibility directly affects the density and the isentropic exponent affects the Y factor, although to a small degree. The instrumentation industry uses many different approaches to calculate flow. Which fluid properties are calculated at each set of flow conditions and which properties are constant must be determined by the customer and McCrometer application engineering.

3.5 Application Sizing

Each V-Cone is tailored to its specific application. Before manufacturing, every V-Cone will have a "sizing" completed according to the physical parameters of the application. The computer generated sizing uses application data as a basis to predict the V-Cone's performance. Full scale DP, working flow range, expected accuracy, and predicted pressure loss are determined by the sizing process.

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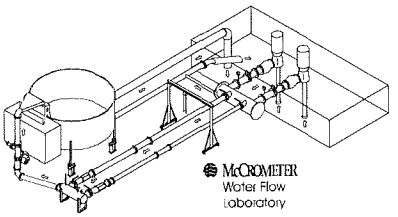
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3.6 Calibration

Wafer-Cone and precision tube flowmeters less than 20" diameter are calibrated in one or more of the following McCrometer calibration facilities:

Calibration Facility	*Size Range*	*Calibration Facility*	*Size Range*
Water 40k lb Gravimetric	3" to 18"	Water 1.5k lb Gravimetric	up to 4"
Water 5k lb Gravimetric	up to 6"	Air 80 cfm	up to 2"

McCrometer recommends that every V-Cone meter be calibrated. A calibration is required when the application requires the best accuracy. Insertion top-plate style flowmeters can be calibrated as an option. If an actual calibration is not requested, the coefficient for the meter can be estimated. Data collected over years of independent testing allows for an estimate of the meter's C_D. For V-Cones intended for use in a compressible fluid with high accuracy requirements, McCrometer recommends calibration in a compressible fluid.



Calibration Facility 40k Gravimetric
Figure 10

3.7 Materials of Construction

All materials used for V-Cone flowmeters are certified. Materials furnished to McCrometer include a certified material test report (CMTR) from the original material manufacturer. The test reports include material composition and applicable material grades. Upon request copies of the material test reports can be supplied to our customers. See section 6.5 for typical materials of construction.

3.8 Valve Manifolds

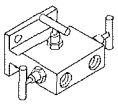
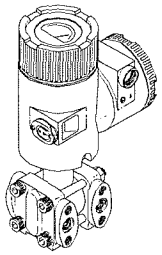


Figure 11

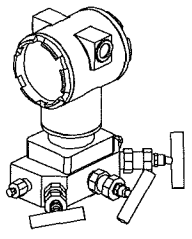
McCrometer recommends a three valve or five valve manifold as part of a V-Cone flow measurement system. Manifolds allow for in-line transmitter calibrations, isolation of the transmitter from the transmission lines, without depressurizing the line, and in-line purging of transmission lines.

3.9 Secondary and Tertiary Instrumentation

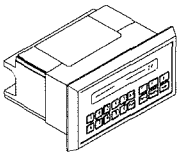
A differential pressure transmitter measures the differential pressure signal from the primary element. Once the signal is measured, the transmitter generates an electronic signal that is then interpreted by a flow monitor or other process control system. For compressible fluids, line pressure and temperature measurements are generally required for accurate flow measurement. McCrometer offers the following flow measurement instrumentation: differential pressure transmitters, flow computers, and pressure and temperature sensors for mass flow measurement.



Typical Dp Trans.
Figure 12



Typ. Dp Transmitter with valve manifold
Figure 13



Flow Computer
Figure 14

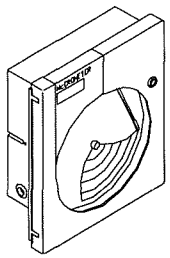


Chart Recorder
Figure 15

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4.0 Installation

4.1 Safety

- Any person installing, inspecting, or maintaining a McCrometer flowmeter should have an understanding of piping configurations and systems under pressure.
- The high and low pressure ports and/or optional instrumentation ports may be fitted with plastic thread protector plugs. These must be removed prior to pressurizing the system. Failure to do so may result in serious injury.
- Before adjusting or removing any meter, be certain the system has been depressurized completely. Never attempt to remove a meter under pressure!



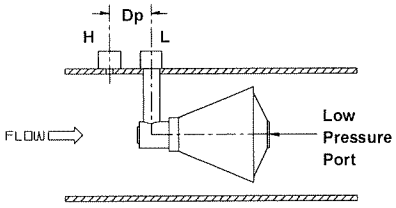
- Be careful when lifting meters. Meters can cause serious injury if lifted incorrectly or dropped.
- Use only necessary and appropriate tools when working on a meter.
- Properly secure all connections before starting a system. Keep a safe and prudent distance away from the meter during system start-up.

4.2 Unpacking

McCrometer tests and inspects all products during manufacture and before shipment. However, inspect the meter and accessories at the time of unpacking to detect any damage that might have occurred during shipment. If there is a question regarding the paperwork or the flowmeter, please contact your McCrometer representative.

4.3 Orientation

A flow label is placed on each V-Cone to show the direction of flow through the meter. For most line sizes, the centerline of the pressure sensing taps are located 2.12" apart. The high pressure tap is upstream. The low pressure tap is downstream. Please refer to figure 16. This information is necessary when connecting the differential pressure measuring device.



High and Low Ports
Figure 16

4.4 Piping Requirements

The recommended straight, unobstructed pipe run upstream of a V-Cone is zero to three diameters. The recommended run downstream of a V-Cone is zero to one diameter. "Diameter" here refers to the nominal pipe size of the pipe run.

McCrometer, along with several independent testing facilities, has tested the V-Cone in several common piping configurations. These tests have proven the V-Cone to be within accuracy specifications even when close coupled with single 90° elbows or double 90° elbows out-of-plane. The V-Cone can also be used in lines slightly larger than the meter tube.

In applications where the meter tube is larger than the adjacent line, such as with cement lined piping, the user should consult the factory for additional installation requirements.

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4.5 Tap Locations

For piping in a horizontal plane, McCrometer recommends the taps be placed on the sides of the pipe in either the three or the nine o'clock position. In vertical pipes, the tap locations are not significant.

4.6 Transmission Lines

If possible install the transmission lines such that at no-flow conditions, there is no differential pressure created. Refer to the instruction manual of the differential pressure measuring device regarding further information on the installation and maintenance of pressure signal transmission lines. Ref. ISO 2186.

TYPICAL INSTALLATIONS

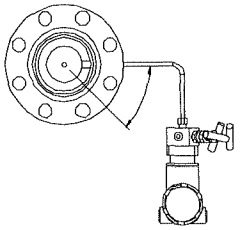


Figure 17
Liquid

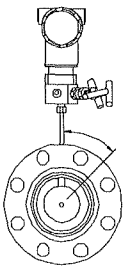


Figure 18
Gas

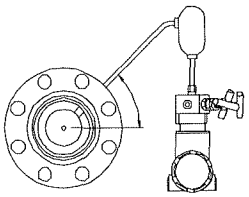


Figure 19
Steam, Wet Gas

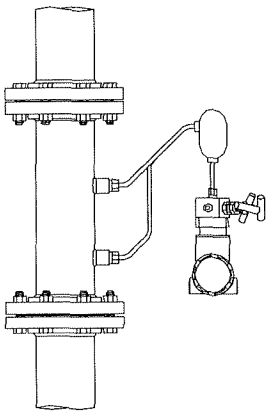


Figure 20
Vertical Steam, Wet Gas

Guidelines for gas or vapor applications where there is the possibility for condensation in the transmission lines.

1. In these instances, the transmission lines from the meter should be installed as shown in Figure 19 to ensure that no vapor will exist in the portions of the transmission lines sloping upward to the condensate pot.

2. Vertical up flow applications require a special V-Cone designed with wall taps. When wet legs are used, you must ensure that the wet legs are equal at all times.

3. Figures 19 and 20 above show condensation pots which may be recommended depending on the flow measurement requirements.

4.7 Valve Manifold

Please refer to the manifold's instructions regarding installation, operation, and maintenance.

4.8 Differential Pressure Transmitters

After the differential transmitter has been installed into a flow measurement system the transmitter zero should be checked and/or set to zero. The transmitter output mode, linear or square root, must be set appropriately. Please refer to the individual instruction manuals for specific information regarding the installation, operation, and maintenance of differential pressure transmitters.

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4.9 Temperature and Pressure Sensors

Please refer to the individual instruction manuals for specific information regarding the installation, operation, and maintenance of temperature and absolute pressure sensors.

4.10 Installation Checklist For The Differential Pressure Transmitter

Verify the following during installation:

- ✓ Is the differential pressure transmitter full scale correct ?
- ✓ Has the differential pressure transmitter zero been checked and/or adjusted on site ?
- ✓ Are the differential pressure transmitter and flow computer both set to the appropriate modes, linear or square root ?
- ✓ Have the transmission lines to the differential pressure transmitter been purged ?
- ✓ Are there any leaks in the transmission lines ?
- ✓ Is the manifold cross valve closed ?
- ✓ Is the V-Cone high pressure port located upstream of the low pressure port ?

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5.0 Dimensions

5.1 Face to Face Dimensions

Please reference the V-Cone configuration sheets for more complete technical data.

Size	Beveled Threaded Plain		Slip On JIS 10K DIN 2576 ANSI 125 ANSI 150,300		Slip On ANSI 600-900		Weld Neck ANSI 150		Weld Neck ANSI 300		Weld Neck ANSI 600	
inch	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm
½	7.75	197	8	203	8	203	11.38	289.1	11.75	298.5	12.25	311.2
¾	7.75	197	8	203	8	203	11.75	298.5	12.13	308.1	12.63	320.8
1	7.75	197	8	203	8	203	12.00	304.8	12.50	317.5	13.00	330.2
1½	9.75	248	10	254	12	305	14.38	365.3	14.88	378.0	15.50	393.7
2	11.63	295	12	305	14	356	16.38	416.1	16.88	428.8	17.63	447.8
2½	11.50	292	12	305	14	356	16.75	425.5	17.25	438.2	18.00	457.2
3	13.50	343	14	356	16	406	18.75	476.3	19.50	495.3	20.25	514.4
4	15.50	394	16	406	18	457	21.25	539.8	22.00	558.8	23.75	603.3
5	21.50	546	22	559	26	660						
6	21.50	546	22	559	26	660	28.25	717.6	29.00	736.6	31.00	787.4
8	25.25	641	26	660	30	762	33.00	838.2	33.75	857.3	36.00	914.4
10	27.25	692	28	711	34	864	35.00	889.0	36.25	920.8	39.50	1003
12	29.25	743	30	762	36	914	38.00	965.2	39.25	997.0	41.75	1060
14	29	737	30	762	34	864	38.75	984.3	40.00	1016	42.25	1073
16	29	737	30	762	34	864	38.75	984.3	40.25	1022	43.25	1099
18	31	787	32	813	36	914	41.75	1061	43.25	1099	45.75	1162
20	35	889	36	914	40	1016	46.13	1171	47.50	1207	50.25	1276
24	47	1194	48	1219	54	1372	58.75	1492	60.00	1524	63.25	1607
30	59	1500	60	1524								
36	59	1500	60	1524								
48	71	1803	72	1829								
60	71	1803	72	1829								

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5.2 Face to Face Dimensions

Size	Weld Neck ANSI 900		Weld Neck RTJ 150		Weld Neck RTJ 300		Wafer ANSI		Wafer DIN, JIS	
mm	inch	mm	inch		inch	mm	inch	mm	inch	mm
½	12.88	327.2	-	-	12.19	309.6	2.25	57.2	2.36	60
¾	13.63	346.2	-	-	12.63	320.8	2.25	57.2	2.36	60
1	13.88	352.6	12.50	317.5	13.00	330.2	2.25	57.2	2.36	60
1½	16.50	419.1	14.88	378.0	15.38	390.7	3	76.2	3.15	80
2	19.88	505.0	16.88	428.8	17.50	444.5	3.38	85.9	3.35	85
2½	20.00	508.0	17.25	438.2	17.87	453.9	4	101.6	3.94	100
3	21.75	552.5	19.25	489.0	20.12	511.0	4.75	120.7	4.72	120
4	24.75	628.7	21.75	552.5	22.62	574.5	6	152.4	5.91	150
6	32.75	831.9	28.75	730.3	29.62	752.3	9.5	241.3	9.45	240
8	38.25	971.6	33.50	850.9	34.37	873.0				
10	42.00	1067	35.50	901.7	36.87	936.5				
12	45.25	1149	38.50	977.9	39.87	1013				
14	46.00	1168	39.25	997.0	40.62	1032				
16	46.25	1175	39.25	997.0	40.87	1038				
18	49.25	1251	42.25	1073	43.87	1114				
20	54.75	1391	46.63	1184	48.25	1226				
24	70.25	1784	59.25	1505	60.88	1546				

6.0 Model Selections

6.1 Wafer-Cone® Model Template

Examples:

Model	Description
VH01-A1SN3	Wafer-Cone 1" line size, S316, ANSI Style, 1/8" NPT Ports, Serrated Face
VH01-A2SN3	Wafer-Cone 25mm line size, S316L, DIN 2633 Style, 1/8" NPT Ports, Serrated Face

	Size		-	Materials		Body Style		Bore		Ports		Face Style	
VH	**0A**	½"		P	CPVC	**1**	**ANSI CL 150 to 2500**	**S**	**Standard**	**N**	**NPT**	1	
	0B	¾"		Q	S304	2	DIN 2633	X	Other	J	RC	2	O-Ring
	01	1"		L	S304L	3	DIN 2635			X	Other	**3**	**Serrated**
	0C	1½"		**A**	**S316L**	4	JIS 10k					X	Other
	02	2"		T	PTFE	X	Other Style						
	0D	2½"		B	Brass								
	03	3"		R	CPVC Body S316 Cone								
	04	4"		X	Other Mat. ‡								
	05	5"											
	06	6"											

NOTES:

1. Bold items in table above are standard construction.
2. Combinations of two different materials can also be specified.
3. Plastic materials limited to sizes 1" to 3". For other sizes please consult factory.

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6.2 Precision Tube V-Cone Model Template

Examples:

Model	Description
VS06QE04N	V-Cone 6" S304 S40 W/ ANSI CL 300 Flanges
VB24SD00N	V-Cone 24" Coated Carbon Steel w/ Beveled Ends

SERIES	
VS	SO
VW	WN
VB	Beveled
VT	NPT
VP	Plain
VC	DIN SO
VD	DIN WN
VJ	JIS SO
VN	JIS WN
VG	Gray Type
VR	ANSI RTJ WN
VQ	ANSI RTJ SO

SIZE	
0A	1/2"
0B	3/4"
01	1"
0C	1½"
02	2"
0D	2½"
03	3"
04	4"
06	6"
08	8"
10	10"
...	...

MATERIALS‡	
Q	S304
L	S304L
A	S316L
D	DUPLEX 2205
H	HASTELLOY C-276
P	CPVC
T	PTFE
N	S304 tube, cone, support & cplgs CS flanges flanges painted HT silver
U	CS tube & flanges S304 cone, support, & cplgs exterior painted per customer
S	CS tube & flanges S304 cone, support, & cplgs coated blue, excluding cone

SCHEDULE	
A	Pipe S10
B	Pipe S20
C	Pipe Bored
D	Pipe Std
E	Pipe S40
F	Pipe S80
J	Pipe S100
K	Pipe S120
L	Pipe S140
G	Pipe S160
H	Pipe XXS
M	Pipe S10S
N	ID 0.437"
P	Pipe XS

END CONNECTIONS	
00	VP SMOOTH ENDS
01	VB BEVELED ENDS
02	VT THREADED ENDS
03	VS SO ANSI CL 150 RF
04	VS SO ANSI CL 300 RF
05	VS SO ANSI CL 600 RF
06	VS SO ANSI CL 900 RF
07	VS SO ANSI CL 1500 RF
08	VQ SO ANSI CL 150 RTJ
09	VQ SO ANSI CL 300 RTJ
10	VQ SO ANSI CL 600 RTJ
11	VQ SO ANSI CL 900 RTJ
12	(VQ) SO ANSI CL 1500 RTJ
13	VC SO DIN 2576 PN 10 FF
14	VW WN ANSI CL 150 RF
15	VW WN ANSI CL 300 RF
16	VW WN ANSI CL 600 RF
17	VW WN ANSI CL 900 RF
18	(VW) WN ANSI CL 1500 RF
19	VR WN ANSI CL 150 RTJ
20	VR WN ANSI CL 300 RTJ
21	VR WN ANSI CL 600 RTJ
22	VR WN ANSI CL 900 RTJ
23	(VR) WN ANSI CL 1500 RTJ

END CONNECTIONS	
24	VD WN DIN 2633 PN 16 RF
25	VD WN DIN 2635 PN 40 RF
26	VJ SO JIS 10k
27	VJ SO JIS 20k
28	(VN) WN JIS 16K
29	(VN) WN JIS 20K
30	VS B16.1 SO CL 125 RF (>24")
31	VS B16.1 SO CL 250 RF (>24")
32	(VR) WN ANSI CL 2500 RTJ
33	AWWA SO FF CL B PLATE
34	AWWA SO FF CL D PLATE
35	AWWA SO FF CL E PLATE
36	AWWA SO FF CL F PLATE
37	(VD) WN DIN 2637 PN 100 RF
38	not used
39	GRAYLOC
40	SO ANSI CL 150 FF
41	SO NORSK NP16 NS2527/DIN 2501
42	SO B16.1 CL 125 FF (>24")
43	(VW)WN API 605 150# RF (ref 46)
44	(VP)VICTAULIC GROOVED ENDS
45	(VW)WN B16.47 A 150# RF (ref 47)
46	(VW)WN B16.47 B 150# RF (ref 43)
47	(VW)WN MSS SP-44 150# RF(ref 45)

(...) - not in current literature

FITTINGS			
N1	¼" NPT	½", ¾", 1"	
S1	¼" Socket	½", ¾", 1"	
J1	¼" RC JIS	½", ¾", 1"	
N2	¼" NPT	3K #	1½"
S2	¼" Socket	3K #	1½"
J3	¼" RC JIS	3K #	1½"
N	½" NPT	3K #	2"+
N3	½" NPT	6K #	
S	½" Socket	3K #	
S3	½" Socket	6K #	
J	½" RC JIS	3K #	
J2	½" 15A JIS	3K #	
N4	¾" NPT	3K #	
S4	¾" Socket	3K #	
N5	1" NPT	3K #	
S5	1" Socket	3K #	
V	Valve	6K #	
S6	½" Sockolet	3K #	

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6.3 Insertion Top-plate V-Cone Model Template

Examples:

Model	Description	Pipeline
VI10SD03N	V-Cone 10" Insertion Top-plate CS Coated	16" OD x 15.25" ID
VI24QD30N	V-Cone 24" Insertion Top-plate All S304	48" OD x 47.25" ID

	SADDLE SIZE	
VI	06	6"
	08	8"
	10	10"
	12	12"
	14	14"
	16	16"
	18	18"
	20	20"
	24	24"
	30	30"
	36	36"

	MATERIALS‡
Q	S304
L	S304L
A	S316L
S	CS COATED / S304 CONE
U	CS / S304 CONE

	SADDLE PIPE SCHEDULE
A	Pipe S10
B	Pipe S20
D	Pipe Std
E	Pipe S40

	FLANGE TYPE
03	B16.5 CL 150 RF
04	B16.5 CL 300 RF
30	B16.1 CL 125 RF (>24")
31	B16.1 CL 250 RF (>24")
33	AWWA CL B
34	AWWA CL D
35	AWWA CL E
36	AWWA CL F

	FITTINGS
N	½" NPT 3000#
S	½" Socket 3000#
J	½" JIS RC 3000#

6.4 V-Cone Special Models

Series {size} – {serially allocated number starting at 01}

examples:

VW06-02

VS12-05

6.5 V-Cone Materials

‡ Construction materials can include the following:

S304	MONEL K400/K500
S304L	S321H
S316L	INCONEL 625
HASTELLOY C-276	CPVC, PVC
DUPLEX 2205	PTFE
CHROMEMOLY P22/P11	KYNAR
CARBON STEELS A350, A333, API5L, A106B	

Combinations of two different materials can also be specified.

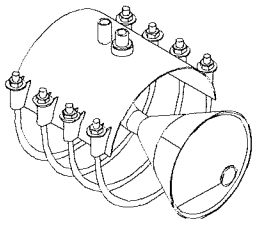
Plastic materials are limited to the VH series and to special VS styles < 8" in size.

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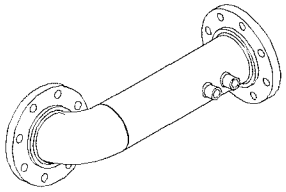
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6.6 Alternative Constructions

McCrometer has the capability of manufacturing special flowmeter designs incorporating spool sections, reductions, elbows and non-standard end connections. Figure 22 is an example flowmeter with integral 90° elbow and flanges.



V-Cone Bolt On Saddle
Figure 21



V-Cone, Elbow and Flanges
Figure 22

7.0 Maintenance

If the meter is installed correctly, there should be no reason for periodic maintenance or re-calibration. In extreme process conditions, periodically inspect the V-Cone for any significant physical damage. Calibrate and maintain secondary and tertiary instrumentation according to the manufacturer's instructions.

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8.0

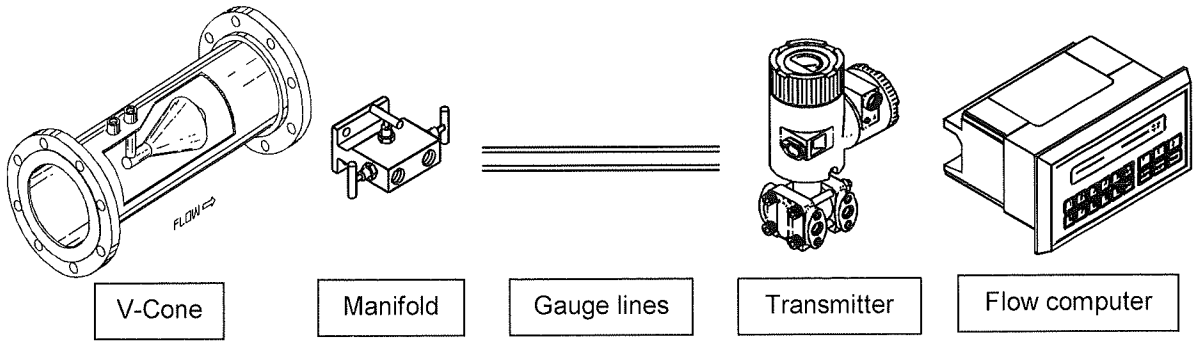
Trouble-shooting

Troubleshooting a V-Cone System On-Site

This guide is intended to help you troubleshoot a V-Cone system. Keep several points in mind as you proceed:

1. Most V-Cones are calibrated devices. The meter has already had flow through it. If a cone is missing or a leak exists inside the meter, this would be discovered during the calibration.
2. A flow measurement requires a system. Do not assume a problem exists with the primary element just because it is called a *V-Cone* system. Most problems occur in the DP transmitter or the flow computer.
3. This guide assumes a simple system of meter, manifold, DP transmitter, and flow computer. Systems can be much more complex with pressure and temperature transmitters, as well as full scale digital control systems. Do not limit your evaluation to just these suggestions.
4. If you discover a problem / solution not listed in this guide, please contact a V-Cone Application Engineer at McCrometer: 1-909-652-6811 or e-mail: mdyer@mccrometer.com.

This guide separates the flow measurement system into areas. These areas are labeled in the diagram below



During troubleshooting, make a preliminary assessment of the symptoms of the problem and consult the chart on the next page.

SYMPTOM	AREA	POSSIBLE PROBLEM / SOLUTION
No signal (0 mA)	Transmitter	No power to transmitter.
	Transmitter	Transmitter not wired correctly. Perform continuity check on wiring.
Negative signal (< 0 mA)	Transmitter	Transmitter wires are reversed.
Low signal (<4 mA)	V-Cone	V-Cone installed backwards, with gauge lines attached as marked. In this case, the high pressure tap would be sensing a lower pressure than the low pressure tap. This negative DP would force the signal below 4 mA.
	Gauge lines	Gauge lines are reversed. Transmitter sees more pressure on low side than high side. Check "H" and "L" marks on V-Cone and transmitter.
	Transmitter	Transmitter is malfunctioning. Some transmitters will send a specified mA signal when a malfunction occurs. This can be set to low values, such as 3.8 mA, or high values, such as 20.1 mA.
Zero signal (4 mA)	V-Cone	Meter has been damaged. Remove meter and visually inspect.
	V-Cone	No flow in pipeline. Check other system locations to verify flow through the meter. The meter could be under pressure but still have no flow.
	Manifold	Manifold / gauge lines closed or blocked. Ensure valves and lines are open. If fluid is safe, open vent valves on transmitter to verify pressure in the gauge lines.

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Zero signal (4 mA)	Transmitter	Transmitter is in check mode. Some transmitters allow for system checks by forcing the signal to 4 or 20 mA. Vent low side of transmitter to ensure the signal responds to pressure changes.
Wrong signal – high or low	V-Cone	Process conditions do not match actual conditions. Contact McCrometer or your sales representative to recalculate using the correct process conditions.
	V-Cone	Wrong meter. Verify serial numbers on meters to ensure correct specifications. Sometimes two meters are interchanged. Remember each V-Cone has a unique flow coefficient.
	Gauge lines	Foreign material trapped in gauge lines. Dirt and sediment can settle into the gauge lines. If the fluid is safe, vent the gauge lines and inspect for spurts of solids, gasses, or liquids (whichever should not be there). If the fluid is not safe, open the center manifold valve for several minutes under high DP. Close the valve and compare the signal level to before. In a horizontal, liquid application, install the meter with the taps on the sides of the pipe (3 or 9 o'clock) For a horizontal, gas application, install at top or sides of the pipe (12, 3, or 9 o'clock).
	Flow computer	Flow calculations are in error. Use loop calibrator and apply 4, 12, and 20 mA to computer / system. Each of these points should correlate with the V-Cone sizing information.
	Flow computer	mA signal is read incorrectly. Apply a known current to the loop and read the raw signal in the computer. Most computers allow the user to see the mA signal directly.
Signal too high	V-Cone	V-Cone is installed backwards. Look for a flow direction arrow on the meter body, near the pressure taps. If no arrow is visible and the meter is large than 2 inches, the flow direction can be determined by the location of the pressure taps. The pressure taps will be closer to the upstream side. On meters less than 2 inches, the gauge lines will need to be removed. Look at the base of both pressure taps. One tap will be smooth at the base, the other will be mostly weld material. The smooth tap is on the upstream side. With a meter measuring backward flow, the DP signal will be approximately 30% too high.
	V-Cone	Flow is going in the opposite direction from what was expected. The assumption of flow direction is sometimes wrong. Verify with other system readings. With a meter measuring backward flow, the DP signal will be approximately 30% too high.
	V-Cone	Partially full pipe (liquids only). A partially full pipe will cause the meter to read too high. This can happen even in pressurized systems. • On horizontal pipes: If the fluid is safe, open a pressure tap on the top of the pipe. Air release will indicate partially full pipe. • On vertical pipes: Up flow will guarantee a full pipe. Down flow is difficult to diagnose if the pipe is full.
	V-Cone	Foreign object lodged in meter. This will increase the restriction of the meter and raise the DP. Remove the meter and visually inspect.
	Gauge lines	Leak on low pressure gauge line. Perform a leak check from the meter to the transmitter.
	Transmitter	Leak on low pressure vent valve. Perform a leak check on valve.
	Transmitter	Zero point has shifted positively. This will cause errors more pronounced at the low end of the transmitter range. Verify by closing the manifold side valves and opening the center valve. The reading should go to zero (4 mA). Recalibrate if necessary.
	Transmitter	DP span is set too low. Use pressure calibrator or handheld communicator to verify span point.

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Signal too high	Transmitter / flow computer	Both the transmitter and flow computer are set to take the square root of the signal. The signal will be correct at 20 mA. The positive error will increase dramatically as the signal decreases from 20 mA. Use a loop calibrator to check 12 mA point.
	Flow computer	4 mA set to minimum flow. Our calculations assume that 4 mA will be equal to zero flow. Sometimes 4 mA is set to equal the minimum flow on the sizing page. This error will be zero at maximum flow and increase as the flow decreases. The amount of error will depend on the zero offset.
Signal too low	Manifold	Manifold is cross-vented. The center valve must be closed. To test, close the two side valves and watch the transmitter signal. If the signal goes to zero (4 ma), the center valve is not closed completely.
	Gauge lines	Leak on high pressure gauge line. Perform a leak check from the meter to the transmitter.
	Transmitter	Leak on high pressure vent valve. Perform a leak check on valve.
	Transmitter	Zero point has shifted negatively. This will cause errors more pronounced at the low end of the transmitter range. Verify by closing the manifold side valves and opening the center valve. The reading should go to zero (4 mA). Recalibrate if necessary.
	Transmitter	DP span is set too high. Use pressure calibrator or handheld communicator to verify span point.
	Transmitter / flow computer	Neither the transmitter nor flow computer is set to take the square root of the signal. The signal will be correct at 20 mA. The negative error will increase dramatically as the signal decreases from 20 mA. Use a loop calibrator to check 12 mA point.
Unsteady signal	V-Cone	Partially full pipe occurring (liquids only). Periods with a partially full pipe will cause erratic readings. See above for details.
	Transmitter	Power supply not supplying enough power to create signal. Check power specifications for transmitter.
Slow response time	Transmitter	Dampening.
Sudden change in readings	V-Cone	Foreign object lodged in meter. This will increase the restriction of the meter and raise the DP. Remove the meter and visually inspect.
	Gauge lines	Leaks have started.

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Recommended Equipment for Troubleshooting a V-Cone Installation On-Site:

1. 4 to 20 mA loop simulator – highly recommended
2. Digital multimeter: with VDC, I, and Ω measurements
3. Pressure calibrator
4. Handheld Communicator for smart instruments
5. Hand tools: Screwdriver(+), Screwdriver (–), 12 inch crescent wrench, 4 inch crescent wrench

Some suggestions for equipment manufacturers and their products follow. A wide range of products is available. We do not necessarily endorse the following products or companies. Please choose a product that fits your needs and resources.

FLUKE.

www.fluke.com

740 Series Documenting Process Calibrators
718 Pressure Calibrator
717 30G Pressure Calibrator
716 Pressure Calibrator
715 Volt/mA Calibrator
714 Thermocouple Calibrator
713 30G/100G Pressure Calibrator
712 RTD Calibrator
787 Process Meter (combination digital multimeter and loop calibrator)
705 Loop Calibrator

9.0 V-Cone Literature

Configuration Sheets:		Configuration Sheets:	
VB Beveled	24509-29	VI Weld On Saddle	24509-46
VP Plain (smooth)	24509-30	w/ Bolt On Top-plate	
VT Threaded	24509-31	VR RTJ Weld Neck	24509-40,41
VS Slip On Flanged	24509-32,33,34	VQ RTJ Slip On	24509-38
VW Weld Neck	24509-35,36		
VD DIN Weld Neck	24509-47		
VC DIN Slip On	24509-42		
VJ JIS Slip On	24509-44		
VH Wafer-Cone	24509-51		

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MANUFACTURER'S WARRANTY

This Warranty shall apply to and be limited to the original purchaser consumer of any McCrometer product. Meters or instruments defective because of faulty material or workmanship will be repaired or replaced, at the option of McCrometer, Inc., free of charge, FOB the factory in Hemet, California, within a period of one (1) year from the date of delivery.

Repairs or modifications by others than McCrometer, Inc. or their authorized representatives shall render this Warranty null and void in the event that factory examination reveals that such repair or modification was detrimental to the meter or instrument. Any deviations from the factory calibration require notification in writing to McCrometer, Inc. of such recalibrations or this warranty shall be voided.

In case of a claim under this Warranty, the claimant is instructed to contact McCrometer, Inc. 3255 West Stetson Ave., Hemet, California 92545, and to provide an identification or description of the meter or instrument, the date of delivery, and the nature of the problem.

The Warranty provided above is the only warranty made by McCrometer, Inc. with respect to its products or any parts thereof and is made expressly in lieu of any other warranties, by course of dealing, usages of trade or otherwise, expressed or implied, including but not limited to any implied warranties of fitness for any particular purpose or of merchantability under the uniform commercial code. It is agreed this warranty is in lieu of and buyer hereby waives all other warranties, guarantees or liabilities arising by law or otherwise. Seller shall not incur any other obligations or liabilities or be liable to buyer, or any customer of buyer for any anticipated or lost profits, incidental or consequential damages, or any other losses or expenses incurred by reason of the purchase, installation, repair, use or misuse by buyer or third parties of its products (including any parts repaired or replaced); and seller does not authorize any person to assume for seller any other liability in connection with the products or parts thereof. This Warranty cannot be extended, altered or varied except by a written instruction signed by seller and buyer.

This Warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

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McCROMETER, INC. 3255 W. Stetson Ave., Hemet, CA 92545 PH 909-652-6811 FAX 909-652-3078 email: info@mccrometer.com

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ULTRA MAG®	Magnetic Flowmeters
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Wafer-Cone®	Differential Pressure Flowmeters
Variable Area	Variable Area Meters

Electronic Instrumentation for Remote Display and Control

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U.S. Patents 4638672, 4812049, 5363699, 4944190 and 5,814,738
Canadian Patent 1325113 European Patent 0277121 Japan patent 1,858,116 Other U.S. and Foreign patents pending

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Appendix J



OPTIBAR DP 7060 C Handbook

Differential pressure transmitter for measuring flow, level, differential pressure, density and interface

Electronic Revision:
ER 1.1.x
(SW.REV. 1.0.x)

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1.1 Intended use



DANGER!
For devices used in hazardous areas, additional safety instructions apply.



CAUTION!
Responsibility for the use of the measuring devices with regard to suitability, intended use and corrosion resistance of the used materials against the measured fluid lies solely with the operator.



INFORMATION!
The manufacturer is not liable for any damage resulting from improper use or use for other than the intended purpose.

The OPTIBAR DP 7060 C is a differential pressure transmitter suitable for measuring flow, level, differential pressure, density and interface of gases, vapours and liquids. The available measurement ranges and the respective permissible overloads are indicated on the nameplate. To observe the intended use, adhere to the following points:

- Observe the instructions in this document.
- Comply with the technical specifications (for further information refer to *Technical data* on page 63).
- Only suitably qualified personnel may install and operate the device.
- Observe the generally accepted standards of good practice.



CAUTION!
- *Any modification to the device, including drilling, sawing, trimming, welding and soldering of parts, or partially painting over or coating, is prohibited.*
- *Neither is it permitted to use the device as a climbing aid e.g. for installation purposes, as a holder for cables, pipes or other loads.*
- *The mounting or installation of parts is only permitted as described in this document, or insofar as it has been authorised by the manufacturer or a certified service partner.*

1.2 Technical limits

The device was constructed solely for use within the technical limits indicated on the nameplate and in the technical data. Applications outside of these limits are not permitted and could lead to significant risk of accident. For this reason, observe the following limits:

- Do not exceed the maximum working pressure (MWP).
- Do not exceed the indicated permissible operating temperature range.
- The permissible ambient temperatures given may not be exceeded or undershot.
- Observe the ingress protection of the housing during use.

1.3 Measured products

The device is designed to measure the pressure of vaporous, gaseous and liquid media. Prior to using any corrosive or abrasive products, the operator must check the resistance of all materials which are in contact with the product.

1.4 Certification

CE marking

The device fulfils the statutory requirements of the following EC directives:

- EMC Directive 2004/108/EC
- EMC specification acc. to EN 61326/A1

The manufacturer certifies successful testing of the product by applying the CE marking.

Pressure equipment directive 97/23/EC

Devices with a permissible pressure PS ≤ 200 bar (20 MPa) / 2900 psi comply with Article 3 Section (3) and are not subject to a conformity assessment. These devices were designed and manufactured in accordance with sound engineering practice (SEP).

The CE marking on the device does not apply to the Pressure Equipment Directive.

1.5 Safety instructions from the manufacturer

1.5.1 Copyright and data protection

The contents of this document have been created with great care. Nevertheless, we provide no guarantee that the contents are correct, complete or up-to-date.

The contents and works in this document are subject to copyright. Contributions from third parties are identified as such. Reproduction, processing, dissemination and any type of use beyond what is permitted under copyright requires written authorisation from the respective author and/or the manufacturer.

The manufacturer tries always to observe the copyrights of others, and to draw on works created in-house or works in the public domain.

The collection of personal data (such as names, street addresses or e-mail addresses) in the manufacturer's documents is always on a voluntary basis whenever possible. Whenever feasible, it is always possible to make use of the offerings and services without providing any personal data.

We draw your attention to the fact that data transmission over the Internet (e.g. when communicating by e-mail) may involve gaps in security. It is not possible to protect such data completely against access by third parties.

We hereby expressly prohibit the use of the contact data published as part of our duty to publish an imprint for the purpose of sending us any advertising or informational materials that we have not expressly requested.

1.5.2 Disclaimer

The manufacturer will not be liable for any damage of any kind by using its product, including, but not limited to direct, indirect or incidental and consequential damages.

This disclaimer does not apply in case the manufacturer has acted on purpose or with gross negligence. In the event any applicable law does not allow such limitations on implied warranties or the exclusion of limitation of certain damages, you may, if such law applies to you, not be subject to some or all of the above disclaimer, exclusions or limitations.

Any product purchased from the manufacturer is warranted in accordance with the relevant product documentation and our Terms and Conditions of Sale.

The manufacturer reserves the right to alter the content of its documents, including this disclaimer in any way, at any time, for any reason, without prior notification, and will not be liable in any way for possible consequences of such changes.

1.5.3 Product liability and warranty

The operator shall bear responsibility for the suitability of the device for the specific purpose. The manufacturer accepts no liability for the consequences of misuse by the operator. Improper installation and operation of the devices (systems) will cause the warranty to be void. The respective "Standard Terms and Conditions" which form the basis for the sales contract shall also apply.

1.5.4 Information concerning the documentation

To prevent any injury to the user or damage to the device it is essential that you read the information in this document and observe applicable national standards, safety requirements and accident prevention regulations.

If this document is not in your native language and if you have any problems understanding the text, we advise you to contact your local office for assistance. The manufacturer can not accept responsibility for any damage or injury caused by misunderstanding of the information in this document.

This document is provided to help you establish operating conditions, which will permit safe and efficient use of this device. Special considerations and precautions are also described in the document, which appear in the form of underneath icons.

1.5.5 Warnings and symbols used

Safety warnings are indicated by the following symbols.



DANGER!
This warning refers to the immediate danger when working with electricity.



DANGER!
This warning refers to the immediate danger of burns caused by heat or hot surfaces.



DANGER!
This warning refers to the immediate danger when using this device in a hazardous atmosphere.



DANGER!
These warnings must be observed without fail. Even partial disregard of this warning can lead to serious health problems and even death. There is also the risk of seriously damaging the device or parts of the operator's plant.



WARNING!
Disregarding this safety warning, even if only in part, poses the risk of serious health problems. There is also the risk of damaging the device or parts of the operator's plant.



CAUTION!
Disregarding these instructions can result in damage to the device or to parts of the operator's plant.



INFORMATION!
These instructions contain important information for the handling of the device.



LEGAL NOTICE!
This note contains information on statutory directives and standards.



- HANDLING
  This symbol designates all instructions for actions to be carried out by the operator in the specified sequence.

➲ RESULT
This symbol refers to all important consequences of the previous actions.

1.6 Safety instructions for the operator



WARNING!
In general, devices from the manufacturer may only be installed, commissioned, operated and maintained by properly trained and authorized personnel.
This document is provided to help you establish operating conditions, which will permit safe and efficient use of this device.

2.1 Scope of delivery

INFORMATION!
Inspect the packaging carefully for damages or signs of rough handling. Report damage to the carrier and to the local office of the manufacturer.

INFORMATION!
Do a check of the packing list to make sure that you have all the elements given in the order.

INFORMATION!
Look at the device nameplate to ensure that the device is delivered according to your order. Check for the correct supply voltage printed on the nameplate.

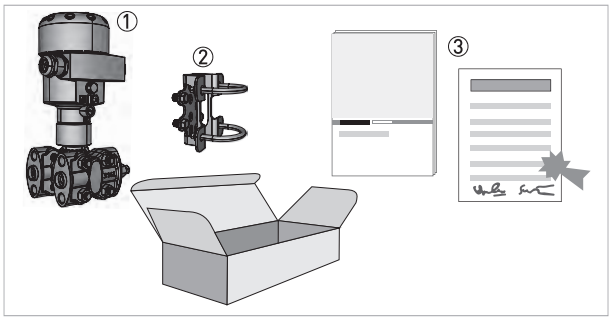


Figure 2-1: Scope of delivery

① Device in the version as ordered
② Mounting bracket
③ Documentation (test reports, factory and material certification (if ordered) and product documentation)

Optional accessories

- Oval flange adapter 1/2-14 NPT (female)
- Manifolds
- Gaskets

INFORMATION!
Assembly materials and tools are not part of the delivery. Use the assembly materials and tools in compliance with the applicable occupational health and safety directives.

2.2 Device description

The setup of the device is carried out via the display and adjustment unit. For further information refer to *Keypad functions* on page 41.

A piezoresistive sensor element is used in the measuring cell.

The measuring device is supplied ready for operation. The factory settings for the process data correspond to your order specifications.

2.2.1 Device design

The following drawings show the basic components of the differential pressure transmitter.

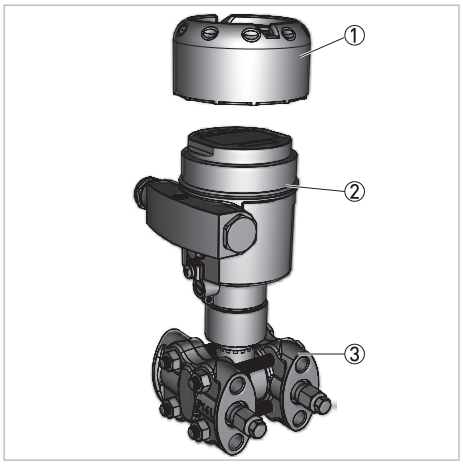


Figure 2-2: Basic components of single chamber differential pressure transmitter

① Housing cover, optional with display and adjustment module below
② Housing with electronics
③ Process assembly with measuring cell

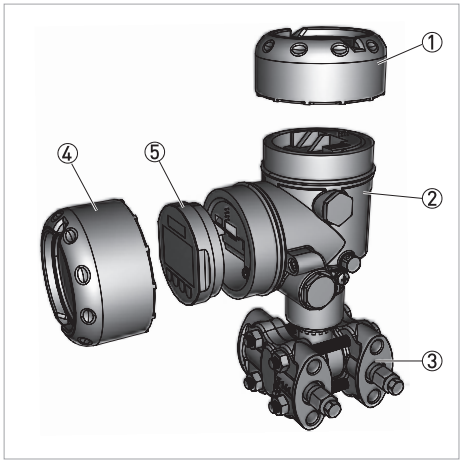


Figure 2-3: Basic components of double chamber differential pressure transmitter

① Housing cover
② Housing with electronics
③ Process assembly with measuring cell
④ Housing cover, optional with display and adjustment module below
⑤ Operating and display module

2.2.2 Connection variants

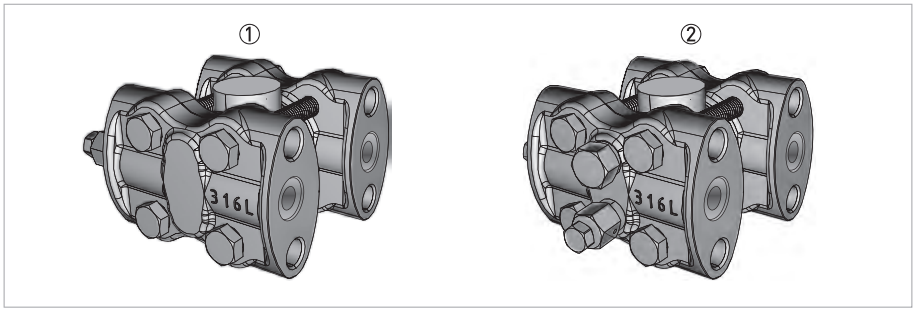


Figure 2-4: Process assembly

① Rear vent on process axis
② Side vent

Following connection variants are available:

- Process connection: 1/4-18 NPT acc. to IEC 61518 (female)
- Optional: oval flange adapter (1/4-18 NPT to 1/2-14 NPT)

The optional vent and drain valves on the device must be chosen according to the installation situation.

2.3 Nameplates

DANGER!
For devices used in hazardous areas, additional safety notes apply; please refer to the Ex documentation.

INFORMATION!
Look at the device nameplate to ensure that the device is delivered according to your order. Check for the correct supply voltage printed on the nameplate.

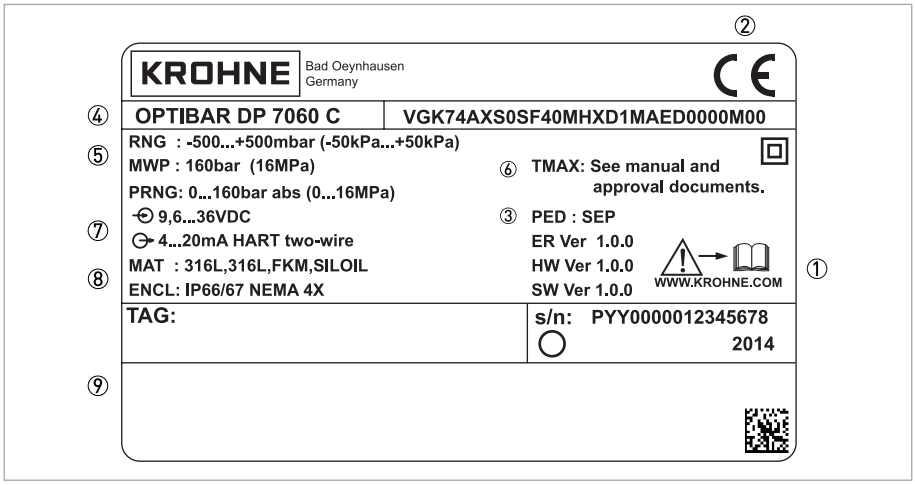


Figure 2-5: Example for a nameplate

① Observe the installation and operating instructions
② CE marking and marking of notified body
③ Hardware and Software version
④ Product name and type code
⑤ Nominal range
Permissible process pressure
Nominal range of absolute pressure measurement
⑥ Permissible temperature range
⑦ Electronics power supply and signal output
⑧ Ingress protection and material of wetted parts
(Diaphragm, process connections, gasket and fill fluid)
⑨ Approvals and approval guidelines

2.4 Terms and abbreviations

The following terms and abbreviations are used in this document.

URL Upper Range Limit	Upper measuring range limit. Also called nominal range. The highest value that can be measured by a particular device.
LRL Lower Range Limit	Lower measuring range limit. The lowest value that can be measured by a particular device.
URV Upper Range Value	The calibrated measuring range or the highest adjusted measured value. This value corresponds to 20 mA signal.
LRV Lower Range Value	The calibrated measuring range or the lowest adjusted measured value. This value corresponds to 4 mA signal.
SPAN Span	Measuring span or measuring range. SPAN = URL – LRL
CAL SPAN Calibrated Span	Calibrated or adjusted measuring span. CAL SPAN = URV – LRV. Also called "cSPAN". This is the span set to the 4...20 mA output.
TD Turn Down	The ratio from the measuring span to the adjusted measuring span. TD= SPAN/(CAL SPAN) = (+URL)/(CAL SPAN) The following applies: URV ≤ URL, CAL SPAN ≤ SPAN, TD ≥ 1

Example for **TD** Turn Down	
LRL= 0 bar **URL**= 3 bar / 43.5 psi	**SPAN**= 3 bar / 43.5 psi
URV= 2 bar / 29 psi **LRV**= 0.5 bar / 7.25 psi	**CAL SPAN**= 1.5 bar / 21.75 psi **TD**= 2:1

3.1 General notes on installation



INFORMATION!
Inspect the packaging carefully for damages or signs of rough handling. Report damage to the carrier and to the local office of the manufacturer.



INFORMATION!
Do a check of the packing list to make sure that you have all the elements given in the order.



INFORMATION!
Look at the device nameplate to ensure that the device is delivered according to your order. Check for the correct supply voltage printed on the nameplate.

3.2 Protection category of the housing

The housing of the differential pressure transmitter fulfills the requirements for ingress protection in accordance with IEC 60529. Housing for protection category IP69K in accordance with ISO 20653 is also available. For further information refer to *Technical data* on page 63.



CAUTION!
The first digit stands for the protection of the inner electronic components against the ingress of foreign bodies including dust. The first digit "6" means that the housing is dust-proof. The second digit designates the protection of the inner electronic components against the ingress of water. The second digit "6" means that the housing is waterproof and also resistant against a strong jet of water resists. The number "7" means that the case is waterproof even under water for a given pressure and time. The number "8" means that the housing is permanently waterproof even under water.

3.3 Packaging



CAUTION!
Devices for oxygen applications are sealed in PE foil and provided with a label "Oxygen! Use no Oil". Remove this foil just before mounting the device! After removing the protection for the process connection the label O_2 *will be visible on the process connection. Penetration of oil, grease and dirt should be avoided. Danger of explosion!*

Your device was protected by packaging during transport. Its capacity to handle normal loads during transport is assured by a test following ISO 22248. The packaging of standard devices consists of environmentally friendly, recyclable cardboard and PE foil. For special versions, PE foam or PE foil is also used. Dispose of the packaging material via specialised recycling companies.

3.4 Storage



CAUTION!
Observe the storage information found on the packaging. Labels on the original packaging must always remain legible and may not be damaged.

- Store the device in a dry and dust-free location.
- Avoid lasting direct exposure to the sun.
- Store the device in the original packaging supplied.
- Do not expose to aggressive media.
- Avoid mechanical shocks.
- Storage temperature of -40 to +80°C / -40 to +176°F.
- Relative air humidity of 20 to 85%.

3.5 Transport

- Use original packaging for transport and ensure that the packaging does not get crushed or damaged by sharp objects or other boxes.
- Do not throw or drop the device.
- Avoid temperatures below -40°C / -40°F and above +80°C / +176°F.
- When transporting by ship, use seaworthy outer packing.

3.6 Installation specifications



INFORMATION!
Observe the relevant directives, ordinances, standards and accident prevention regulations (e.g. VDE/VDI 3512, DIN 19210, VBG, Elex V, etc.).

The accuracy of the measurement is only guaranteed if the transmitter and accompanying impulse line(s), if any, have been correctly installed. In addition, extreme ambient conditions including large fluctuations in temperature, vibrations and shocks should be kept as far away as possible from the measuring equipment.

3.7 Mounting



CAUTION!

- *Prior to installing the pressure transmitter, it is essential to verify whether the version of the device on hand completely fulfils the technical and safety requirements of the measuring point. This applies in particular to the measuring range, overpressure resistance, temperature, explosion protection and operating voltage.*
- *Check the materials used for the wetted parts (e.g. gasket, process connection, separating diaphragm etc.) for suitability as regards process compatibility.*

3.7.1 Rotating the housing

The transmitter housing can be rotated 350° for better readability of the display or access to the wiring. A stop prevents the housing from being rotated too far.

- On all 2 chamber housings, the locking screw must first be loosened at the neck of the housing.

➲ The housing can then be rotated to the desired position.

- Once the desired position is reached, the locking screw is tightened again.

3.7.2 Mounting the display and adjustment module

The optional display and adjustment module can be set in any one of four different positions at 90° intervals. The installation of the adjustment module is carried out as per the illustrations below. To do so, unscrew the housing cover and insert the adjustment module clockwise. The display can be installed rotated at 90°. It is not necessary to interrupt the power supply.

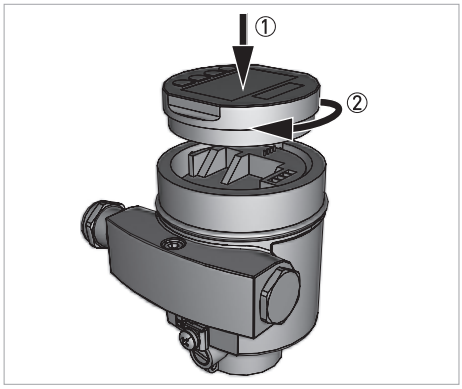


Figure 3-1: Installation in single chamber housing

① Insert the display and adjustment module into the housing
② Turn the display and adjustment module clockwise

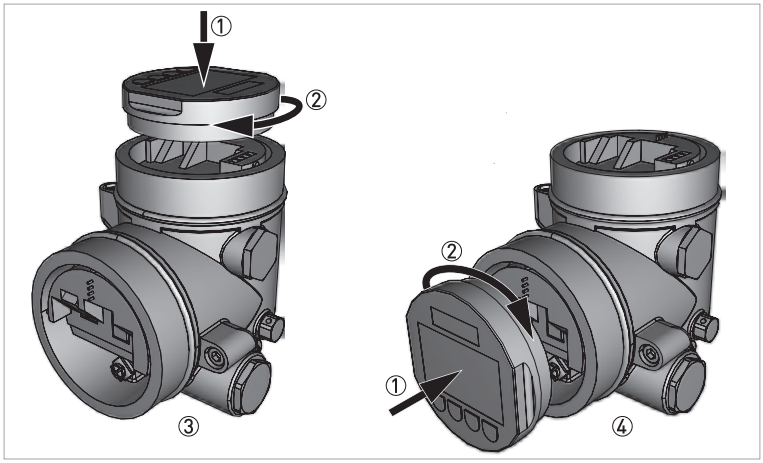


Figure 3-2: Installation in double chamber housing

① Insert the display and adjustment module into the housing
② Turn the display and adjustment module clockwise
③ Mounting on top
④ Mounting at side

3.7.3 Process connections

Before mounting of the device, please check the correct position of the high (H) and low (L) pressure side. You can see the designations (H / L) underneath the measuring cell acc. to the figure.

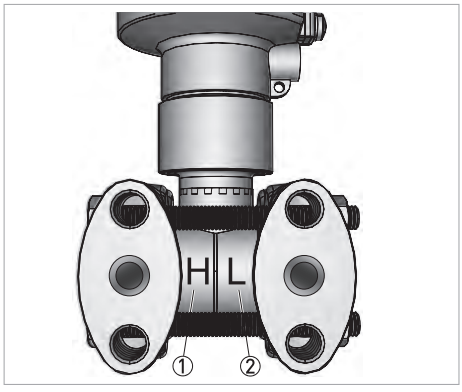


Figure 3-3: Process connection of the differential pressure transmitter

① High-pressure side
② Low-pressure side

The process connections of the differential pressure transmitter are usually 1/4-18 NPT (female) at a distance of 54 mm / 2.13". Through optional oval flange adapters the connections 1/2-14 NPT (female) are also selectable.

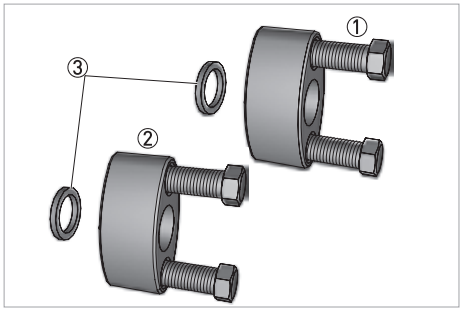


Figure 3-4: Oval flange adapter

① 7/16 UNF bolts
② Oval flange adapter
③ Sealing ring

If the adapter is not supplied pre-assembled, proceed as follows:

- Position the adapter with inserted O-ring.
- Use the screws supplied to screw the adapter to the transmitter.
- Tighten the screws to a torque of 25 Nm (stainless steel screws) or 12.5 Nm (stainless steel acc. to NACE).

3.7.4 Mounting bracket

A mounting bracket for easy pipe or wall mounting is included with each differential pressure transmitter.

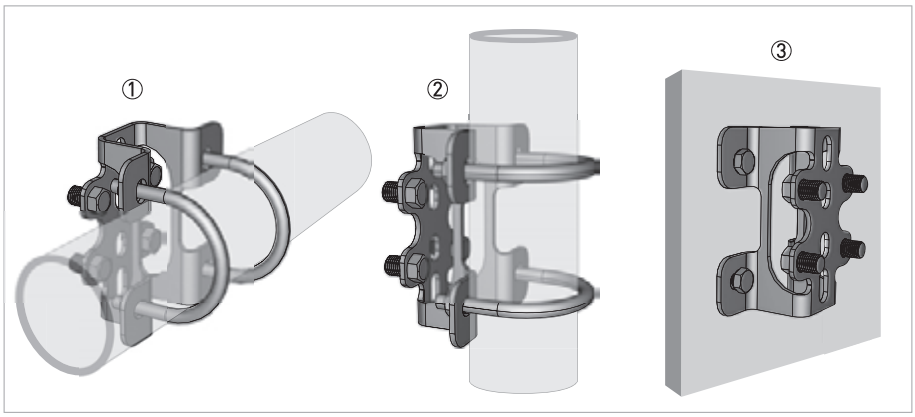


Figure 3-5: Mounting bracket

① Horizontal 2" pipe mounting
② Vertical 2" pipe mounting
③ Wall mounting

3.7.5 Manifolds

Manifolds allow for easy installation and commissioning of the transmitter. They separate the device from the process side and ensure simple control of the measuring point. They are available as 3-way and 5-way versions. The integrated outlet valve allows pressure equalization between the high (H) and low (L) pressure side during commissioning. With the manifold, it is possible to disassemble the differential pressure transmitter without interrupting the process. This means higher system availability and even simpler commissioning or maintenance purposes. The 3-way manifold with double-sided flange adapters allows a mechanically robust connection between the differential pressure transmitter and, for example, the impulse lines or the flange adapters of a averaging pitot tube. With a 5-way manifold, two additional valves allow to blow out of the impulse lines and the calibration of the differential pressure transmitter in place.

3.7.6 Primary element

Primary elements, such as averaging pitot tubes, orifice plates or venturis are designed for certain line sizes and flow conditions. Therefore, prior to installation, the line size and pressure rating has to be checked and the measuring point number compared. For detailed instructions on installing a primary element refer to DIN EN ISO 5167.

3.7.7 Pressure connection with impulse line

Please review the following information for pressure connection with impulse line:

- Select the shortest impulse line possible and install without sharp bends.
- Avoid material deposits and blockages in the impulse line. Accordingly, install the impulse lines so that such occurrences are impossible. Do not exceed a slope of approx. 8% in the piping.
- Ensure that the impulse line flows freely before installation and rinse with compressed air or, even better, with the product itself.
- When measuring liquid, the impulse line must be completely purged of air.
- Run the impulse line so that trapped air (when measuring liquids) or condensate (when measuring gas) can flow back into the process.
- Hot steam must not enter the process connection (the over temperature will destroy the device). To avoid this situation, a suitable water trap (such as a syphon filled with water prior to installation) can be installed upstream from the measuring device.
- All connections must be tight and fixed properly.
- The process lines must be installed so that the medium cannot be blown out of the measuring chambers.

3.7.8 Vibrations

In case of strong vibrations at the measuring point, the device should be mounted via impulse lines in a calm place.

3.7.9 Temperature limits

Higher process temperatures often mean also higher ambient temperatures for electronics and connection cables. Make sure that the upper temperature limits for the environment of the electronics housing and connection cable are not exceeded. For further information refer to *Technical data* on page 63.

3.8 Instructions for oxygen applications

Oxygen and other gases can be explosive when brought into contact with oils, grease and plastics, so the following measures must also be taken:

- All components of the plant, such as e.g. measuring devices must be cleaned according to the requirements of BAM (DIN 19247).
- Depending on the seal material, certain temperatures and pressures must not be exceeded in oxygen applications, refer to *Technical data* on page 63.



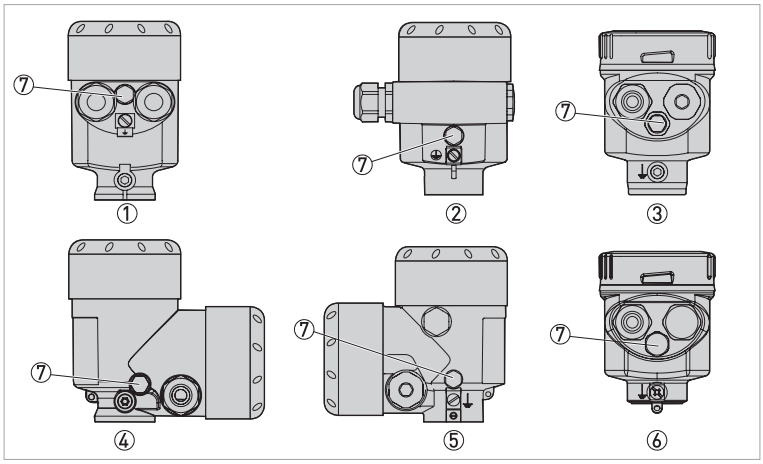
CAUTION!
Devices for oxygen applications are sealed in PE foil and provided with a label "Oxygen! Use no Oil". Remove this foil just before mounting the device! After removing the protection for the process connection the label O_2 will be visible on the process connection. Penetration of oil, grease and dirt should be avoided. Danger of explosion!

3.9 Venting

The ventilation for the electronics housing is assured via a filter element in the vicinity of the cable glands, which is permeable to air but water-absorbent.

CAUTION!
In order to ensure effective ventilation, the filter element must be always free of deposits.

CAUTION!
Do not use a high-pressure cleaner to clean the housing. The filter element may become damaged and as a result moisture can penetrate into the housing. The exception to this is the IP69K single chamber housing.



① Single chamber housing, plastic, stainless steel precision casting
② Single chamber housing, aluminium
③ Single chamber housing, electro-polished stainless steel
④ Double chamber housing, plastic
⑤ Double chamber housing, aluminium
⑥ Single chamber housing IP69k
⑦ Filter element

3.10 Measurement setup for flow measurement

3.10.1 In gases and liquids with solids content

- Include the pressure tapping points above or to the side on the process line.
- The device must be mounted above the chosen tapping point.

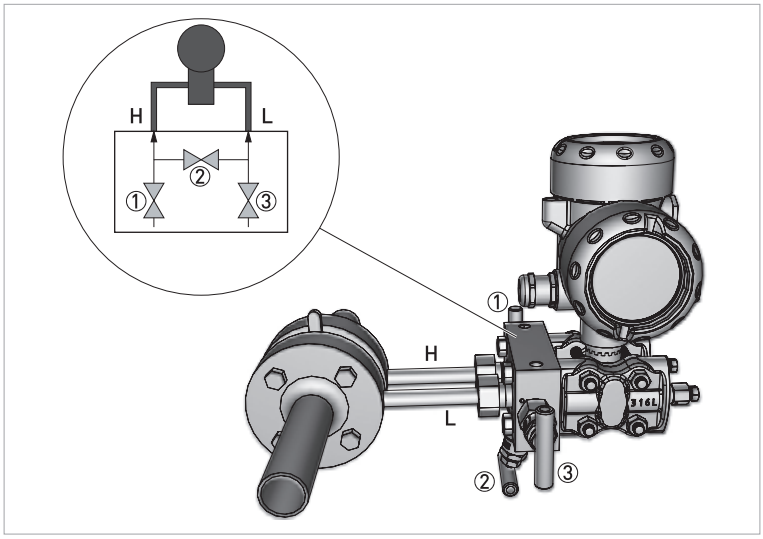


Figure 3-6: Application example

① Shut-off valve
② Equalizing valve
③ Shut-off valve

3.10.2 In vapours and pure liquids

- Include the pressure tapping points to the side on the process line.
- The device must be mounted at the same height or underneath the tapping points.
- In steam applications, fill the impulse lines and/or condensate vessels with an appropriate liquid.

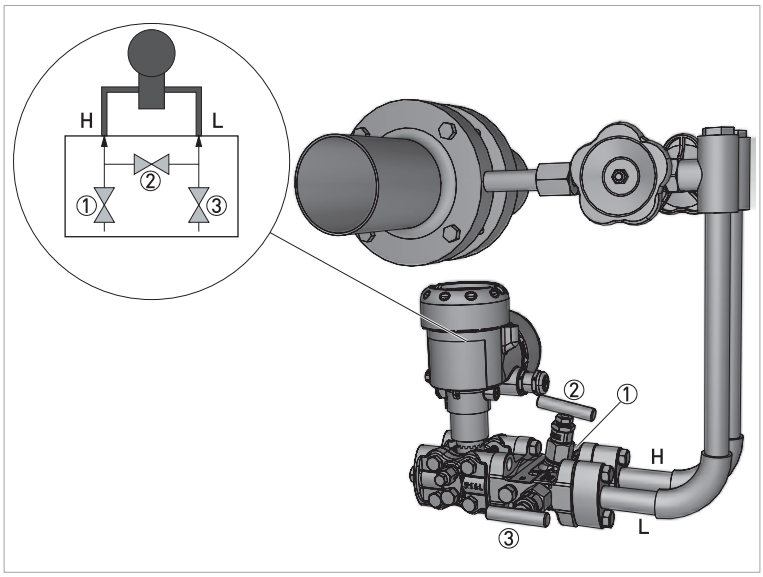


Figure 3-7: Application example

① Shut-off valve
② Equalizing valve
③ Shut-off valve

3.11 Measurement setup for level measurement

3.11.1 In open vessels with impulse line

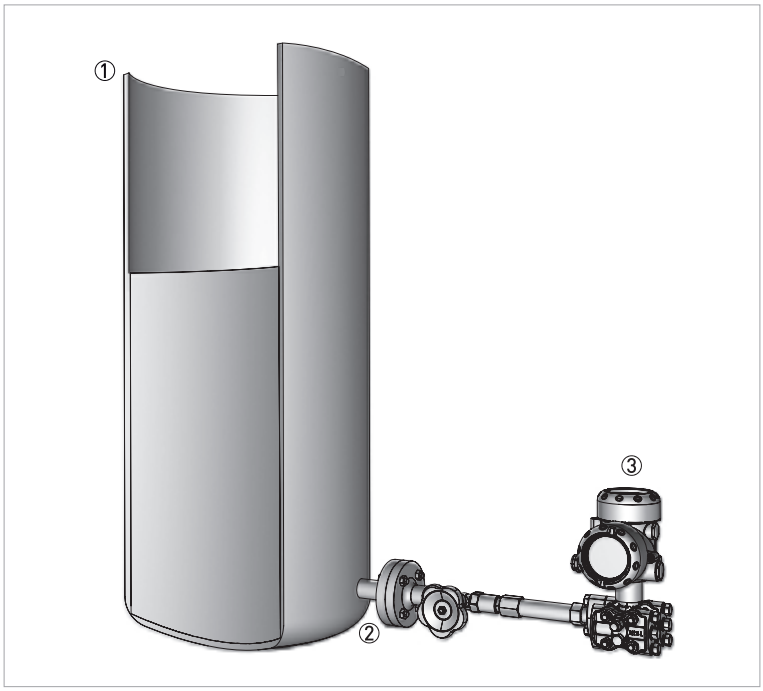


Figure 3-8: Application example

① Tank
② Impulse line
③ Differential pressure transmitter

The following points should be observed in this application:

- Mount the differential pressure transmitter below the lower process connection so that the impulse lines are always filled with liquid.
- The low pressure side (L) is open to atmospheric pressure.
- For measurements in products with solid content, the installation of separators and drain valves is recommended to enable collection and removal of debris and sediment.

3.11.2 In closed vessels with gas-filled impulse lines

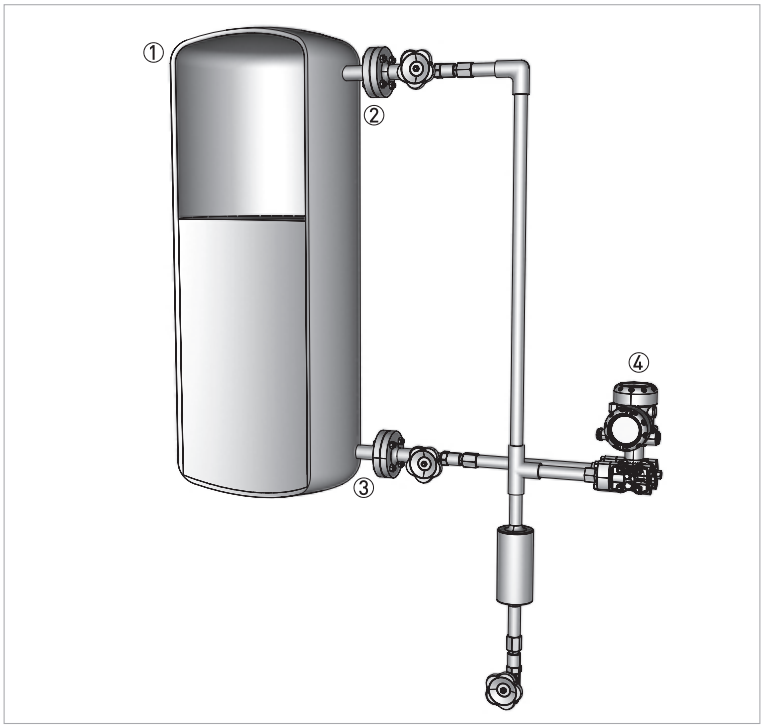


Figure 3-9: Application example

① Tank
② Low-pressure line (L)
③ High-pressure line (H)
④ Differential pressure transmitter

The following points should be observed in this application:

- Mount the differential pressure transmitter below the lower process connection so that the impulse line is always filled with liquid.
- The low pressure side (L) must always be connected above the maximum level.
- For measurements of fluids with solid content, the installation of separators and drain valves is recommended to enable collection and removal of debris and sediment.

3.11.3 In closed vessels with liquid / condensate filled impulse lines



Figure 3-10: Application example

① Tank
② Low-pressure line (L)
③ High-pressure line (H)
④ Differential pressure transmitter

The following points should be observed in this application:

- Mount the differential pressure transmitter below the lower process connection so that the impulse lines are always filled with liquid.
- The low pressure side (L) must always be connected above the maximum level.
- For measurements of fluids with solid content, the installation of separators and drain valves is recommended to enable collection and removal of debris and sediment.

4.1 Safety instructions



DANGER!
All work on the electrical connections may only be carried out with the power disconnected. Take note of the voltage data on the nameplate!



DANGER!
Observe the national regulations for electrical installations!



WARNING!
Observe without fail the local occupational health and safety regulations. Any work done on the electrical components of the measuring device may only be carried out by properly trained specialists.



INFORMATION!
Look at the device nameplate to ensure that the device is delivered according to your order. Check for the correct supply voltage printed on the nameplate.

4.2 Notes for electrical cables



DANGER!
The device must be grounded to a spot in accordance with regulations in order to protect personnel against electric shocks.



DANGER!
Cables may only be connected when the power is switched off! Since the transmitter has no switch-off elements, overcurrent protection devices, lightning protection and/or energy isolating devices must be provided by the customer.

4.2.1 Requirements for signal cables provided by the customer

If the signal cable was not ordered, it is to be provided by the customer. The following requirements regarding the electrical specifications of the signal cable must be observed:

Specifications for standard signal cables

- Test voltage: ≥ 500 VAC RMS (750 VDC)
- Temperature range: -40...+105°C / -40...+221°F
- Capacity: ≤ 200 pF/m / 61 pF/ft
- Inductance: ≤ 0.7 µH/m / 0.2 µH/ft
- Use cable with round cross section.
- A cable outer diameter of 5...9 mm / 0.2 ... 0.35" ensures the seal effect of the cable gland. If you are using cable with a different diameter or cross-section, exchange the seal or use a suitable cable gland.
- We generally recommend the use of a shielded cable for HART® multidrop mode.

4.2.2 Laying electrical cables correctly

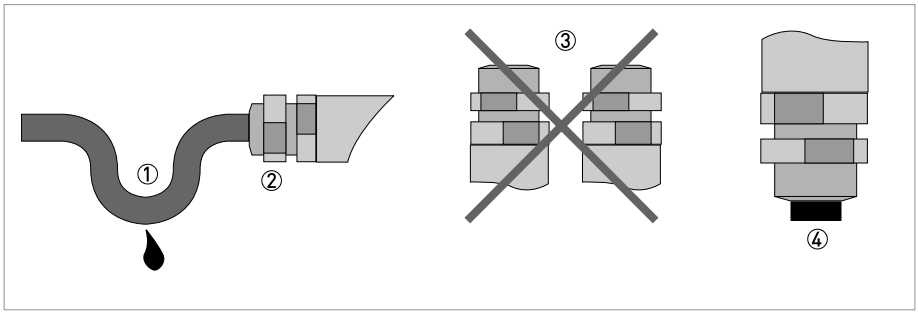


Figure 4-1: Protect housing from dust and water

① Lay the cable in a loop just before the housing.
② Tighten the screw connection of the cable entry securely.
③ Never mount the housing with the cable entries facing upwards.
④ Seal cable entries that are not needed with a plug.

4.2.3 Cable preparation

The device is connected with standard two-wire cable without shielding. If electromagnetic interference is expected which is above the test values of EN 61326-1 for industrial areas, a shielded cable should be used.

Check which outer diameter is suitable for the cable gland in order to ensure the sealing effect according to the specified IP protection class.

- 5...9 mm / 0.20...0.35" (standard)
- 6...12 mm / 0.24...0.47" (optional)
- 10...14 mm / 0.40...0.55" (optional)

The terminals in the terminal compartment are designed for wire cross-sections of up to 1.5 mm². To ensure a proper connection, you should strip the cable 40…50 mm / 1.6...2".

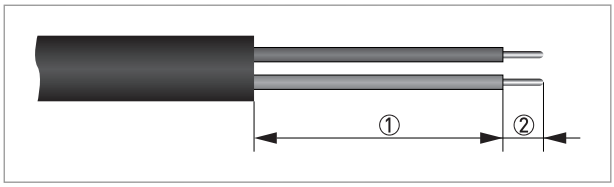


Figure 4-2: Stripping the cable

① 40...50 mm / 1.6...2"
② 5 mm / 0.2"

4.2.4 Cable entry 1/2-14 NPT (female)

With plastic housings, the NPT cable gland or the conduit steel tube must be screwed without grease into the thread. For further information about max. torque for all housings refer to *Technical data* on page 63.

4.2.5 Connector pin assignment

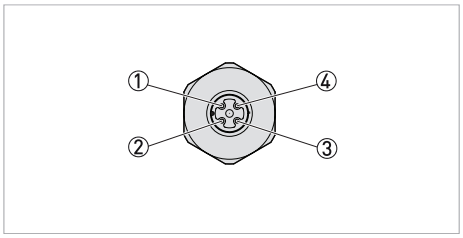


Figure 4-3: Connector M12 x 1, 4-pin

① VS+
② Not connected
③ Not connected
④ VS-

Contact pin	Colour of cable	Electronic insert for terminal
Pin ①	Brown	1
Pin ④	Blue	2

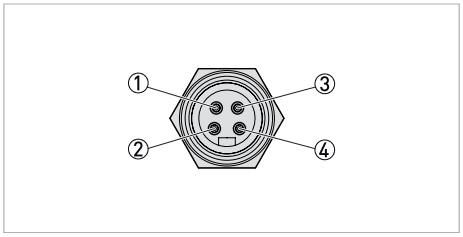


Figure 4-4: 7/8 connector, Foundation Fieldbus (FF)

① VS-
② VS+
③ Not connected
④ Cable shield

Contact pin	Colour of cable	Electronic insert for terminal
Pin ①	Blue	1
Pin ②	Brown	2
Pin ④	Green / yellow	Grounding

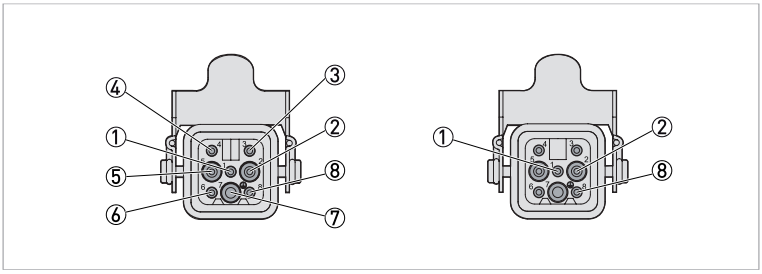


Figure 4-5: Connector, Harting HAN 8D (left) and Harting HAN 7D (right)

① VS-
② VS+

Contact pin	Colour of cable	Electronic insert for terminal
Pin ①	Black	1
Pin ②	Blue	2
Pin ⑧	Green / yellow	Grounding

4.2.6 Connection to the power supply

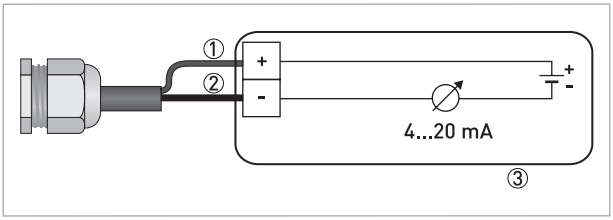


Figure 4-6: Connection to the power supply

① Red
② Black
③ Power supply with load

4.2.7 Cable shield and grounding

If a shielded cable is necessary, connect the cable shield on both ends to the grounding potential.

In the device, the cable shield must be connected directly to the internal ground terminal.

The ground terminal outside on the housing must be connected to the grounding potential with low impedance.



DANGER!
In hazardous areas, the grounding is carried out according to the installation instructions.



CAUTION!
Significant potential differences exist inside galvanization plants as well as on vessels with cathodic corrosion protection. A two-sided shield grounding can cause unacceptably high shield currents as a result.



CAUTION!
The metallic and wetted parts (process connection, cap flange, measuring cell and separating diaphragm etc.) are conductive connected with the inner and outer ground terminal on the housing.

4.3 Electrical connection

The connection of the power supply and the signal output is carried out via spring-loaded terminals in the housing. The display and adjustment module is connected via contact pins with the interface adapter.

4.3.1 Connection in the terminal compartment

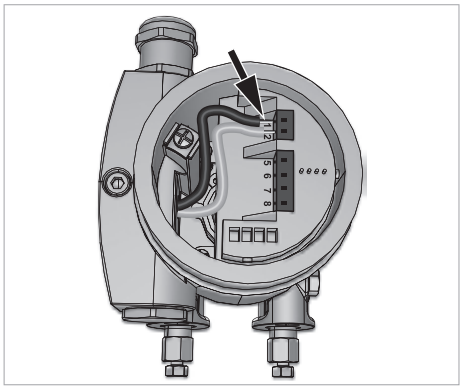


Figure 4-7: Terminal compartment from above

Procedure

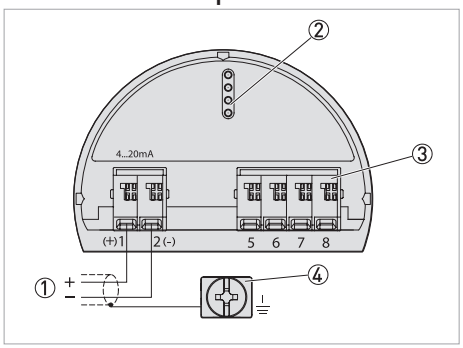
- Unscrew the housing cover.
- If present, remove the display and adjustment module by turning it to the left.
- Loosen union nut of the cable gland.
- For preparation of connection cable refer to *Cable preparation* on page 31.
- Push the cable through the cable gland into the terminal compartment.
- Insert the wire ends into the open terminals according to the wiring plan. Flexible cores with cable end sleeves as well as solid cores can be inserted directly into the terminal openings. In case of flexible cores, press the spring terminal with a small screwdriver to open the terminal opening.
- Check the proper hold of the wires in the terminals by lightly pulling on them.
- Connect the cable shield to the internal ground terminal, connect the outer ground terminal to the customer/plant equipotential bonding.
- Tighten the union nut of the cable gland. The sealing ring must completely enclose the cable.
- Screw the housing cover back on.

4.3.2 Single chamber housing

DANGER!
For devices used in hazardous areas, additional safety notes apply; please refer to the Ex documentation.

The following illustration applies to both the non-Ex as well as the Ex ia, the Ex d and the Ex d ia version.

Electronics compartment



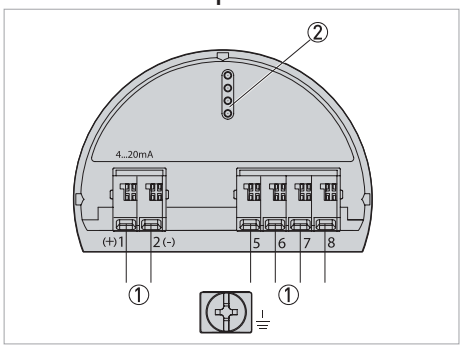
① Power supply / signal output
② Interface adapter for the display and adjustment module
③ Digital interface
④ Ground terminal for connection of the cable shield

4.3.3 Double chamber housing

DANGER!
For devices used in hazardous areas, additional safety notes apply; please refer to the Ex documentation.

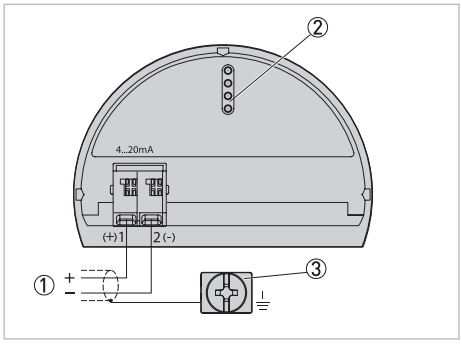
The following illustration applies to both the non-Ex as well as the the Ex ia, and the Ex d version.

Electronics compartment



① Internal connection to terminal compartment
② Interface adapter for the display and adjustment module

Terminal compartment

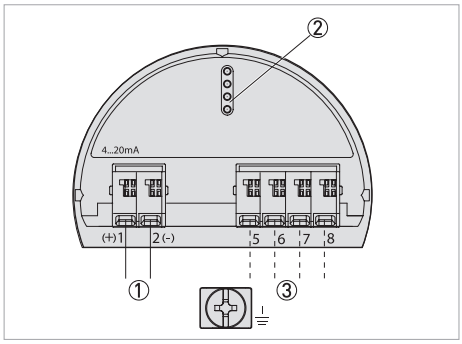


① Power supply / signal output
② Interface adapter for the display and adjustment module
③ Ground terminal for connection of the cable shield

4.3.4 Double chamber housing Ex d ia

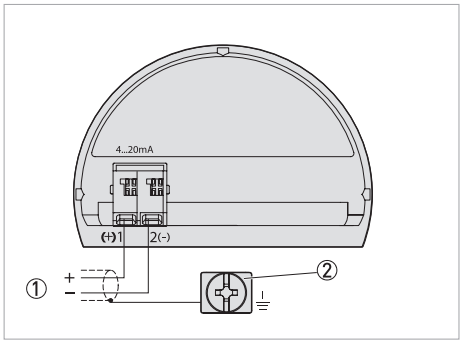
DANGER!
For devices used in hazardous areas, additional safety notes apply; please refer to the Ex documentation.

Electronics compartment



① Power supply / signal output
② Interface adapter for the display and adjustment module
③ Digital interface

Terminal compartment



① Power supply / signal output
② Ground terminal for connection of the cable shield

4.4 Grounding the measuring device



WARNING!
Within galvanic plants as well as vessels with cathodic corrosion protection there are considerable potential differences. Considerably equipotential bonding currents can be caused via the cable shield when the shield is grounded on both ends. To avoid this, the cable shield must only be connected to the grounding potential on one side of the control cabinet in such applications. The cable shield must not be connected to the internal ground terminal in the device and the outer ground terminal on the housing not to the equipotential bonding!



CAUTION!
The metallic and wetted parts (process connection, cap flange, measuring cell and separating diaphragm etc) are conductive connected with the inner and outer ground terminal on the housing.

If a shielded cable is necessary, connect the cable shield on both ends to the grounding potential. In the signal converter, the cable shield must be connected directly to the internal ground terminal. The ground terminal outside on the housing must be connected to the equipotential bonding with low impedance. If equipotential bonding currents are expected, the evaluation side must be connected with a ceramic capacitor (e.g. 1 nF, 1500 V). The low frequency equipotential bonding currents are thus suppressed, but the protective effect against high frequency interference signals remains.

4.5 Description of the current output

The current output is a 2-wire 4...20 mA output with a low alarm of 3.6 mA and high alarm of 21 mA set by default. A high frequency HART® signal superimposes this signal. For further information on the current output, refer to *Technical data* on page 63.

5.1 Start-up

The pressure transmitter may only be started up after it has been completely installed and checked by appropriately qualified personnel. Switch on the operating voltage for start-up. Prior to applying the operating voltage, it is essential to check the correctness of the process connection and the electrical connection and ensure that the impulse line has been completely filled with the process medium. Then proceed with start-up.

Prior to applying the operating voltage check that

1. the process connection fits properly
2. the signal and, if necessary, supply lines are properly connected
3. the impulse lines are completely filled with the process medium

After connecting the differential pressure transmitter to the power supply or after voltage recovery, the device performs a self test for approximately 10 seconds.

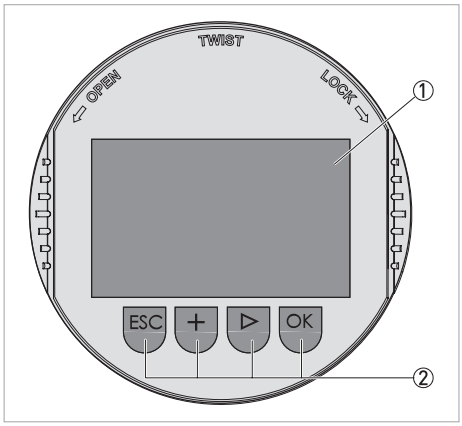
Self test routine

1. Internal check of the electronics.
2. Indication of the device type, hardware and software version as well as the measurement loop name on the display or PC.
3. Indication of a status message on the display or PC.
4. Output signal jumps to the set alarm current.
5. After that the current measuring value is outputted to the signal cable.

5.2 Keypad functions

INFORMATION!
The device can be configured either via the relevant fieldbus or the adjustment module.

The display and adjustment module is used for indication of measuring values, adjustment and diagnosis.



① LCD display
② Function buttons

The device is operated via the four keys of the display and adjustment module ②. The LC display ① indicates the individual menu items. Approx. 60 minutes after the last pressing of a key, an automatic reset in the indication of measuring values is triggered. Any values not confirmed with [OK] will not be saved.

[OK]

- Move back to the menu overview
- Confirm selected menu
- Editing the parameters
- Store value

[▷]

- Change measured value
- Select list entry
- Select editing position

[+]

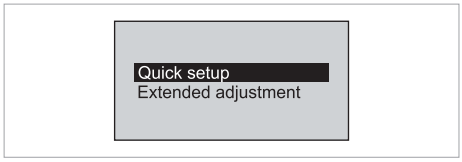
- Change value of the parameter

[ESC]

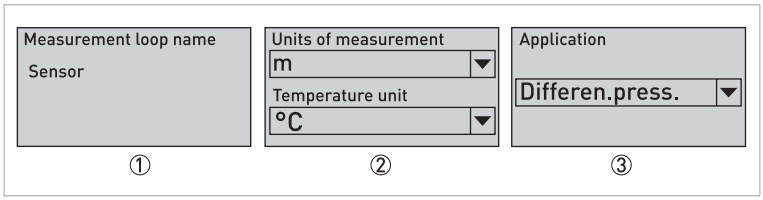
- Cancel entry
- Jump to next higher menu

5.3 Quick setup

To quickly and easily adapt the device to the application, select the menu item "Quick setup". This parameter adjustment essentially involves the selection of the application, position correction and adjustment of the span.



In this chapter, not all settings are displayed graphically but all settings are described.



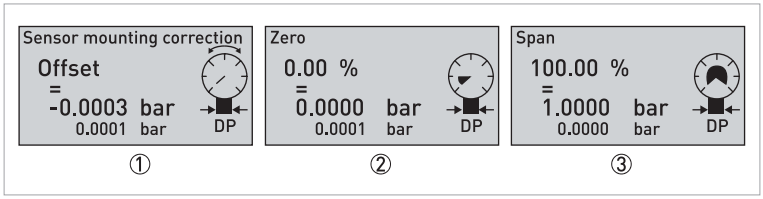
① **Measurement loop name**
Assign a suitable measurement loop name

② **Adjustment units**
Determine the adjustment and temperature units of the device.
and
Unit of static pressure
Determine the unit of static pressure.

③ **Application**
The selection includes differential pressure, level, flow, interface and density measurement.

5.3.1 Adjustment differential pressure

Adjustment differential pressure



① **Sensor mounting correction**
In this menu item you compensate the influence of the installation position of the device (offset) on the measured value.

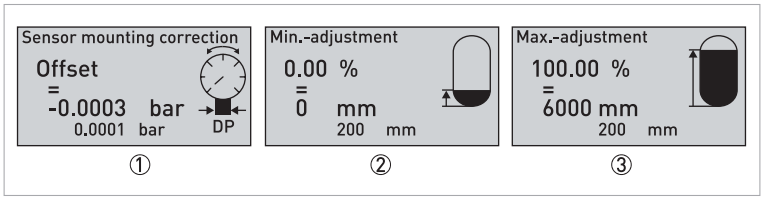
② **Zero**
In this menu item you determine the zero point of your measurement (LRV)
This value corresponds to the output signal of 4 mA.

③ **Span**
This value corresponds 100%, or rather an output signal of 20 mA (URV)
If the zero point is actually 0, this value corresponds to the measuring span.

In bidirectional measurements the zero point has to be set in the negative measurement range.
e.g.
Zero 0%: -250 mbar
Span 100%: 250 mbar
Total span: 500 mbar

5.3.2 Adjustment level

Adjustment level



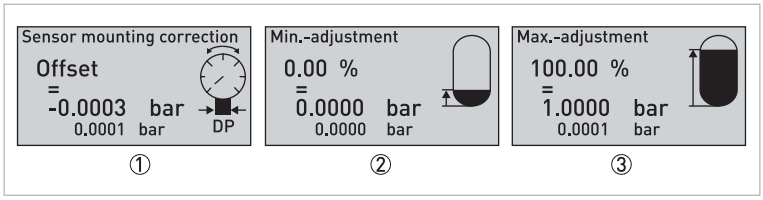
① **Sensor mounting correction**
In this menu item you compensate the influence of the installation position of the device (offset) on the measured value.

② **Min.-adjustment**
Enter the (pressure) value for the min. level.
At 0% this corresponds to the output signal of 4 mA.

③ **Max.-adjustment**
Enter the (pressure) value for the max. level.
At 100% this corresponds to the output signal of 20 mA.

5.3.3 Adjustment flow

Adjustment flow



① **Sensor mounting correction**
In this menu item you compensate the influence of the installation position of the device (offset) on the measured value.

② **Min.-adjustment**
Enter the (pressure) value for the min. flow.
At 0% this corresponds to the output signal of 4 mA.

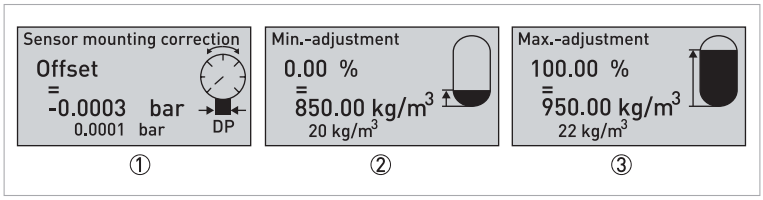
③ **Max.-adjustment**
Enter the (pressure) value for the max. flow.
At 100% this corresponds to the output signal of 20 mA.

④ **Linearization**
The following output characteristics are available for selection:
Linear (Standard)
To square root
Bi-directional linear
Bi-directional square root
User programmable

The adjustment "flow" is equal to the adjustment "differential pressure", with the additional setting for square root characteristics and low-flow cut-off.

5.3.4 Adjustment density

Adjustment density



① **Sensor mounting correction**
In this menu item you compensate the influence of the installation position of the device (offset) on the measured value.

Distance max./min..
Enter the distance between both measuring points.

② **Min.-adjustment**
Enter the (pressure) value for the min. density.
This corresponds to the output signal of 4 mA.

③ **Max.-adjustment**
Enter the (pressure) value for the max. density.
At 100% this corresponds to the output signal of 20 mA.

5.4 Extended adjustment

The main menu is divided into five sections:

- Start-up
- Display
- Diagnosis
- Additional adjustments
- Info

5.4.1 Start-up

Measurement loop name	Assign a unique device ID. This is useful or even necessary in digital systems and for monitoring large systems.	
Application	In this menu item you select the application: differential pressure, level, flow, density and interface are available. The default setting is differential pressure.	
Units	In this menu item the adjustment units, as well as the temperature unit are determined. The selection of the adjustment unit determines the unit displayed in the "Min-adjustment" and "Max-adjustment" items. In "Level" mode, it is possible to carry out the adjustment in a height unit (e.g. meters). To do so, the density of the medium must also be specified.	
	Adjustment units	**Differential pressure and flow** mbar, bar, Pa, kPa, MPa, psi, mmH2O, mmHg, inH2O, inHg and user-defined
		Level Density input required: mm, cm, m, in and ft
		Density measurement kg/dm^3 and lb/ft^3
		Interface mm, cm, m, in and ft with density input/unit of media
	Temperature unit	°C, °F and K
	Static pressure	mbar, bar, Pa, kPa, MPa, psi, mmH2O, mmHg, inH2O and inHg

Sensor mounting correction	The mounting position of the device has a great impact on the measured value (offset), especially with small measuring ranges and isolating systems. The sensor mounting correction compensates this offset. The sensor mounting correction can automatically take on the current measured value as correction value (auto correct). Alternatively, this correction value can also be manually entered using the "Edit" function. Once the sensor mounting correction has taken place, the measured value is corrected to 0. The sensor mounting correction can compensate a maximum of 20% of the nominal range.	
	Offset	Input in adjustment unit, automatic transfer of the current measured value
Adjustment	Adjustment refers to setting the zero point (zero) and maximum measured value (span). These values correspond to the values of 4 and 20 mA. If the adjustment ranges are exceeded, the message "Outside parameter limits" is displayed.	
	Distance	**Density** Distance in m (for kg/cm^3) and ft (for lb/ft^3) **Interface** Distance in mm, cm, m, in and ft
	Min.-adjustment / Zero	**Process pressure, differential pressure** Zero in %, pressure **Level and flow (standard 0%)** Min. in X %, pressure or filling height **Density** Min. in X %, density **Interface** Min. in X %, interface
	Max.-adjustment / Span	**Process pressure, differential pressure** Span in %, pressure **Level and flow (standard 100%)** Min. in X %, pressure or filling height **Density** Min. in X %, density **Interface** Min. in X %, interface
Damping	For the damping of process-dependent measured value fluctuations, you can choose a suitable integration time. The values which can be entered are from 0 ... 999 seconds with an increment of 0.1 seconds.	
	Integration time	In 0.1 second increments
Linearization	A linearization is necessary for all vessels in which the volume does not increase linearly with the level height, e.g. in a horizontal cylindrical or spherical tank, and the indication or output of the volume is required. Corresponding linearization curves are preprogrammed for these vessels. They represent the correlation between the level percentage and vessel volume. By activating the appropriate curve, the volume percentage of the vessel is displayed correctly. Enter the desired parameters using the function buttons and save the entries. Note the following if the differential pressure signal converter with corresponding approval is used as part of an overfill protection system according to WHG (Water Resources Act): If a linearization curve is selected, the measuring signal is no longer linearly proportional to the level. This must be taken into consideration by the user, particularly when setting the switching point on the limit signal indicator.	
	Type of linearization	**Level** Linear, Horiz.cylinder, Sphere and User programmable
	The square of the flow is proportional to the pressure differential at the orifice plate or averaging pitot tube: $q^2 \sim dp$ To establish a linear relationship between flow rate and output variable, a square root extraction is required: $q \sim \sqrt{dp}$ The differential pressure transmitter has this square root function. It is selected in menu item "linearization curve". Enter the desired parameter using the appropriate keys and save your entries. When selecting the "bi-directional square root" flow, the minimum adjustment must be entered with a negative sign.	
	Type of linearization	**Flow** Linear, To square root, Bi-directional linear, Bi-directional square root and User programmable

Current output	In the current output menu, the saturation region for above or below a threshold is set. Under "Current output min./max." these limit values can be set. The factory setting is 3.8 mA and 20.5 mA. This corresponds to the NAMUR recommendation NE 43.		
	Mode	Output characteristic	0...100% = 4...20 mA or 0...100% = 20...4 mA Additional bi-directional flow: 20...4...20 mA or 4...20...4 mA
		Failure mode	≤ 3.6 mA, ≥ 21 mA, last valid measured value
	Min. and Max.	Min. current	3.8 mA, 4 mA
		Max. current	20.5 mA, 20 mA
Lock adjustment / Unlock adjustment	In this menu item, a 4-digit PIN can be activated, which protects against undesirable or unintended changes of the settings. With a PIN active, remote access via software or other systems is also no longer possible.		
	Run now		

5.4.2 Display

Menu language	In this menu item you can set the desired language. Factory settings: English	
	German, English, French, Spanish, Portuguese, Italian, Dutch, Russian, Turkish, Polish and Czech	
Displayed value 1 and 2	In this menu item you can define how the measured value should be presented on the display. The factory setting is "Linear percent".	
	"Level"	Filling height or Pressure (Adjustment units), Static pressure, Percent, Scaled, Current output, Linear percent, Meas. cell temp. and Electronics temperature
	"Differential pressure"	Differential pressure, Static pressure, Percent, Scaled, Current output, Linear percent, Meas. cell temp. and Electronics temperature
	"Flow"	Flow, Differential pressure, Static pressure, Pressure/percent, Scaled, Current output, Linear percent, Totalizer 1, Totalizer 2, Meas. cell temp. and Electronics temperature
	"Interface"	Interface height, Differential pressure, Percent, Scaled, Current output, Linear percent, Meas. cell temp. and Electronics temperature
	"Density"	Density, Differential pressure, Percent, Scaled, Current output, Linear percent, Meas. cell temp. and Electronics temperature
Backlight	A backlight on the display is available, which can be turned on or off in this menu. By default, this function is disabled.	
	Off, On	

5.4.3 Diagnosis

Device status	Status signals	Check function, Out of Specification, Maintenance required, Failure
Peak value	The respective minimum and maximum pressure values are stored in the device. Under "Peak values", these values can be viewed or reset. In addition to the pressure, the minimum and maximum values of the sensor cell and the electronics temperature is stored. These can be viewed or reset here.	
	Peak value "Pressure"	Reset peak value
	Peak value "Differential pressure"	Reset peak value
	Peak value "Static pressure"	Reset peak value
	Peak value "Meas. cell temp."	Reset peak value
	Peak value "Electronics temperature"	Reset peak value
Simulation	In menu item "Simulation", measured values can be simulated via the current output. These are issued as both analogue and digital (via HART ®). The simulation is automatically cancelled 60 minutes after the last key stroke.	
	For applications "Differential pressure"	Differential pressure, Static pressure, Percent, Current output, Linear percent, Meas. cell temp. and Electronics temperature
	For applications "Flow"	Flow, Differential pressure, Static pressure, Pressure, Scaled, Current output, Linear percent, Meas. cell temp. and Electronics temperature
	For applications "Level"	Filling height or Pressure (Adjustment units), Static pressure, Percent, Current output, Linear percent, Meas. cell temp. and Electronics temperature
	For applications "Interface"	Interface height, Differential pressure, Percent, Current output, Linear percent, Meas. cell temp. and Electronics temperature
	For applications "Density"	Density, Differential pressure, Percent, Current output, Linear percent, Meas. cell temp. and Electronics temperature

5.4.4 Additional adjustments

PIN	In this menu item the PIN can be changed. This option is only available if it has been enabled under "Setup - Lock adjustment". The PIN is "0000" by default factory conditions.	
	0000	Change PIN
Date / Time	Internal clock setting	
	Write date, time, data in device	
Reset	For further information refer to *Reset* on page 51.	
	Factory settings, Basic settings, Totalizer 1 and Totalizer 2	
Copy instrument settings	For further information refer to *Saving the device settings* on page 52.	
	Copy instrument settings	
Special parameters	Changing these settings is possible only after consultation with a service employee.	
Scaling	In menu item "Scaling variable" you define the scaling variables and the scaling unit for the level mode. In menu item "Scaling format" you define the scaling format on the display and the scaling of the level measurement for 0% and 100%.	
	Scaling variable	Scaling variable
		Scaling unit
	Scaling format	Scaling format
		100% corresponds - user-defined value
		0% corresponds - user-defined value
Current output	In this menu item it is determined which measured variable relates to which current output. Under "Current output - Adjustment", the current output can be assigned a corresponding measured value.	
	Current output variable	For applications "Level" Filling height or Pressure (Adjustment units), Static pressure, Percent, Scaled, Linear percent, Meas. cell temp. and Electronics temperature
		For applications "Differential pressure" Differential pressure, Static pressure, Percent, Linear percent, Meas. cell temp. and Electronics temperature
		For applications "Flow" Flow, Differential pressure, Static pressure, Pressure, Percent, Scaled, Linear percent, Meas. cell temp. and Electronics temperature
		For applications "Interface" Interface height, Differential pressure, Percent, Scaled, Linear percent, Meas. cell temp. and Electronics temperature
		For applications "Density" Density, Differential pressure, Percent, Scaled, Linear percent, Meas. cell temp. and Electronics temperature
	Current output, adjustment	0% = 0% or 100% = 100%
HART®-Mode	The differential pressure transmitter offers the HART® modes "Analogue current output" and "Fix current (4 mA). Under "Fix current (4 mA)", up to 64 sensors can be operated on a two-wire multidrop mode. Each device must be assigned a HART® address between 0 und 63. The analogue signal is fixed at 4 mA. Under "Analogue current output", however, a 4…20 mA signal can also be issued for the assigned HART® address in multidrop mode.	
	HART® address	0...63
	Output mode	Analogue current output with HART® or Fix current (4 mA) with HART®

Flow element charact.	In this menu item more information can be given on the primary elements used in the "flow" application. This can be displayed as either flow or mass flow. The respective display and adjustment units can then be selected accordingly.	
	Unit	Volume flow, Mass flow and User-defined mbar, bar, Pa, kPa, MPa, psi, mmH2O, mmHg, inH2O, inHg and User-defined
	Adjustment	0 % = xxxx m^3/h, 100 % = xxxx m^3/h

5.4.5 Info

Device name	Device name
	Serial number
Instrument version	Software version
	Hardware version
Factory calibration	Factory calibration date
	Date of last change
Sensor characteristics	Order-related device characteristics

5.5 Reset

The reset function resets specific user entries. There are two reset functions available.

5.5.1 Delivery status

Restore the default values at the time of delivery, including the order-specific settings. A false signal suppression, user programmable linearization curve as well as the measured value memory will be deleted.

5.5.2 Basic settings

Reset the set data, including special parameters to the default values of the manufacturer. A false signal suppression, user programmable linearization curve as well as the measured value memory will be deleted.

The following menu items are affected during a reset

Menu item	Parameter	Default
Measurement loop name		Sensor
Application		No reset
Unit	Adjustment units	mbar (cell ≤ 500 mbar) bar (cell ≥ 1 bar)
	Temperature unit	°C
Sensor mounting correction		0.00 bar
Adjustment	Zero / Min. adjustment	0.00 bar - 0.00%
	Span / Max. adjustment	+URL in bar - 100%
Damping	Integration time	0.0 seconds

Menu item	Parameter	Default
Current output	Current output mode	Output characteristic 4...20 mA Failure mode ≤ 3.6 mA
	Current output variable	Linear percent - Level
	Current output, adjustment	0...100% = 4...20 mA
	Current output min./max.	Min. 3.8 mA Max. 20.5 mA
Lock adjustment		Unlock
Language		English
Displayed value 1		Current output in %
Displayed value 2		Meas. cell temp. in °C
Backlight		Off
Simulation		Differential pressure
PIN		0000
Scaling	Scaling variable	Volume in L
	Scaling format	0% = 0 L / 100% = 0 L
HART® mode		Address 0

5.6 Saving the device settings

We recommended noting the parameters and archiving them afterwards. They are thus available for multiple use or service purposes. If the pressure transmitter is equipped with a display and adjustment module, the most important data can be read out of the sensor into the display and adjustment module. The data remain there permanently even if the sensor power supply fails. If it is necessary to exchange the signal converter, the display and adjustment module is inserted into the replacement device and the data are written into the signal converter under the menu item "Copy device data".

5.6.1 Copy device settings

This function allows you to upload the selected data to the display and adjustment module or download selected data to the signal converter. This function serves as a backup of the data, since it is retained even if the power fails.

The following settings are saved:

- all settings from the "Setup" and "Display" menus
- the menu items "Reset" and "Date/Time"
- Special parameters

5.7 Diagnosis memory

The device has several internal memories which are available for diagnosis purposes. The data remain even with voltage interruption.

Measured value memory
Up to 60,000 measured values can be stored in a ring memory. Each entry contains a time stamp as well as the respective measured value. Storable values are for example:

- Differential pressure
- Static pressure
- Level
- Flow rate
- Density
- Interface
- Percent value
- Linear percent
- Scaled values
- Meas. cell temp.
- Electronic temperature

With the default factory settings, the measured value memory is active and stores differential pressure, measurement reliability and electronics temperature every minute. The requested values and recording conditions are set via a PC with PACTware^{TM}/DTM or the control system with EDD.

Event memory
Up to 500 events are automatically stored with a time stamp in the event memory (non-deletable). Each entry contains date/time, event type, event description and value. Event types are for example:

- Modification of a parameter
- Switch-on and switch-off times
- Status message acc. to NE 107
- Error message acc. to NE 107

The data are read out via a PC with PACTware^{TM}/DTM or the control system with EDD.

5.8 Failures and diagnostics

The operator of the system is responsible for taking suitable measures to remove interferences. The differential pressure transmitter offers maximum reliability. Nevertheless, faults can occur during operation. The first measures are to evaluate the error messages, check the output signals as well as the verification of measurement errors.

Asset Management and diagnostics acc. to NE 107
The device features self-monitoring and diagnostics according to NE 107 and VDI/VDE 2650. In addition to the status messages in the following tables there are more detailed error messages available under the menu item "Diagnostics" via the display and adjustment module, PACTware™/DTM and EDD.

Status messages
The status messages are divided into the following categories in accordance with NE 107:

- **Failure**
  Due to a malfunction in the device, a failure message is outputted. This status message is always active. It cannot be deactivated by the user.
- **Check function**
  The device is in operation, the measured value is temporarily invalid. This status message is inactive by default. It can be activated by the user via PACTware/DTM or EDD.
- **Out of specification**
  The measured value is unstable because the device specification is exceeded. This status message is inactive by default. It can be activated by the user via PACTware™/DTM or EDD.
- **Maintenance required**
  Due to external influences, the device function is limited. The measurement is affected, but the measured value is still valid. Plan in maintenance for the device because a failure is expected in the near future. This status message is inactive by default. It can be activated by the user via PACTware™/DTM or EDD.

5.8.1 Error codes

Failure

Code Text message	Cause	Action or description
F013 No measurement value available	No valid measured value available	Overpressure, underpressure, measuring cell defective
F017 Adjustment span too small	Adjustment not within specification	Change adjustment according to the limit values
F025 Error in the linearisation table	Index markers are not continuously rising, for example illogical value pairs	Check linearisation table, Delete table/Create new
F36 No operable sensor software	Failed or interrupted software update	Repeat software update Check electronics version Exchange the electronics or send device for repair
F40 Error in the electronics	Hardware defect	Exchange the electronics or send device for repair
F041 Error in the electronics	No connection to sensor electronics	Check connection to sensor electronics (with remote version)
F080	General software error	Disconnect operating voltage briefly
F113 Communication error with the display and adjustment module, operating software PACTware TM disturbed	EMC interference	Remove EMC influences
F125 Inadmissible electronics temperature	Temperature of the electronics in the non-specified section	Check ambient temperature Isolate electronics Use device with higher temperature range
F260 Error in the calibration	Error in the calibration carried out in the factory Error in EEPROM	Exchange the electronics Send device for repair
F261 Error in the configuration	Error during setup Error when carrying out a reset	Repeat setup, Repeat reset
F265 Measurement function disturbed	Sensor no longer carries out a measurement	Carry out a reset Disconnect operating voltage briefly
F266 Inadmissible operating voltage	Operating voltage is below the specified range	Check electrical connection - if necessary, increase operating voltage

Check function

Code Text message	Cause	Action or description
C700 Simulation active	A simulation is active	Finish simulation Automatic end after 60 minutes

Out of specification

Code Text message	Cause	Action or description
S600 Inadmissible electronics temperature	Temperature of the electronics in the non-specified section	Check ambient temperature Isolate electronics Use device with higher temperature range
S603 Inadmissible operating voltage	Operating voltage below specified range	Check electrical connection - if necessary, increase operating voltage

Maintenance required

Code Text message	Cause	Action or description
M500 Error with the reset delivery status	Saved reset delivery status is incorrect	Send device for repair
M501 Error in the non-active linearization table	Index markers are not continuously rising, for example illogical value pairs	Check linearisation table, Delete table/Create new
M502 Error in the event memory	Hardware error in EEPROM	Exchange the electronics Send device for repair
M504 Error on a device interface	Hardware defect	Check connections Exchange the electronics Send device for repair
M507 Error in the device settings	Error during setup Error when carrying out a reset	Repeat setup, Repeat reset

5.8.2 Check 4...20 mA signal

Connect a multimeter in the suitable measuring range according to the wiring plan.

Error code	Cause	Action or description
4...20 mA signal is missing	Faulty connection to power supply	Check connection and if necessary correct according to wiring plan
	No power supply	Check cable for breaks; repair if necessary
	Operating voltage too low or load-resistance too high	Check, adapt if necessary
Signal is >22 mA or <3.6 mA	Electronic module or sensor defective	Exchange the device or send device for repair



DANGER!
In hazardous area applications, the regulations for the wiring of intrinsically safe circuits must be observed.

5.8.3 Error messages via the display and operating module

Error code	Cause	Action or description
E013	No measurement value available or pressure greater than nominal range	Exchange the device or send device for repair
E017	Adjustment span too small	Repeat with modified values
E036	No executable signal converter software	Carry out software update or send device for repair
E041	Hardware error	Exchange the device or send device for repair

Depending on the reason for the fault and the measures taken, the steps described previously may need to be carried out again.

5.8.4 Change electronic insert

In case of a defect, the electronic insert can be exchanged by the user against an identical type. If no electronic insert is available on site, it can be ordered from the respective local sales representative. To order a replacement, the serial number is required. This is located on the nameplate of the device or on the delivery note.



WARNING!
Installation, assembly, start-up and maintenance may only be performed by personnel trained in ***explosion protection****. Additional regional standards, safety directives and laws must be observed at all times.*

5.8.5 Software update

The following components are required for an update of the device software:

- Sensor
- Power supply
- USB interface adapter
- PC with PACTware™
- Software update as file

The latest version of the device software can be found on the manufacturer website. Further information is provided in the software update file.

Certain approvals can be subject to a specific software version. Therefore, when carrying out an update, ensure the approval is retained.

6.1 Replacement



DANGER!
All work on the electrical connections may only be carried out with the power disconnected. Take note of the voltage data on the nameplate!



WARNING!
Installation, assembly, start-up and maintenance may only be performed by personnel trained in ***explosion protection****. Additional regional standards, safety directives and laws must be observed at all times.*



DANGER!
Observe the national regulations for electrical installations!



WARNING!
Observe without fail the local occupational health and safety regulations. Any work done on the electrical components of the measuring device may only be carried out by properly trained specialists.



DANGER!
Check whether the ambient air around the differential pressure transmitter is explosive. Opening the device in an explosive atmosphere may result in ignition and explosion.



CAUTION!
The process medium may cause the differential pressure transmitter to become extremely hot. Possible risk of burning. For this reason, promptly shut off the process or isolate the differential pressure transmitter sufficiently from the product prior to starting work and check that it has cooled down to room temperature.

6.2 Maintenance

When used correctly, no maintenance is required in normal operation. In some applications, the measurement can be distorted by adhesive media. In this case, suitable measures should be taken to avoid adhesions and especially hardening on the diaphragm surface and in the pressure connection.

6.3 Spare parts availability

The manufacturer adheres to the basic principle that functionally adequate spare parts for each device or each important accessory part will be kept available for a period of 3 years after delivery of the last production run for the device.

This regulation only applies to spare parts which are subject to wear and tear under normal operating conditions.

6.4 Availability of services

The manufacturer offers a range of services to support the customer after expiration of the warranty. These include repair, maintenance, technical support and training.



INFORMATION!
For more precise information, please contact your local sales office.

6.5 Repairs

Repairs may be carried out exclusively by the manufacturer or the manufacturer authorised specialist companies.

6.6 Returning the device to the manufacturer

6.6.1 General information

This device has been carefully manufactured and tested. If installed and operated in accordance with these operating instructions, it will rarely present any problems.



CAUTION!
Should you nevertheless need to return a device for inspection or repair, please pay strict attention to the following points:

- *Due to statutory regulations on environmental protection and safeguarding the health and safety of our personnel, manufacturer may only handle, test and repair returned devices that have been in contact with products without risk to personnel and environment.*
- *This means that the manufacturer can only service this device if it is accompanied by the following certificate (see next section) confirming that the device is safe to handle.*



CAUTION!
If the device has been operated with toxic, caustic, flammable or water-endangering products, you are kindly requested:

- *to check and ensure, if necessary by rinsing or neutralising, that all cavities are free from such dangerous substances,*
- *to enclose a certificate with the device confirming that is safe to handle and stating the product used.*

6.6.2 Form (for copying) to accompany a returned device

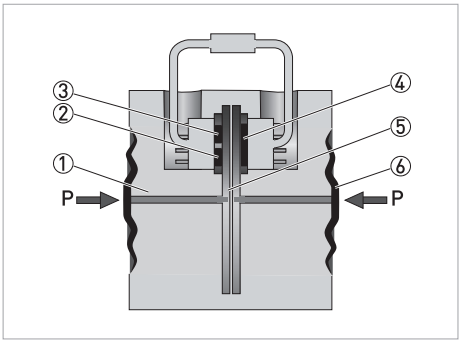
Company:		Address:
Department:		Name:
Tel. no.:		Fax no.:
Manufacturer's order no. or serial no.:		
The device has been operated with the following medium:		
This medium is:	☐	water-hazardous
	☐	toxic
	☐	caustic
	☐	flammable
	☐	We checked that all cavities in the device are free from such substances.
	☐	We have flushed out and neutralized all cavities in the device.
We hereby confirm that there is no risk to persons or the environment through any residual media contained in the device when it is returned.		
Date:		Signature:
Stamp:		

6.7 Disposal



CAUTION!
Disposal must be carried out in accordance with legislation applicable in your country.

7.1 Measuring principle



① Fill fluid
② Temperature sensor
③ Absolute pressure sensor
④ Differential pressure sensor
⑤ Overload system
⑥ Separating diaphragm

The process pressure is transferred via the separating metallic diaphragms ⑥ of the high and low pressure side and the fill fluid ① to the piezoresistive silicon sensor. Through the prevailing pressure differential, the silicon diaphragm of the differential pressure sensor ④ is deflected and changes the resistance value of the four piezoresistive elements in the bridge circuit. The change in resistance of the bridge circuit is proportional to the differential pressure. Additionally, the measured cell temperature ② and the prevailing static pressure ③ on the low pressure side is measured and then made available to the signal converter for further processing. If the measurement limit is exceeded, the overload system ⑤ restricts the prevailing process pressure at the differential pressure sensor and protects it from damage.

7.2 Technical data

INFORMATION!

- *The following data is provided for general applications. If you require data that is more relevant to your specific application, please contact us or your local sales office.*
- *Additional information (certificates, special tools, software,...) and complete product documentation can be downloaded free of charge from the website (Download Center).*

Measuring system

Measuring principle	Piezoresistive differential pressure cell
Application range	• Flow measurement (volume or mass flow) with corresponding differential pressure transmitter in gases, vapours and liquids • Differential pressure measurement • Interface and density measurement • Level, volume and mass measurement of liquids
Measuring range	30 mbar...16 bar / 0.44...232 psi
Display and user interface	
Display on signal converter	• Dot-matrix display 45x27 mm / 1.77x1.06", illuminated • Display turnable in 90° steps • Digit size 13x7 mm / 0.51x0.27" • Ambient temperatures below -20°C / -4°F may affect the readability of the display
Display function	• Measured value display or derived measured value such as filling height, density, interface position, volume or mass flow and total counter • Warning and diagnostic information • All parameters are accessible via the operating menu
Operating and display languages	German, English, French, Spanish, Portuguese, Italian, Dutch, Russian, Turkish, Polish and Czech
Operation	Local operation via 4 push buttons on the display and adjustment module
Remote operation	• PACTware™, incl. Device Type Manager (DTM) • HART® Hand Held Communicator from Emerson Process • AMS® from Emerson Process • PDM® from Siemens
Integrated clock	
Date format	Day / Month / Year
Time format	12 hours / 24 hours
Time zone	CET (Factory setting)
Rate deviation	Maximum 10.5 minutes / year

Measuring accuracy

<table>
<tr><td colspan="6">Differential pressure</td></tr>
<tr><td>Reference conditions acc. to IEC 60770-1</td><td colspan="5">• Ambient temperature (constant): +18...+30°C / +64...+86°F
• Relative humidity (constant): 45...75%
• Ambient pressure (constant): 860...1060 mbar / 12.5...15.4 psi
• Mounting position: vertical
• Rising characteristics
• Measurement start at 0.00 bar / psi
• Process diaphragm: 316 L / 1.4404
• Fill fluid: silicone oil
• Material of process flanges: 316 L / 1.4404
• Power supply: 24 VDC ±3 VDC
• Load for HART®: 250 Ω</td></tr>
<tr><td rowspan="7">Reference conditions acc. to DIN EN 61298</td><td colspan="5">Includes the non-linearity, hysteresis and repeatability under reference conditions Applies to the digital interfaces (HART®, Profibus PA, Foundation Fieldbus) as well as for the analogue 4…20 mA current output.
[% of the set span]</td></tr>
<tr><td></td><td>TD < 5:1</td><td>TD > 5:1</td><td>TD < 10:1</td><td>TD > 10:1</td></tr>
<tr><td>30 mbar / 0.44 psi</td><td>< ±0.10%</td><td>< ± 0.02% x TD</td><td></td><td></td></tr>
<tr><td>100 mbar / 1.5 psi</td><td rowspan="3">-</td><td rowspan="3">-</td><td rowspan="3">< ±0.065%</td><td><±-0.035% + 0.01% x TD</td></tr>
<tr><td>500 mbar / 7.3 psi</td><td rowspan="2"><±0.015% + 0.005% x TD</td></tr>
<tr><td>3 bar / 43.51 psi</td></tr>
<tr><td>16 bar / 232.1 psi</td><td><±-0.035% + 0.01% x TD</td></tr>
<tr><td rowspan="7">Effect of ambient temperature</td><td colspan="5">Ambient temperature effect on zero and span in relation to the set measuring span. Applies to the digital interfaces (HART®, Profibus PA, Foundation Fieldbus) as well as for the analogue 4…20 mA current output.
[% of the set span]</td></tr>
<tr><td></td><td>up to TD</td><td colspan="2">-10...+60°C / +14...+140°F</td><td>-40...+85°C / -40...+185°F</td></tr>
<tr><td>30 mbar / 0.44 psi</td><td>30:1</td><td colspan="2"><± 0.10% + 0.10% x TD</td><td><± 0.15% + 0.15% x TD</td></tr>
<tr><td>100 mbar / 1.5 psi</td><td rowspan="4">100:1</td><td colspan="2"><± 0.15% + 0.15% x TD</td><td><± 0.15% + 0.20% x TD</td></tr>
<tr><td>500 mbar / 7.3 psi</td><td colspan="2" rowspan="2"><± 0.08% + 0.05% x TD</td><td rowspan="2"><± 0.12% + 0.06% x TD</td></tr>
<tr><td>3 bar / 43.51 psi</td></tr>
<tr><td>16 bar / 232.1 psi</td><td colspan="2"><± 0.15% + 0.015% x TD</td><td><± 0.15% + 0.20% x TD</td></tr>
<tr><td rowspan="7">Effect of system pressure</td><td colspan="5">Ambient temperature effect on zero point and span in relation to the set measuring span. Zero point errors can be calibrated out under operating pressure. Applies to the digital interfaces (HART®, Profibus PA, Foundation Fieldbus) as well as for the analogue 4…20 mA current output.
[% of the set span]</td></tr>
<tr><td></td><td>up to nominal pressure</td><td>on zero</td><td colspan="2">on span</td></tr>
<tr><td>30 mbar / 0.44 psi</td><td>40 bar / 580 psi</td><td rowspan="5"><± 0.10% x TD</td><td colspan="2" rowspan="5"><± 0.10%</td></tr>
<tr><td>100 mbar / 1.5 psi</td><td rowspan="4">160 bar / 2320 psi</td></tr>
<tr><td>500 mbar / 7.3 psi</td></tr>
<tr><td>3 bar / 43.51 psi</td></tr>
<tr><td>16 bar / 232.1 psi</td></tr>
<tr><td rowspan="2">Effect of mounting position</td><td colspan="5">A position-dependent zero offset can be corrected.</td></tr>
<tr><td colspan="5">≤0.1 mbar per 10° inclination</td></tr>
</table>

<table>
<tr><td rowspan="2">Long-term stability acc. to DIN 16086 and IEC 60770-1</td><td colspan="4">Applies to the digital interfaces (HART®, Profibus PA, Foundation Fieldbus) as well as for the analogue 4…20 mA current output.
[% of the set span]</td></tr>
<tr><td colspan="4"><0.1% x TD (Turn Down) over a period of 5 years</td></tr>
<tr><td rowspan="9">Total performance in accordance with DIN 16086</td><td colspan="4">At a temperature change of -10...+60°C / +14...+140°F, up to the indicated nominal pressure.
[% of the set span]</td></tr>
<tr><td></td><td>up to TD</td><td>Nominal pressure</td><td>-10...+60°C / +14...+140°F</td></tr>
<tr><td>30 mbar / 0.44 psi</td><td rowspan="5">1:1</td><td>40 bar / 580 psi</td><td><± 0.24%</td></tr>
<tr><td>100 mbar / 1.5 psi</td><td rowspan="4">160 bar / 2320 psi</td><td><± 0.32%</td></tr>
<tr><td>500 mbar / 7.3 psi</td><td rowspan="3"><± 0.18%</td></tr>
<tr><td>3 bar / 43.51 psi</td></tr>
<tr><td>16 bar / 232.1 psi</td><td><± 0.32%</td></tr>
<tr><td colspan="4">The details of total performance comprise the reference accuracy, the effect of the ambient temperature on the zero signal and the measuring span as well as the effect of the static pressure on the measuring span.</td></tr>
<tr><td colspan="4">$E_{perf}=\sqrt{([E_{\Delta TZ}+E_{\Delta TS}]^2+E_{\Delta PS}^2+E_{lin}^2)}$
$E_{\Delta TZ}$= Effect of ambient temperature on the zero signal
$E_{\Delta TS}$= Effect of ambient temperature on the measuring span
$E_{\Delta PS}$= Effect of the static pressure on the measuring span
E_{lin} = Reference accuracy</td></tr>
<tr><td>Dynamic output behaviour</td><td colspan="4">These parameters depend on the filling medium, temperature and, if applicable, the chemical seal.
For more information refer to Dynamic output behaviour on page 71</td></tr>
<tr><td>Damping</td><td colspan="4">63% of the input variable 0…999 seconds, adjustable in 0.1 second steps.</td></tr>
<tr><td colspan="5">Temperature</td></tr>
<tr><td colspan="5">The evaluation is made using the HART® output signal</td></tr>
<tr><td>Resolution</td><td colspan="4">1°C / 1.8°F</td></tr>
<tr><td>Accuracy</td><td colspan="4">± 1°K</td></tr>
<tr><td colspan="5">System pressure</td></tr>
<tr><td>Reference conditions acc. to IEC 60770-1</td><td colspan="4">• Ambient temperature (constant): +18...+30°C / +64...+86°F
• Relative humidity (constant): 45...75%
• Ambient pressure (constant): 860...1060 mbar / 12.5...15.4 psi
• Mounting position: vertical</td></tr>
<tr><td rowspan="7">Reference accuracy acc. to DIN EN 61298</td><td colspan="4">Includes the non-linearity, hysteresis and repeatability under reference conditions. Applies to the digital interfaces (HART®, Profibus PA, Foundation Fieldbus) as well as for the analogue 4…20 mA current output. [% of URL]</td></tr>
<tr><td colspan="2"></td><td>up to nominal pressure acc. to URL absolute pressure</td><td>TD 1:1</td></tr>
<tr><td colspan="2">30 mbar / 0.44 psi</td><td>40 bar / 580 psi</td><td rowspan="5"><± 0.10%</td></tr>
<tr><td colspan="2">100 mbar / 1.5 psi</td><td rowspan="4">160 bar / 2320 psi</td></tr>
<tr><td colspan="2">500 mbar / 7.3 psi</td></tr>
<tr><td colspan="2">3 bar / 43.51 psi</td></tr>
<tr><td colspan="2">16 bar / 232.1 psi</td></tr>
</table>

Effect of ambient temperature	Ambient temperature effect on zero and span. [% of URL]			
		up to nominal pressure acc. to URL absolute pressure	-10...+60°C / +14...140°F	-40...+80°C / -40...+176°F
	30 mbar / 0.44 psi	40 bar / 580 psi	<± 0.10%	<± 0.15%
	100 mbar / 1.5 psi	160 bar / 2320 psi		
	500 mbar / 7.3 psi			
	3 bar / 43.51 psi			
	16 bar / 232.1 psi			
Long-term stability acc. to DIN EN 61298-1	<± 0.1% of URL over a period of 5 years			

Operating conditions

Temperature	
Operating temperature / nominal temperature range	-40...+80°C / -40...+176°F
Ambient temperature	-40...+80°C / -40...+176°F
Storage temperature	-40...+80°C / -40...+176°F
Climate category	4K 4H (air temperature: -20...+55°C, humidity: 4...100% according to DIN EN 60721-3-4)

Further operating conditions

Ingress protection acc. to IEC 529 / EN 60529			
Plastic (PBT)	Single chamber	IP66 / IP67	NEMA 4X / 6P
	Double chamber	IP66 / IP67	NEMA 4X
Aluminium	Single chamber	IP66 / IP68 (0.2 bar / 2.9 psi)	NEMA 4X / 6P
		IP 68 (1 bar / 14.5 psi)	-
	Double chamber	IP66 / IP67	NEMA 4X
		IP66 / IP68 (0.2 bar / 2.9 psi)	NEMA 4X
Stainless steel (electro-polished)	Single chamber	IP69K	-
	Single chamber	IP66 / IP68 (0.2 bar / 2.9 psi)	NEMA 4X / 6P
Stainless steel (precision casting)	Single chamber	IP66 / IP68 (0.2 bar / 2.9 psi)	NEMA 4X / 6P
		IP 68 (1 bar / 14.5 psi)	NEMA 4X
	Double chamber	IP66 / IP67	NEMA 4X
		IP66 / IP68 (0.2 bar / 2.9 psi)	NEMA 4X
Stainless steel	Sensor for external housing	IP 68 (25 bar / 362.6 psi)	-

Vibration	
Reference conditions	• Without mounting bracket • Process flanges 316 L / 1.4404 PN 160 • Single chamber housing, aluminium
Vibration resistance acc. to IEC 60770-1	10...58 Hz, 0.35 mm 58...1000 Hz, 20 m/s^2 1 octave per minute, 10 cycles per axis
Shock resistance acc. to IEC 60770-1	500 m/s^2, 6 ms 100 shocks per axis
Noise acc. to IEC 60770-1	10...200 Hz, 1 $(m/s^2)^2/Hz$ 200...500 Hz, 0.3 $(m/s^2)^2/Hz$ 4 hours per axis

Materials

Gaskets	
EPDM	-40...+85°C / -40...+185°F
FKM	-15...+85°C / -4...+185°F
PTFE	-40...+85°C / -40...+185°F
NBR	-25...+85°C / -4...+185°F
Filling oil	
Silicone oil	-40...+85°C / -40...+185°F
Wetted parts	
Process connection, screwed flange	316 L / 1.4404
Separating diaphragm	316 L / 1.4404
Drain and vent valves	316 L / 1.4404
Internal transmission fluid	Silicone oil
Non-wetted parts	
Electronics housing	Plastic PBT (Polyester), powder coated die-cast aluminium, 316 L / 1.4404
Housing cover sealing ring	Silicone (aluminium or plastic housing), NBR (stainless steel housing)
Inspection window in housing cover (display, adjustment module)	Polycarbonate (UL746-C listed)
Screws and bolts for the side flanges	PN 160: hexagon screw DIN 931 M8 x 90 A4 70, hexagon nut DIN 934 M8 A4 70
Grounding flange	316 Ti, 316 L / 1.4404

Process connection

Standard	1/4-18 NPT (female)

Electrical connections

Mechanical	
Cable gland	M20 x 1.5 mm
Cable diameter	5...9 mm / 0.20...0.35" 6...12 mm / 0.24...0.47" 10...14 mm / 0.39...0.55"
Cable entry 1/2 NPT	Blind plug: M20 x 1.5 mm, 1/2-14 NPT
	Closing cap: M20 x 1.5 mm, 1/2-14 NPT
	Connector option: M12 x 1, Harting HAN 7D,8D, 7/8 FF
Core cross-section	Solid wire with cords: 0.2 mm...2.5 mm^2 / AWG 24...14
	Cord with wire end sleeve: 0.2 mm...1.5 mm^2 / AWG 24...16
Electrical	
Supply voltage	Non-Ex device: 9.6...35 VDC
	Ex ia device: 9.6...30 VDC
	Ex d device: 9.6...35 VDC
	Ex ia d device: 15...35 VDC
Reverse polarity protection	Integrated
Permissible residual ripple	
Non-Ex devices	for U_n 12 VDC (9.6 < UB < 14 VDC) ≤0.7 V_{eff} (16...400 Hz)
Ex ia devices, Ex ia d devices	for U_n 24 VDC (18 < UB < 35 VDC) ≤1.0 V_{eff} (16...400 Hz)
Load	$R_{L,max}$=(UB-9.6) / 22 mA
Potential connection in device	Electronics: not electrically isolated
	Ground terminal: galvanically connected with process connection
Overvoltage category	III
Protection class	II

Inputs and outputs

Output signal	
Output signal	4...20 mA / HART® version 7.3 3.8...20.5 mA (factory setting acc. to. NAMUR recommendation)
Signal resolution	0.3 µA
Error signal of current output (adjustable)	High alarm ≥21 mA Low alarm ≤3.6 mA, last valid measurement
Max. output current	21.5 mA
Boot-up current	≤10 mA for 5 ms after switching on, then ≤3.6 mA
Damping	0...999 seconds, adjustable

Approvals and certificates

CE	The device fulfils the statutory requirements of the EC directives. The manufacturer certifies that these requirements have been met by applying the CE marking.
Electromagnetic compatibility (EMC)	EMC conformity for EN 61326-1 (05/2006)
NAMUR	NE 21 - Electromagnetic compatibility of equipment NE 43 - Signal level for the failure information of digital transmitters NE 53 - Compatibility of field devices and display/adjustment components NE 107 - Self-monitoring and diagnosis of field devices
Classification according to Pressure Equipment Directive (PED 97/23/EC)	PN160 (MWP 2320 psi) - For gases of fluid group 1 and liquids of fluid group 1, the requirements are fulfilled according to article 3, paragraph 3 (sound engineering practice).

7.3 Pressure ranges

Nominal range	30 mbar	100 mbar	500 mbar	3 bar	16 bar
Limit URL (upper)	30 mbar	100 mbar	500 mbar	3 bar	16 bar
Limit LRL (lower)	-30 mbar	-100 mbar	-500 mbar	-3 bar	-16 bar
Smallest adjustable measuring span	1 mbar	1 mbar	5 mbar	30 mbar	160 mbar
Turn down	30:1	100:1	100:1	100:1	100:1
MWP (maximum system pressure) ①	40 bar	160 bar	160 bar	160 bar	160 bar
Minimum system pressure	5 mbar abs (under reference conditions)				

① MWP corresponds to the PS designation in the PED (maximum system pressure)

Nominal range	0.44 psi	1.50 psi	7.30 psi	43.51 psi	232.1 psi
Limit URL (upper)	0.44 psi	1.50 psi	7.30 psi	43.51 psi	232.1 psi
Limit LRL (lower)	-0.44 psi	-1.45 psi	-7.25 psi	-43.51 psi	-232.1 psi
Smallest adjustable measuring span	0.015 psi	0.015 psi	0.073 psi	0.44 psi	2.32 psi
Turn down	30:1	100:1	100:1	100:1	100:1
MWP (maximum system pressure) ①	580 psi	2321 psi	2321 psi	2321 psi	2321 psi
Minimum system pressure	0.073 psi abs (under reference conditions)				

① MWP corresponds to the PS designation in the PED (maximum system pressure)

7.4 Ambient temperature effect on current output

< 0.05% / 10 K, max. < 0.15%, each case at -40...+80°C / -40...+176°F

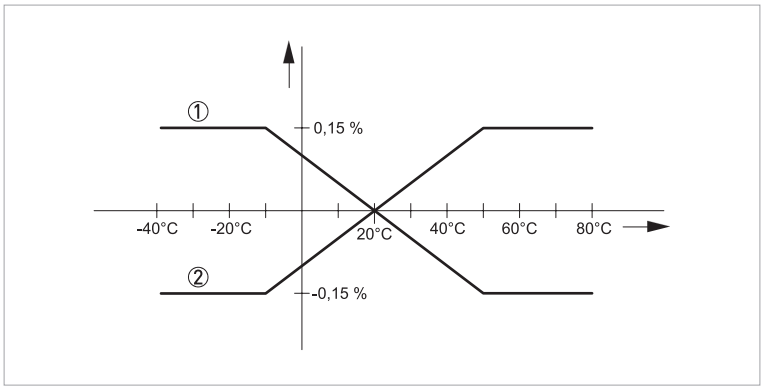


Figure 7-1: Ambient temperature effect on current output

① Falling characteristics
② Rising characteristics

7.5 Dynamic output behaviour

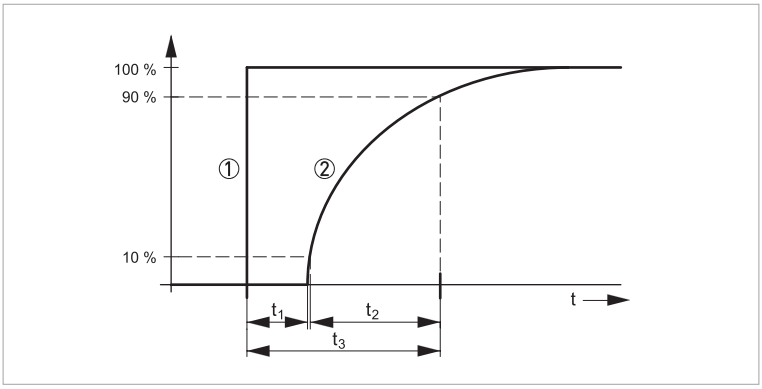


Figure 7-2: Behaviour for an sudden change of the process variable.
t_1 - dead time; t_2 - rise time; t_3 - step response time

① Process variable
② Output signal

These parameters depend on the filling medium, temperature and, if applicable, the chemical seal.

	Dead time (t1) [ms]	T90% (t2) [ms]	Step response time (t3) [ms] ①
30 mbar / 0.44 psi	90	115	205
100 mbar / 1.50 psi	60	95	155
500 mbar / 7.3 psi		75	135
3 bar / 43.51 psi		60	120
16 bar / 232.1 psi			

① Step response time is the sum of dead time and T90%

7.6 Dimensions and weights

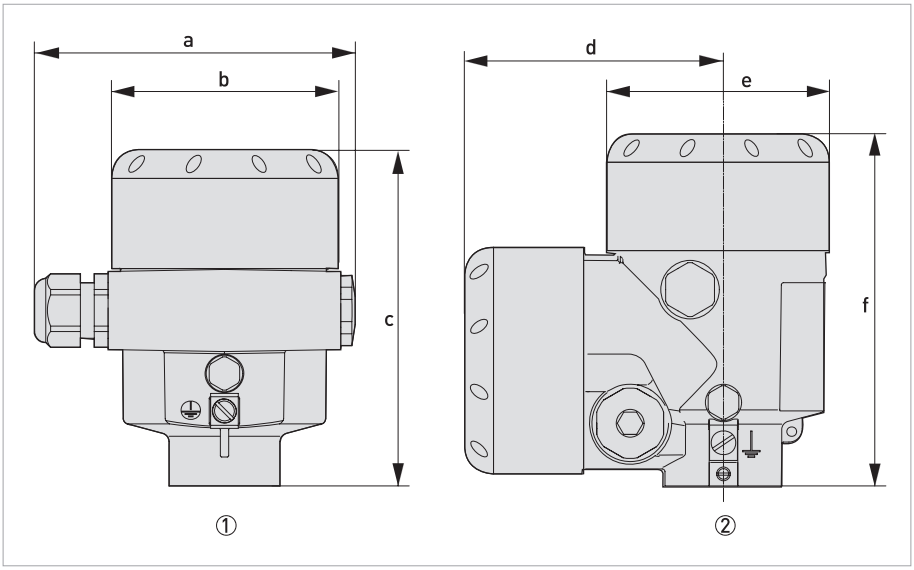


Figure 7-3: Aluminium housing

① Single chamber
② Double chamber

	Dimension [mm]	Dimension [inch]
a	116	4.57
b	86	3.39
c	116	4.57
d	87	3.43
e	86	3.39
f	120	4.72

Housing version	Weight [kg]	Weight [lb]
Single chamber, aluminium	0.83	1.84
Double chamber, aluminium	1.24	2.73

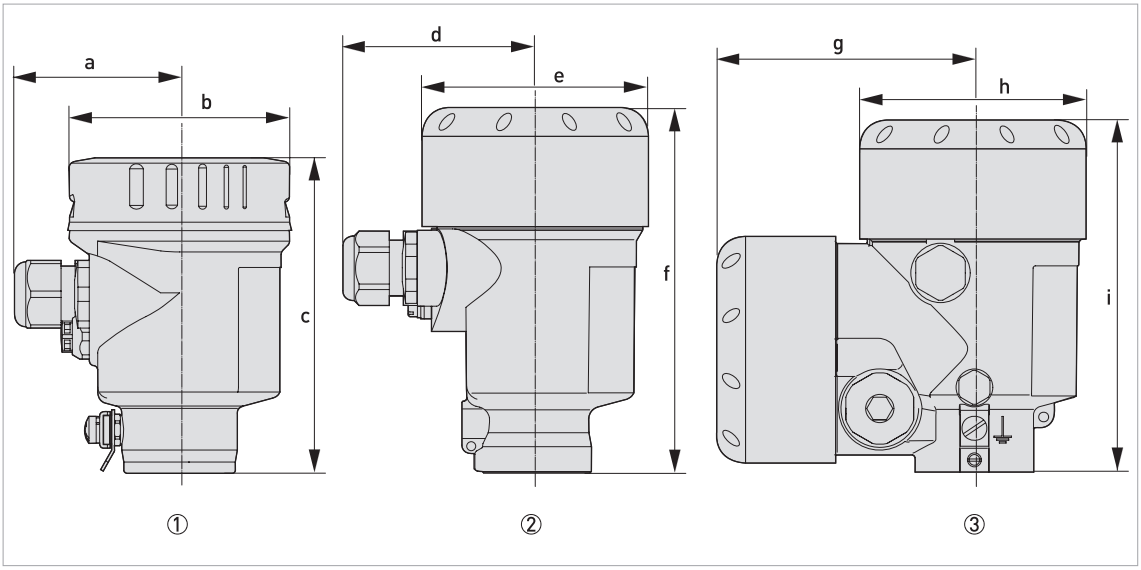


Figure 7-4: Stainless steel housing

① Single chamber, stainless steel (electro-polished)
② Single chamber, precision casting
③ Double chamber, precision casting

	Dimension [mm]	Dimension [inch]
a	59	2.32
b	80	3.15
c	112	4.41
d	69	2.72
e	79	3.11
f	117	4.61
g	87	3.42
h	79	3.11
i	120	4.72

Housing version	Weight [kg]	Weight [lb]
Single chamber, stainless steel (electro-polished)	0.73	1.61
Single chamber, precision casting	1.31	2.89
Double chamber, precision casting	2.86	6.31

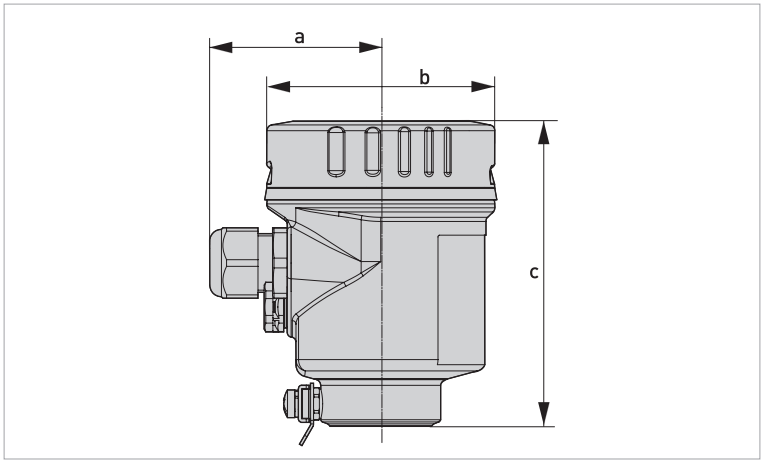


Figure 7-5: IP 69 K, stainless steel (electro-polished)

	Dimension [mm]	Dimension [inch]
a	59	2.32
b	80	3.15
c	104	4.10

Housing version	Weight [kg]	Weight [lb]
Single chamber, stainless steel (electro-polished)	0.73	1.61

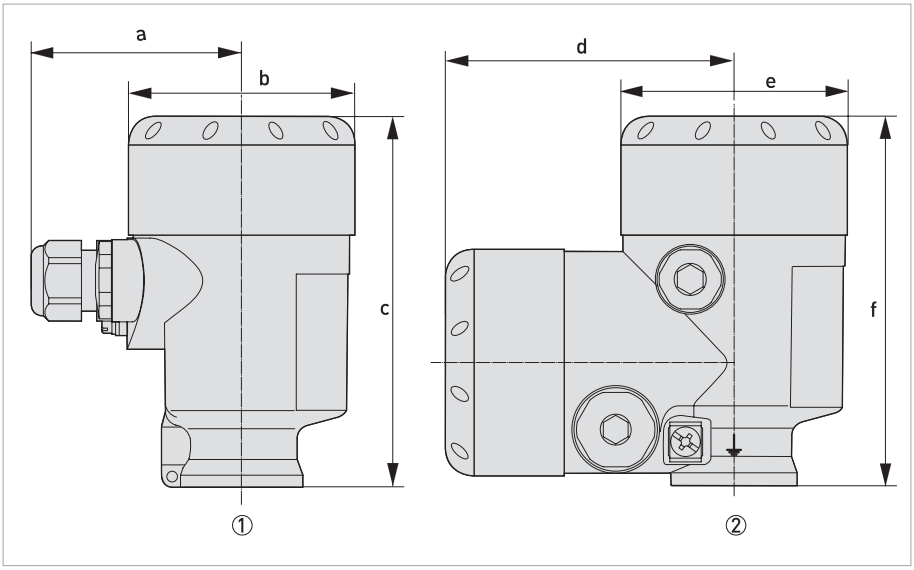


Figure 7-6: Plastic housing

① Single chamber
② Double chamber

	Dimension [mm]	Dimension [inch]
a	69	2.72
b	79	3.11
c	112	4.41
d	84	3.31
e	79	3.11
f	112	4.41

Housing version	Weight [kg]	Weight [lb]
Single chamber, plastic	0.40	0.88
Double chamber, plastic	0.51	1.13

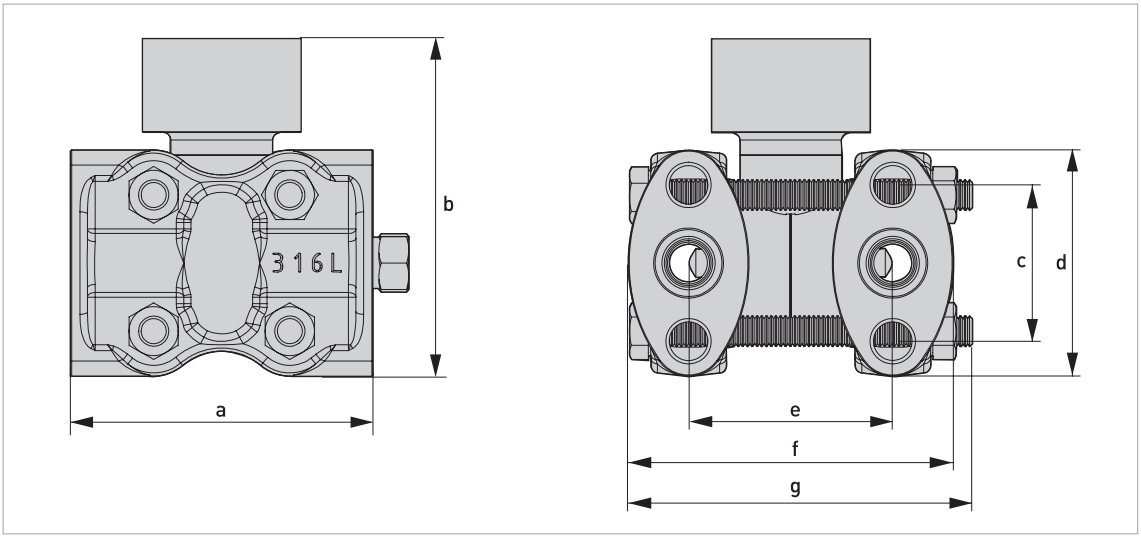


Figure 7-7: 1/4-18 NPT process connection

	Dimension [mm]	Dimension [inch]
a	80	3.15
b	88	3.46
c	41.3	1.63
d	60	2.36
e	54	2
f	86	3.39
g	91	3.58

	Weight [kg]	Weight [lb]
Process connection	2.0	4.41

INFORMATION!
Overall height of the differential pressure transmitter = b (process connection) + overall height of the respective housing

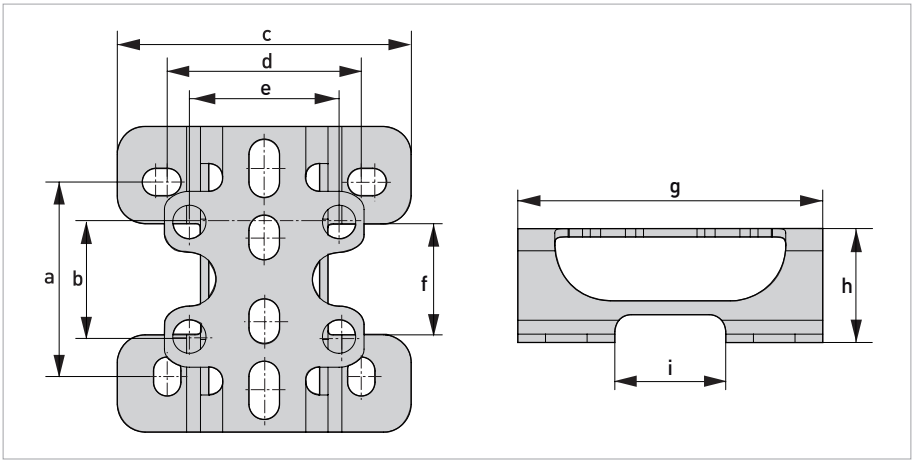


Figure 7-8: Mounting bracket

	Dimension [mm]	Dimension [inch]
a	70	2.76
b	41.3	1.63
c	106	4.17
d	70	2.76
e	54	2.13
f	40	1.57
g	110	4.33
h	41	1.61
i	40	1.57

	Weight [kg]	Weight [lb]
Mounting bracket	0.33	0.73

8.1 General description

The open HART® protocol, which can be used for free, is integrated into the signal converter for communication.

Devices which support the HART® protocol are classified as either operating devices or field devices. When it comes to operating devices (Master), both manual control units (Secondary Master) and PC-supported workstations (Primary Master) are used in, for example, a control centre.

HART® field devices include measuring sensors, signal converters and actuators. The field devices range from 2-wire to intrinsically safe versions for use in hazardous areas.

The HART® data are superimposed over the analogue 4...20 mA signal via FSK modem. This way, all of the connected devices can communicate digitally with one another via the HART® protocol while simultaneously transmitting the analogue signals.

When it comes to the field devices and secondary masters, the FSK or HART® modem is integrated. If a PC is used, an external modem must be connected to the serial interface (USB interface). There are, however, other connection variants which can be seen in the following connection figures.

8.2 Software history

INFORMATION!
In the table below, "x" is a placeholder for possible multi-digit alphanumeric combinations, depending on the available version.

Release date	SW version	HW version	HART®	
			Device Revision	DD Revision
2013-04-01	1.0.x	1.0.x	1	1

HART® identification codes and revision numbers

Manufacturer ID:	69 (0x45)
Device:	195 (0xC5)
Device Revision:	1
DD Revision:	1
HART® Universal Revision:	7
FC 475 system SW.Rev.:	≥ 3.7
PDM version:	≥ 8.0
FDT version:	≥ 1.2

8.3 Connection variants

The signal converter is a 2-wire device with a passive 4...20 mA current output and a HART® interface.

- **Point-to-Point is supported**
  In conventional point-to-point operation, the signal converter communicates as a slave with the master.
- **Multidrop mode is supported**
  In a multidrop communication system, more than 2 devices are connected to a common transmission cable.
- **Burst mode is not supported**
  In the burst operation a slave device transfers cyclic pre-defined response telegrams, to get a higher rate of data transfer.

There are two ways of using the HART® communication:

- as Point-to-Point connection and
- as multidrop connection, with 2-wire connection.

8.3.1 Point-to-Point connection - analogue / digital mode

Point-to-Point connection between the signal converter and the HART® Master.

The current output of the device is passive.

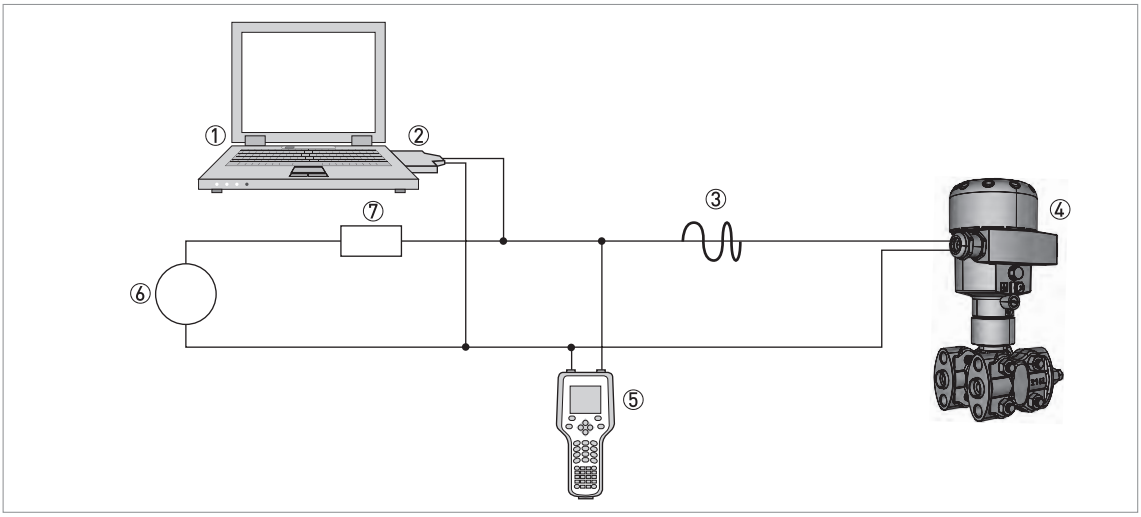


Figure 8-1: Point-to-Point connection

① Primary master with e.g. PACTware™ FDT/DTM
② FSK modem
③ HART® signal
④ OPTIBAR DP 7060 C
⑤ Secondary master with HART® DD
⑥ Power supply for devices (slaves) with passive current output
⑦ Load ≥ 250 Ω (Ohm)

8.4 Inputs/outputs and HART® dynamic variables and device variables

PV = Primary Variable; SV = Secondary Variable; TV = Third Variable; QV = Quarternary Variable

HART® dynamic variable			
PV	SV	TV	QV
Linear percent value	Physical unit	Meas. cell temp.	Electronic temperature

Table 8-1: HART® output values acc. to HART® 7 (factory setting)

8.5 Field Communicator 475 (FC 475)

The Field Communicator is a hand terminal from Emerson Process Management that is designed to configure HART® and Foundation Fieldbus devices. Device Descriptions (DDs) are used to integrate different devices into the Field Communicator.

8.5.1 Installation

The HART® Device Description for the signal converter must be installed on the Field Communicator. Otherwise only the functions of a generic DD are available to the user and the entire device control is not possible. A "Field Communicator Easy Upgrade Programming Utility" is required to install the DDs on the Field Communicator.

The Field Communicator must be equipped with a system card with "Easy Upgrade Option". For details consult the Field Communicator User's Manual.

8.5.2 Operation

Operating the signal converter via the Field Communicator is very similar to manual device control using the keyboard.

8.6 Field Device Tool / Device Type Manager (FDT / DTM)

A Field Device Tool Container (FDT Container) is basically a PC program used to configure a field device via HART®. To adapt to different devices, the FDT container uses a so-called Device Type Manager (DTM).

8.6.1 Installation

If the DTM for the signal converter has not yet been installed on the FDT Container, setup is required and is available for download from the website or on CD-ROM. See the supplied documentation for information on how to install and set up the DTM.



KROHNE product overview

- Electromagnetic flowmeters
- Variable area flowmeters
- Ultrasonic flowmeters
- Mass flowmeters
- Vortex flowmeters
- Flow controllers
- Level meters
- Temperature assemblies
- Pressure transmitters
- Analysis products
- Products and systems for the oil & gas industry
- Measuring systems for the marine industry

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47058 Duisburg (Germany)
Tel.:+49 203 301 0
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info@krohne.com

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www.krohne.com

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Appendix K

WORLD™ WIDE FITTINGS inc.

PRODUCT CATALOG

ENGINEERING | INNOVATION | SERVICE

World Wide Fittings Inc.™

Mission:

To consistently meet customer requirements in a efficient manner with continuous improvement to our quality system.

Quality is about more than product performance.
It's about people and processes performing, too.
At World Wide, we approach our work with intense attention to detail that starts with manufacturing and continues until the part is delivered to you, error-free.
It's the only way to ensure our customers' success.

You are only a click away from ordering quality fittings.
You can find us at www.worldwidefittings.com.
Our professional staff will help you with the orders.

World Wide Fittings Management

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SAFETY INFORMATION

WARNING

Selection of proper tubing, tube fittings, and proper installation is essential to the proper operation and safe use of products and related equipment.

IMPROPER SELECTION OR IMPROPER USE OF THE PRODUCTS DESCRIBED WITHIN THIS CATALOG CAN CAUSE DEATH, PERSONAL INJURY, AND PROPERTY DAMAGE.

World Wide Fittings has prepared this document and other information to provide product and / or system options for further analysis by users having technical expertise. Due to the variety of operating conditions and applications for these products, the user through its own analysis and testing, is solely responsible for making the final selection of the products and assuring that all performance, safety, and warning requirement of the application are met. Below are some of the factors which should be considered when specifying components and equipment for your application.

TYPE OF MEDIA
TUBE SIZE
INSIDE DIAMETER
PRESSURE
SAFETY FACTOR

TUBING MATERIAL
WALL THICKNESS
TEMPERATURE
NECESSARY FLOW RATE

The products described herein, including product specification, designs, pricing, and availability, are subject to change by World Wide Fittings Corporation at time without notice.

TUBE FITTING THREAD CHART

Dash No.	Tube Size	Flareless 7000 - 8000		37° Flare 5000	Pipe 3000	Face-seal 4000	Swivel Adapters 9000	Straight Thread “O” Ring Boss	7/8 Taper Pressure Plugs 100 P	Metric	BSPP
1	1/16”	-	-	-	1/16-27	-	-	-	1/16-27	M8 X 1.0	1/16-28
2	1/8”	5/16-24	5/16-24	5/16-24	1/8-27	-	1/8-27	5/16-24	1/8-27	M10 X 1.0	1/8-28
3	3/16”	3/8-24	3/8-24	3/8-24	-	-	-	3/8-24	-	M12 X 1.5	
4	1/4”	7/16-20	1/2-20	7/16-20	1/4-18	9/16-18	1/4-18	7/16-20	1/4-18	M14 X 1.5	1/4-19
5	5/16”	1/2-20	9/16-18	1/2-20	-	-	-	1/2-20	-	M16 X 1.5	
6	3/8”	9/16-18	5/8-18	9/16-18	3/8-18	11/16-16	3/8-18	9/16-18	3/8-18	M18 X 1.5	3/8-19
8	1/2”	3/4-16	3/4-16	3/4-16	1/2-14	13/16-16	1/2-14	3/4-16	1/2-14	M20 X 1.5	1/2-14
10	5/8”	7/8-14	15/16-16	7/8-14	-	1-14	7/8-14	7/8-14	-	M22 X 1.5	5/8-14
12	3/4”	1-1/16-12	1-1/16-16	1-1/16-12	3/4-14	1-3/16-12	3/4-14	1-1/16-12	3/4-14	M27 X 2.0	3/4-14
14	7/8”	1-3/16-12	1-3/16-16	1-3/16-12	-	-	-	1-3/16-12	-	M30 X 2.0	
16	1”	1-5/16-12	1-5/16-16	1-5/16-12	1-11-1/2	1-7/6-12	1-11-12	1-5/16-12	1-11-1/2	M33 X 2.0	1-16
20	1-1/4”	1-5/8-12	1-5/8-16	1-5/8-12	1-1/4-11-1/2	1-11/16-12	1-1/4-11-1/2	1-5/8-12	1-1/4-11-1/2	M42 X 2.0	1-1/4-11
24	1-1/2”	1-7/8-12	1-7/8-16	1-7/8-12	1-1/2-11-1/2	2-12	1-1/2-11-1/2	1-7/8-12	1-1/2-11-1/2	M48 X 2.0	1-1/2-11
32	2”	2-1/2-12	2-1/2-12	2-1/2-12	2-11-1/2	-	2-11-1/2	2-1/2-12	2-11-1/2	M60 X 2.0	2-11

PRODUCT SPECIFICATION / INTERCHANGEABILITY

World Wide Fittings products are manufactured from various manufacturing processes which include cold heading, impact extrusion, hot and cold forging, and the conventional methods of making tube fittings on screw machines. World Wide products meet the SAE - J514, ASME Standard, NFPA Standard, and Military Standard - MIL - F - 18866, Class 1 for hydraulic and pneumatic fittings. World Wide Fittings 4000 Series “O” Ring Face Seal Fittings meet or exceed the requirements of the SAE - J1453 Specification.

Most of World Wide Fittings products fall under the Federal Supply Class #4730. All World Wide Fittings products are interchangeable with our competition’s provided their fittings are made to the applicable SAE, ASME,NFPA, and Military Standards.

HOW TO ORDER

When specifying hydraulic fittings, the hose or tubing, as well as the thread sizes, are measured in sixteenths of an inch. When ordering tube fittings, customers must always specify the tube ends first followed by the opposite pipe, SAE straight thread, or female swivel end.

Customers who want to order fittings as “bodies only” that are normally sold as assemblies, must include the prefix letter “B” in front of the fitting number. Fittings which are sold as “bodies only” may be ordered as “assemblies” by including the prefix number “3” in front of the fitting number.

When ordering 3000 and 9000 Series fittings where tube ends are not present, refer to the proper fitting section and the individual listing of the fitting to be assured of ordering the correct part configuration.

(Contact World Wide Fittings when ordering fittings in configurations which are nonstandard or not listed in this catalog.)

EXAMPLE:

B	*7405*	*X 04 X 04*
Body Only	*Fitting*	*1/4” Tube O.D.*
Prefix	*Number*	*1/4” Male Pipe Thread*
3	*F5515*	*X 08 X 08*
Assembly	*Fitting*	*1/2” Tube O.D.*
Prefix	*Number*	*1/2” Male Straight Thread*

PORT AND THREAD ASSEMBLIES

Hydraulic tube and pipe fittings are most commonly used with three different types of port threads:
1) SAE Straight Thread “O” Ring 2) ISO Metric Thread “O” Ring 3) National Pipe Thread

SAE STRAIGHT THREAD “O” RING PORTS

SAE straight threads can be machined for either adjustable or nonadjustable hydraulic fittings. Carefully machined internal and external UN/UNF straight threads provide the holding power for hydraulic fittings when installed in high pressure hydraulic systems.

SAE straight threads sealing power comes from the use of a high quality 90-durometer Buna-N “O” Ring as specified by SAE-J514. During assembly, the straight threads provide adjustability on shape fittings where maneuverability and alignment are necessary for tube line routing.

After the hydraulic fittings with the SAE straight thread have been properly installed, the hydraulic “O” Ring provides a high pressure seal by becoming seated between the angular groove in the female port and the male end of the hydraulic fittings.

ASSEMBLY INSTRUCTIONS

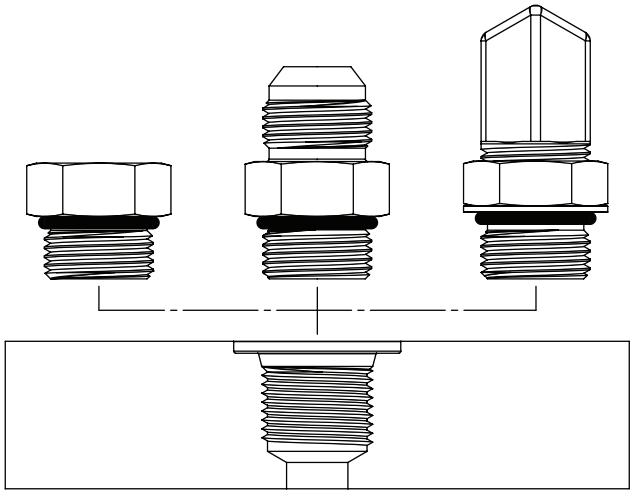
1. Inspect the hydraulic fitting and mating port to ensure that there is no foreign matter present or nicks in the “O” Ring to cause a leak.
2. Lubricate the “O” Ring with a light coating of oil or hydraulic fluid.
3. On the fittings adjustable thread, back the locknut off as far as possible and screw the fitting into the port until the flat back-up washer makes contact with the face of the port.
4. Align the adjustable fitting with the end of the tube assembly by unscrewing the fitting to the proper direction. (Do not unscrew the fitting more than one full turn.)
5. Using a wrench to hold the fitting in the desired position, tighten the locknut to the proper torque value as shown in the torque chart for adjustable SAE threads.
6. Visually inspect the fitting assembly to confirm that the “O” Ring has seated properly in the female ports angular seating groove and the back-up washer is seated flat against the face of the port.

Inspect threads before assembly to be assured that the male thread and female port are free of burrs and other foreign matter.

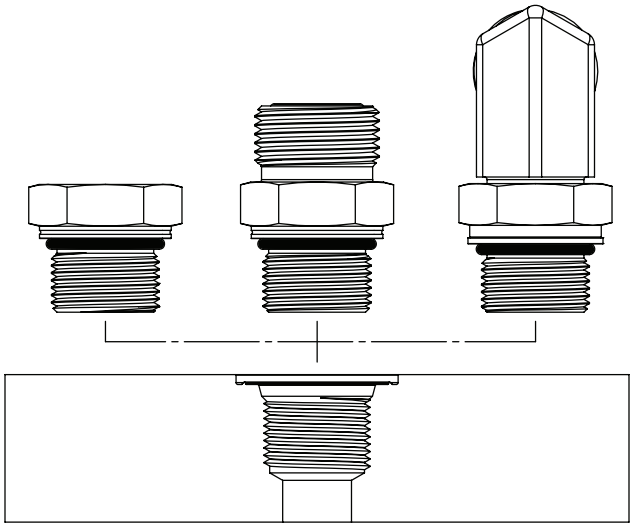
Lubricate the hydraulic “O” Ring before installing the fitting to prevent the “O” Ring from possible damage during installation.

Hydraulic fittings machined from forgings may have higher assembly torque values than are shown in the chart below.

(See drawing below for example of proper installation.)



Straight thread adjustable and non-adjustable assembly



Metric thread adjustable and non-adjustable assembly

PORT AND THREAD ASSEMBLIES

The charts below shows the approximate assembly torque values for hydraulic fittings and “O” Ring plugs with adjustable and non-adjustable SAE straight threads and ISO metric threads.

J1926-2
ORFS ADJUSTABLE & NON-ADJUSTABLE

STUD END QUALIFICATION TORQUE

DASH SIZE	*THREAD*	*TORQUE [N•m][1] +10% - 0%*
3	3/8-24	10[(2)]
4	7/16-20	20[(2)]
5	1/2-20	40
6	9/16-18	45
8	3/4-16	85
10	7/8-14	115
12	1-1/16-12	170
14	1-3/16-12	215
16	1-5/16-12	270
20	1-5/8-12	285
24	1-7/8-12	370
32	2-1/2-12	540

1. To convert from N•m to lb.ft, multiply by 0.737.
2. These values are for adjustable stud end. Nonadjustable values are 15 and 35 for sizes 3/8-24 and 7/16-20, respectively.

J1926-3
JIC, FLARELESS ADJUSTABLE & NON-ADJUSTABLE

STUD END QUALIFICATION TORQUE

DASH SIZE	*THREAD*	*TORQUE [N•m][1] +10% - 0%*
2	5/16-24	8
3	3/8-24	10
4	7/16-20	18
5	1/2-20	25
6	9/16-18	30
8	3/4-16	50
10	7/8-14	60
12	1-1/16-12	95
14	1-3/16-12	125
16	1-5/16-12	150
20	1-5/8-12	200
24	1-7/8-12	210
32	2-1/2-12	300

1. To convert from N•m to lb.ft, multiply by 0.737.

J1926-4

TEST TORQUE FOR INTERNAL HEX PORT PLUGS AND TEST TORQUES FOR HEAVY-DUTY (S-SERIES) EXTERNAL HEX PLUG SCREWS

DASH SIZE	*PORT OR PLUG THREAD SIZES*	*PLUG*	
		INTERNAL HEX	*EXTERNAL HEX*
		TORQUE [N•m] +10% - 0%	
2	5/16-24	7	12
3	3/8-24	14	20
4	7/16-20	20	35
5	1/2-20	27	40
6	9/16-18	45	45
8	3/4-16	85	85
10	7/8-14	110	110
12	1-1/16-12	170	170
14	1-3/16-12	235	235
16	1-5/16-12	310	270
20	1-5/8-12	340	340
24	1-7/8-12	420	420
32	2-1/2-12	510	510



Straight Thread Port Assembly

PORT AND THREAD ASSEMBLIES

ISO 6149-2
ORFS ADJUSTABLE & NON-ADJUSTABLE

TORQUES FOR STUD END QUALIFICATION TEST

THREAD	*TORQUE [N•m] +10% - 0%*
M8 X 1	10
M10 X 1	20
M12 X 1.5	35
M14 X 1.5	45
M16 X 1.5	55
M18 X 1.5	70
M20 X 1.5[a]	80
M22 X 1.5	100
M27 X 2.0	170
M30 X 2.0	215
M33 X 2.0	310
M42 X 2.0	330
M48 X 2.0	420
M60 X 2.0	500

a. For plugs for cartridge valve cavities only (see ISO 6149-4 and ISO 7789).

ISO 6149-3
JIC,FLARELESS ADJUSTABLE & NON-ADJUSTABLE

TORQUES FOR STUD END QUALIFICATION TEST

THREAD	*TORQUE [N•m] +10% - 0%*
M8 X 1	8
M10 X 1	15
M12 X 1.5	25
M14 X 1.5	35
M16 X 1.5	40
M18 X 1.5	45
M22 X 1.5	60
M27 X 2.0	100
M30 X 2.0	130
M33 X 2.0	160
M42 X 2.0	210
M48 X 2.0	260
M60 X 2.0	315

ISO 6149-4

TORQUES FOR PLUG QUALIFICATION TEST

THREAD	*PLUG*	
	INTERNAL HEX	*EXTERNAL HEX*
	TORQUE [N•m] +10% - 0%	
M8 X 1	8	10
M10 X 1	15	20
M12 X 1.5	22	35
M14 X 1.5	45	45
M16 X 1.5	55	55
M18 X 1.5	70	70
M20 X 1.5[a]	80	80
M22 X 1.5	100	100
M27 X 2.0	170	170
M30 X 2.0	215	215
M33 X 2.0	310	310
M42 X 2.0	330	330
M48 X 2.0	420	420
M60 X 2.0	500	500

a. For cartridge valve cavity applications only (see ISO 7789).



Metric Thread Port Assembly

PORT AND THREAD ASSEMBLIES

DRYSEAL PIPE THREADS

NPTF threads are formed to have a 3/4" taper with tightly machined tolerances to provide contact at the crest and root of the thread as well as the flank. The metal to metal seal of the thread crest, root, and flank, together provide a complete seal to help prevent the possibility of spiral leakage.

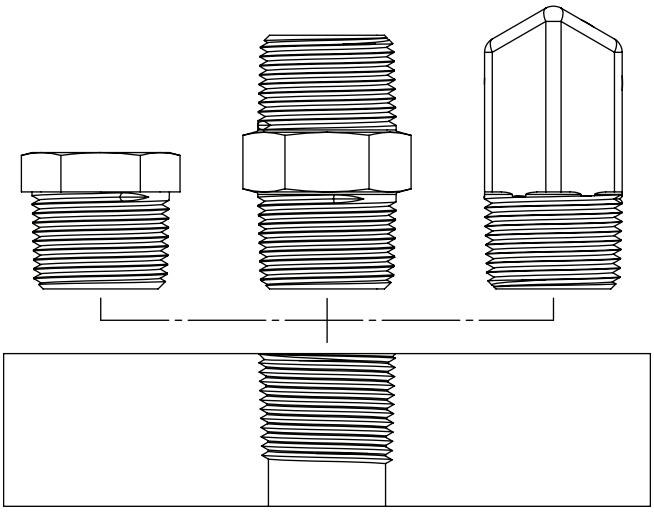
NPTF threads also provide the holding power for the connection while in high pressure service, which limits the reliability of the seal which the threads are making with the female port.

For high pressure applications where constant vibration is running through the hydraulic systems, hydraulic fittings with SAE straight threads which connect to female or male ports are recommended.

ASSEMBLY INSTRUCTIONS

1. Visually inspect the fitting and the mating port and remove any burrs or foreign matter which may be present.
2. Apply thread sealant if needed to the male threads. Do not apply thread sealant to the beginning 1/3rd of the male threads so as to keep the hydraulic system free from being contaminated by sealant which enters the system from the fitting connection.
3. Install the fitting to the finger-tight position. Using a wrench turn the fitting approximately 2 - 2 1/2 turns past the finger-tight position.

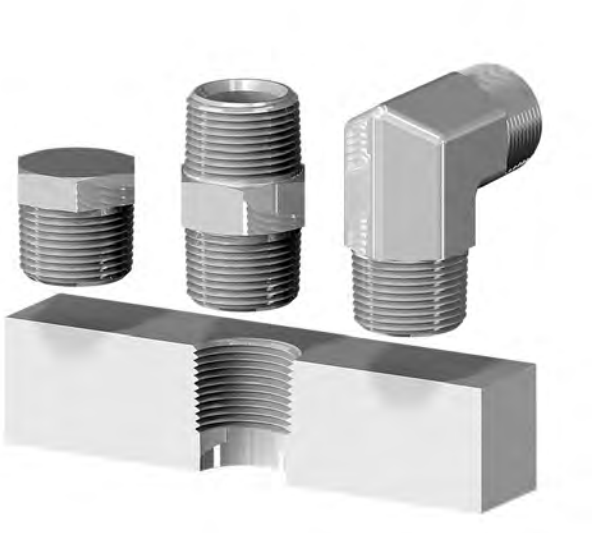
(See drawing below for example of proper installation.)



Pipe thread assembly

TAPERED PIPE THREAD SIZE	
NPTF	**T.F.F.T.**
1/8-27	2 - 3
1/4-18	2 - 3
3/8-18	2 - 3
1/2-14	2 - 3
3/4-14	2 - 3
1-11-1/2	1.5 - 2.5
1-1/4-11-1/2	1.5 - 2.5
1-1/2-11-1/2	1.5 - 2.5
2-11-1/2	1.5 - 2.5

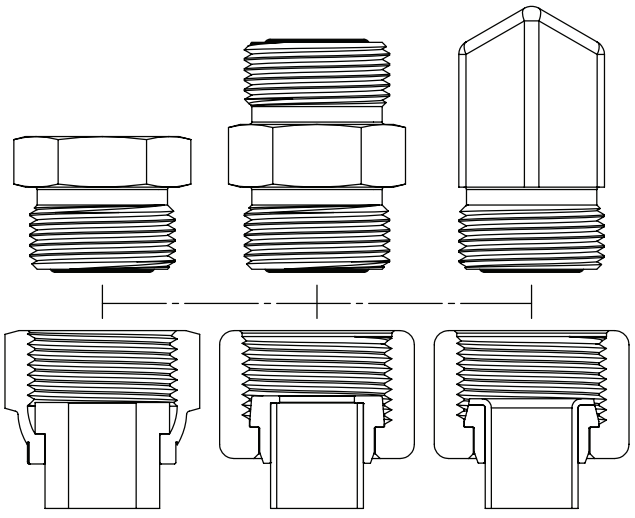
Assembly turns from finger tight (T.F.F.T.) values for steel, stainless steel and brass pipe fittings.



Pipe Thread Port Assembly

PORT AND THREAD ASSEMBLIES

J1453-2 & J1453-3				
FACE SEAL END QUALIFICATION TORQUE				
NOMINAL METRIC TUBE OD MM	*INCH TUBE OD OR HOSE ID DASH SIZE*	*NOMINAL INCH TUBE OD MM*	*"O" RING FACE SEAL END THREAD INCH*	*TORQUE [N•m]*
6	4	6.35	9/16-18	25
8	5	7.94	5/8-18	30
10	6	9.52	11/16-16	40
12	8	12.70	13/16-16	55
16	10	15.88	1-14	60
20	12	19.05	1-3/16-12	90
22	14	22.23	1-5/16-12	115
25	16	25.40	1-7/16-12	125
30	20	31.75	1-11/16-12	170
38	24	38.10	2-12	200



Face Seal thread assembly



Face Seal Thread Assembly

TUBING SELECTION

TUBING DESIGN PRESSURES

FOR STEEL AND STAINLESS STEEL TUBING BASED ON 4 - 1 SAFETY FACTOR

TUBE O.D.	WALL THICKNESS	TUBE I.D.	STEEL C1010	STAINLESS 304 & 316
0.125	0.028	0.069	6661	7994
0.125	0.035	0.055	8445	10134
0.188	0.028	0.132	4245	5094
0.188	0.035	0.118	5435	6521
0.188	0.049	0.090	7839	9407
0.250	0.028	0.194	3104	3725
0.250	0.035	0.180	3965	4758
0.250	0.049	0.152	5753	6903
0.250	0.065	0.120	7819	9382
0.250	0.083	0.084	9964	11957
0.313	0.028	0.257	2433	2919
0.313	0.035	0.243	3098	3718
0.313	0.049	0.215	4486	5383
0.313	0.065	0.183	6131	7357
0.313	0.083	0.147	7982	9579
0.313	0.095	0.123	9156	10987
0.375	0.028	0.319	2004	2405
0.375	0.035	0.305	2547	3056
0.375	0.049	0.277	3675	4410
0.375	0.065	0.245	5021	6025
0.375	0.083	0.209	6575	7890
0.375	0.095	0.185	7607	9128
0.375	0.109	0.157	8771	10526
0.500	0.035	0.430	1871	2245
0.500	0.049	0.402	2684	3221
0.500	0.065	0.370	3654	4385
0.500	0.083	0.334	4786	5744
0.500	0.095	0.310	5558	6670
0.500	0.109	0.282	6467	7760
0.500	0.120	0.260	7179	8615
0.500	0.134	0.232	8071	9685
0.500	0.148	0.204	8932	10719
0.500	0.188	0.124	11051	13262
0.625	0.035	0.555	1478	1773
0.625	0.049	0.527	2111	2534
0.625	0.065	0.495	2863	3436
0.625	0.083	0.459	3741	4489

TUBE O.D.	WALL THICKNESS	TUBE I.D.	STEEL C1010	STAINLESS 304 & 316
0.625	0.095	0.435	4342	5210
0.625	0.109	0.407	5055	6067
0.625	0.120	0.385	5623	6748
0.625	0.134	0.357	6350	7620
0.750	0.035	0.680	1221	1465
0.750	0.049	0.652	1739	2087
0.750	0.065	0.620	2351	2821
0.750	0.083	0.584	3064	3676
0.750	0.095	0.560	3551	4261
0.750	0.109	0.532	4132	4958
0.750	0.120	0.510	4595	5514
0.750	0.134	0.482	5193	6231
0.750	0.148	0.454	5796	6955
0.750	0.188	0.374	7521	9026
0.875	0.035	0.805	1040	1248
0.875	0.049	0.777	1478	1773
0.875	0.065	0.745	1993	2392
0.875	0.083	0.709	2591	3110
0.875	0.095	0.685	3000	3600
0.875	0.109	0.657	3487	4184
0.875	0.120	0.635	3876	4651
0.875	0.134	0.607	4378	5253
0.875	0.148	0.579	4887	5864
1.000	0.035	0.930	906	1087
1.000	0.049	0.902	1285	1542
1.000	0.065	0.870	1730	2076
1.000	0.083	0.834	2244	2693
1.000	0.095	0.810	2596	3115
1.000	0.109	0.782	3013	3616
1.000	0.120	0.760	3347	4016
1.000	0.134	0.732	3778	4533
1.000	0.148	0.704	4216	5059
1.000	0.156	0.688	4468	5362
1.000	0.188	0.624	5494	6592
1.000	0.220	0.560	6532	7838
1.250	0.049	1.152	1018	1222
1.250	0.065	1.120	1367	1641

TUBING DESIGN PRESSURES

FOR STEEL AND STAINLESS STEEL TUBING BASED ON 4 - 1 SAFETY FACTOR

TUBE O.D.	WALL THICKNESS	TUBE I.D.	STEEL C1010	STAINLESS 304 & 316
1.250	0.083	1.084	1769	2123
1.250	0.095	1.060	2042	2451
1.250	0.109	1.032	2367	2840
1.250	0.120	1.010	2625	3150
1.250	0.134	0.982	2959	3551
1.250	0.148	0.954	3298	3958
1.250	0.156	0.938	3494	4193
1.250	0.188	0.874	4291	5149
1.250	0.220	0.810	5107	6128
1.500	0.065	1.370	1130	1356
1.500	0.083	1.334	1459	1751
1.500	0.095	1.310	1683	2019
1.500	0.109	1.282	1947	2336
1.500	0.120	1.260	2158	2589
1.500	0.134	1.232	2429	2915
1.500	0.148	1.204	2704	3245
1.500	0.156	1.188	2863	3436
1.500	0.188	1.124	3510	4212
1.500	0.220	1.060	4174	5008
1.500	0.250	1.000	4808	5769
2.000	0.065	1.870	839	1007
2.000	0.083	1.834	1080	1296
2.000	0.095	1.810	1244	1492
2.000	0.109	1.782	1436	1724
2.000	0.120	1.760	1589	1907
2.000	0.134	1.732	1786	2143
2.000	0.148	1.704	1985	2382
2.000	0.156	1.688	2100	2520
2.000	0.188	1.624	2566	3079
2.000	0.220	1.560	3043	3652
2.000	0.250	1.500	3500	4200
2.000	0.281	1.438	3980	4776

When using thick walled tubing where flaring is impractical, the use of **Flareless Fittings** is recommended. Pressures listed above are given in PSI.

Selection of hydraulic tubing size is calculated by evaluating several different factors.

These factors include:
1. Type of fluid in the application
2. Maximum working pressure
3. Type of service (Normal, Severe, Hazardous)
4. Operating Temperature of application
5. Flow rate of application

Tubing design pressures can be calculated using one of three equations as shown in SAE - J1065. The values which are shown in the tubing design pressure chart were calculated using (LAME's) equation. Values as shown in the tubing design pressure chart are given using a safety factor of 4 to 1, which is rated for normal service.

LAME'S equation

$$P = S \left(\left(D2 - d2 \right) / \left(D2 + d2 \right) \right)$$

D = Outside tube diameter (Inches)
d = Inside tube diameter (Inches)
P = Recommended design pressure
S = Allowable stress of material (PSI)

** Values for allowable stress of materials
- C1010 Steel tubing: 12,500 PSI
- 304 and 316 Stainless tubing: 15,000 PSI

** Tubing design pressure values have not been derated for severity of service or elevated operating temperatures.

** Consult your tubing supplier for detailed information regarding pressure and temperature ratings for tubing.

TUBING SELECTION

1010 STEEL TUBING WALL THICKNESS

	6:1 SAFETY FACTOR					8:1 SAFETY FACTOR				
TUBE O.D.	WORKING PRESSURES (PSI)					WORKING PRESSURES (PSI)				
	1000	2000	3000	4000	5000	1000	2000	3000	4000	5000
1/8	.028	.028	.028	.028	.035	.028	.028	.028	.035	-
3/16	.030	.030	.030	-	-	.030	.030	-	-	-
1/4	.030	.030	.042	.058	-	.030	.035	.058	-	-
5/16	.032	.032	.058	.065	-	.032	.049	.065	-	-
3/8	.032	.042	.083	-	-	.032	.058	-	-	-
1/2	.032	.058	-	-	-	.042	.072	-	-	-
5/8	.035	.072	-	-	-	.049	.095	-	-	-
3/4	.049	.083	-	-	-	.058	.109	-	-	-
7/8	.049	.095	-	-	-	.065	-	-	-	-
1	.058	.109	-	-	-	.072	-	-	-	-
1-1/4	.072	-	-	-	-	.095	-	-	-	-
1-1/2	.083	-	-	-	-	.109	-	-	-	-
2	.109	-	-	-	-	-	-	-	-	-

304 & 316 STAINLESS STEEL TUBING WALL THICKNESS

	6:1 SAFETY FACTOR					8:1 SAFETY FACTOR				
TUBE O.D.	WORKING PRESSURES (PSI)					WORKING PRESSURES (PSI)				
	1000	2000	3000	4000	5000	1000	2000	3000	4000	5000
1/8	.028	.028	.028	.028	.035	.028	.028	.028	.028	.035
3/16	.030	.030	.030	.030	.035	.030	.030	.030	.035	-
1/4	.030	.030	.030	.042	.058	.030	.030	.035	.058	.065
5/16	.032	.032	.035	.058	.065	.032	.032	.049	.065	-
3/8	.032	.042	.065	.083	-	.032	.042	.058	-	-
1/2	.032	.042	.065	.083	-	.032	.058	.083	-	-
5/8	.035	.058	.083	.095	-	.035	.065	-	-	-
3/4	.035	.065	.095	-	-	.049	.083	-	-	-
7/8	.049	.072	.109	-	-	.049	.095	-	-	-
1	.049	.083	.120	-	-	.058	.109	-	-	-
1-1/4	.058	.109	-	-	-	.065	.134	-	-	-
1-1/2	.065	.120	-	-	-	.083	-	-	-	-
2	.083	-	-	-	-	.109	-	-	-	-

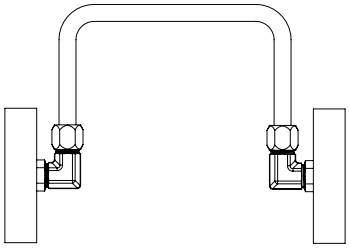
TUBE LINE FABRICATION

TUBE LINE FABRICATION

Equipment which makes use of hydraulic or pneumatic fluid lines must be properly designed for efficiency, ease of assembly, and leak free operation. Consider the following points when designing a fluid system.

1. Proper routing of lines to avoid pressure drops and excessive strain on joints.
2. Make joints accessible for easy installation and future maintenance.
3. Have tube supports installed to further eliminate strain on tube lines and excess noise from the system.

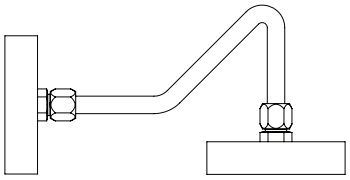
** Refer to drawings of fluid line fabrications for examples of proper and improper routing.



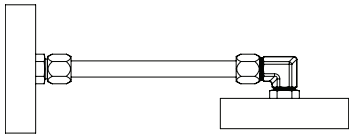
Correct routing



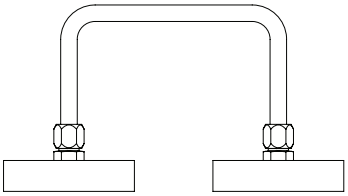
Incorrect routing



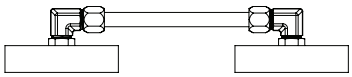
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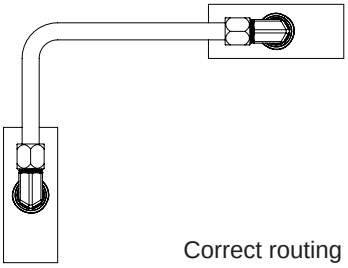
Incorrect routing



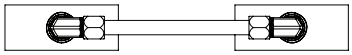
Correct routing



Incorrect routing



Correct routing



Incorrect routing

NOTES

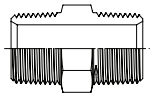
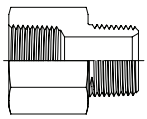
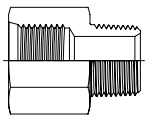
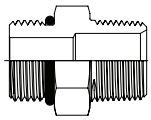
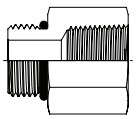
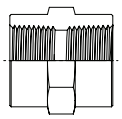
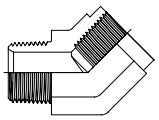
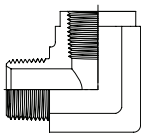
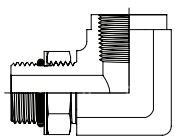
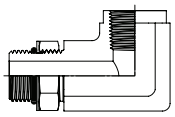
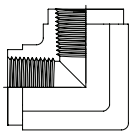
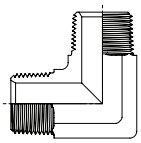
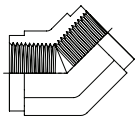
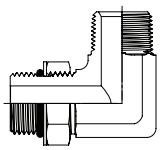
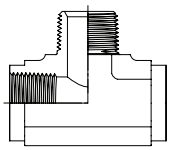
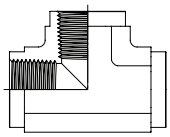
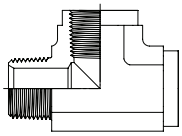
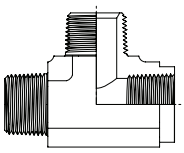
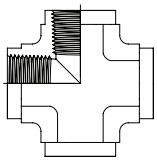
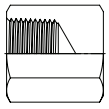
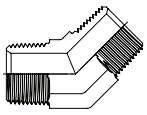
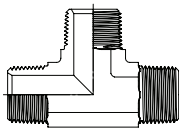
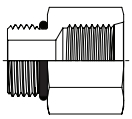
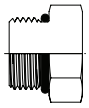
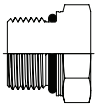


Steel Pipe Fittings

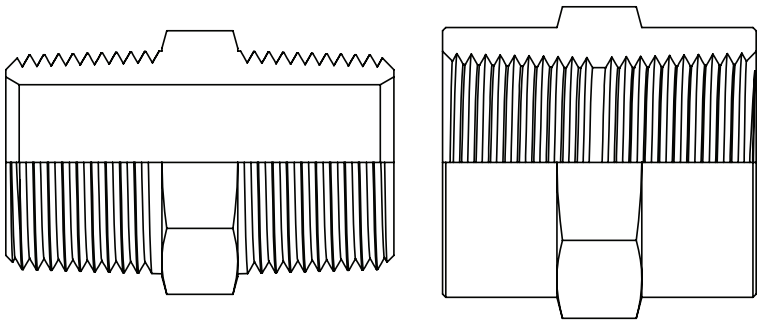
3000 SERIES

3000 SERIES - STEEL PIPE FITTINGS

A

0404 Page 20	Page 20	**5404** Page 21	**5406** Page 22	**5406-P** Page 23	**5406-HP** Page 23	**5406-SHP** Page 24
						
0404 Male Pipe Braze Connector	100P 7/8" Taper Pressure Plug	3069 Hexagon Pipe Nipple	3109 Reducer Bushing	3159 Hexagon Outside Head Pipe Plug	3169 Hex Socket Plug	3179 Square Inside Head Pipe Plug
5405 Page 24	**6404** Page 25	**6401** Page 26	**6405** Page 27	**5000** Page 28	**5503** Page 29	**5502** Page 30
						
3209 Adapter	3239 Female Straight to Male Pipe Adapter	3249 Male SAE to Male Pipe Adapter	3269 Straight Thread "O" Ring Adapter	3309 Hexagon Pipe Coupling	F3359 45º Street Elbow	F3409 90º Street Elbow
6805 Page 31	**6805-L** Page 31	**5504** Page 32	**5500** Page 32	**5505** Page 33	**6806** Page 34	**5604** Page 34
						
F3459 90º Straight Thread Elbow	F3469 90º Straight Thread Elbow Long	F3509 90º Female Pipe Elbow	F3529 90º Male Pipe Elbow	F3559 45º Female Pipe Elbow	F3569 90º Str. Thr. Male to Male Pipe Elbow	F3609 Male Branch Tee
5605 Page 35	**5602** Page 35	**5603** Page 36	**5652** Page 36	**5406-C** Page 37	**5501** Page 37	**5600** Page 38
						
F3709 Female Pipe Tee	F3759 Male Run Tee	F3809 Female Run Tee	F3959 Female Pipe Cross	5406C Pipe Cap	5501 45º Male Pipe Elbow	5600 Male Pipe Tee
6410 Page 38	**6408** Page 40	**8555-P** Page 40	**6408-H** Page 41	Page 41	**8555-H** Page 42	**9522-H** Page 42
						
6410 Male SAE to Female SAE Adapter	7237S External Hex Port Plug	7237M External Hex Port Plug - Metric	7238 Internal Hex Port Plug	7238M Internal Hex Port Plug - Metric	7240G DIN BSP Plug	7240M DIN Metric Plug
Page 165	Page 166					
						
7629 90 Durometer "O" Ring	7269M 90 Durometer Metric "O" Ring					

3000 SERIES - STEEL PIPE FITTINGS



3000 Series Assembly

CONSTRUCTION
Straight pipe fittings are machined from cold drawn bar stock. Shape fittings (elbows, tees, and crosses) are made from forgings. 3000 Series pipe fittings are machined with NPTF threads for greater holding power and resistance to leakage.

APPLICATIONS
For use in lubrication, instrumentation, and most high pressure hydraulic systems.

PRESSURE RATINGS
Working pressures up to 5000 PSI - Working Pressure will vary depending on Tube & Fitting Size.
(For applications using extreme pressures at 5000 PSI or above, contact World Wide Fittings.)

MATERIAL
Steel - 12L14, 1045
Stainless Steel - Type 316

PLATING
Clear Zinc Trivalent
Passivated

HOW TO ORDER
3000 Series pipe fittings are available in sizes 1/8" through 2" (Contact World Wide Fittings for availability of specific shapes and sizes.)

CONFORMANCE
3000 Series fittings meet SAE J514 specifications.

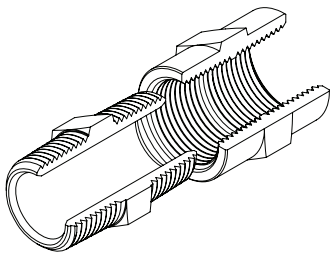
ASSEMBLY INSTRUCTIONS

Dryseal Threads:

1. Inspect the male and female threads for cleanliness.
2. Lightly lubricate the male and female threads.
3. Using a wrench turn the fitting approximately 2 - 2 1/2 turns past the finger-tight position. (Thread sealant may be applied for added protection against leakage.)

SAE "O" Ring Threads:

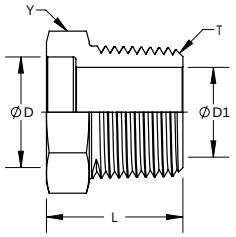
1. Inspect the male and female SAE straight threads for cleanliness.
2. Lubricate the hydraulic "O" Ring before installing the fitting to prevent the "O" Ring from possible damage during installation. Install the fitting to the finger-tight position.
3. Using a wrench tighten the fitting to the proper torque value.



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Description: **Male Pipe Braze Connector**
WWF Part No.: **0404**
WWF Stainless Part No.: **0404-SS**
SAE: ***/***

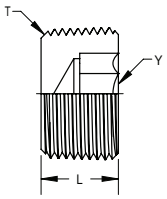
Air-Way: 0404
Parker: /
Aeroquip: 73056
Gates: /



WWF	Y HEX	T	D	D1	L
0404X04X02	0.500	1/8-27	0.256	0.188	0.563
0404X06X04	0.625	1/4-18	0.381	0.281	0.813
0404X08X06	0.813	3/8-18	0.506	0.406	0.844
0404X10X08	0.938	1/2-14	0.631	0.531	1.078
0404X12X12	1.125	3/4-14	0.757	0.719	1.094
0404X16X16	1.375	1-11-1/2	1.007	0.938	1.313
0404X20X20	1.688	1-1/4-11-1/2	1.258	1.250	1.406
0404X24X24	2.000	1-1/2-11-1/2	1.508	1.500	1.500
0404X32X32	2.625	2-11-1/2	2.008	1.938	1.781

Description: **Hex Socket Plug**
WWF Part No.: **100P**
WWF Stainless Part No.: ***/***
SAE: ***/***

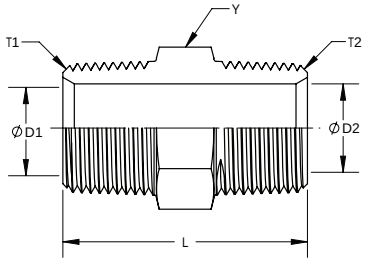
Air-Way: /
Parker: /
Aeroquip: /
Gates: /



WWF	Y HEX	T	L
100PX01	0.156	1/16-27	0.250
100PX02	0.188	1/8-27	0.250
100PX04	0.250	1/4-18	0.406
100PX06	0.313	3/8-18	0.406
100PX08	0.375	1/2-14	0.531
100PX12	0.563	3/4-14	0.531
100PX16	0.625	1-11-1/2	0.656
100PX20	0.750	1-1/4-11-1/2	0.656
100PX24	0.750	1-1/2-11-1/2	0.656
100PX32	1.000	2-11-1/2	0.656

Description: **Hexagon Pipe Nipple**
WWF Part No.: **3069**
WWF Part Stainless No.: **5404-SS**
SAE: **140137**

Air-Way: 5404
Parker: FF
Aeroquip: 2083
Gates: MP-MP

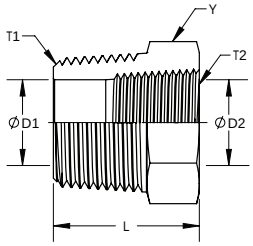


WWF	Y HEX	T1	D1	T2	D2	L
3069X02X02	0.438	1/8-27	0.188	1/8-27	0.188	1.060
3069X04X02	0.625	1/4-18	0.281	1/8-27	0.188	1.260
3069X04X04	0.625	1/4-18	0.281	1/4-18	0.281	1.450
3069X06X02	0.750	3/8-18	0.406	1/8-27	0.188	1.260
3069X06X04	0.750	3/8-18	0.406	1/4-18	0.281	1.450
3069X06X06	0.750	3/8-18	0.406	3/8-18	0.406	1.450
3069X08X02	0.875	1/2-14	0.531	1/8-27	0.188	1.510
3069X08X04	0.875	1/2-14	0.531	1/4-18	0.281	1.700
3069X08X06	0.875	1/2-14	0.531	3/8-18	0.406	1.700
3069X08X08	0.875	1/2-14	0.531	1/2-14	0.531	1.890
3069X12X06	1.125	3/4-14	0.719	3/8-18	0.406	1.770
3069X12X08	1.125	3/4-14	0.719	1/2-14	0.531	1.960
3069X12X12	1.125	3/4-14	0.719	3/4-14	0.719	1.960
3069X16X06	1.375	1-11-1/2	0.938	3/8-18	0.406	1.960
3069X16X08	1.375	1-11-1/2	0.938	1/2-14	0.531	2.150
3069X16X12	1.375	1-11-1/2	0.938	3/4-14	0.719	2.150
3069X16X16	1.375	1-11-1/2	0.938	1-11-1/2	0.938	2.340
3069X20X12	1.750	1-1/4-11-1/2	1.250	3/4-14	0.719	2.260
3069X20X16	1.750	1-1/4-11-1/2	1.250	1-11-1/2	0.938	2.450
3069X20X20	1.750	1-1/4-11-1/2	1.250	1-1/4-11-1/2	1.250	2.480
3069X24X12	2.000	1-1/2-11-1/2	1.500	3/4-14	0.719	2.360
3069X24X16	2.000	1-1/2-11-1/2	1.500	1-11-1/2	0.938	2.550
3069X24X20	2.000	1-1/2-11-1/2	1.500	1-1/4-11-1/2	1.250	2.580
3069X24X24	2.000	1-1/2-11-1/2	1.500	1-1/2-11-1/2	1.500	2.610
3069X32X20	2.500	2-11-1/2	1.938	1-1/4-11-1/2	1.250	2.760
3069X32X24	2.500	2-11-1/2	1.938	1-1/2-11-1/2	1.500	2.790
3069X32X32	2.500	2-11-1/2	1.938	2-11-1/2	1.938	2.820

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Description: **Reducer Bushing**
WWF Part No.: **3109**
WWF Stainless Part No.: **5406-SS**
SAE: **140140**

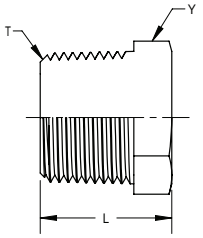
Air-Way: 5406
Parker: PTR
Aeroquip: 2081
Gates: MP-FPS



WWF	Y HEX	T1	D1	T2	D2	L
3109X04X02	0.625	1/4-18	0.281	1/8-27	0.332	0.850
3109X06X02	0.750	3/8-18	0.332	1/8-27	0.332	0.850
3109X06X04	0.750	3/8-18	0.406	1/4-18	0.438	0.850
3109X08X02	0.875	1/2-14	0.332	1/8-27	0.332	1.100
3109X08X04	0.875	1/2-14	0.438	1/4-18	0.438	1.100
3109X08X06	0.875	1/2-14	0.531	3/8-18	0.563	1.100
3109X12X02	1.125	3/4-14	0.332	1/8-27	0.332	1.170
3109X12X04	1.125	3/4-14	0.438	1/4-18	0.438	1.170
3109X12X06	1.125	3/4-14	0.563	3/8-18	0.563	1.170
3109X12X08	1.125	3/4-14	0.703	1/2-14	0.703	1.170
3109X16X04	1.375	1-11-1/2	0.438	1/4-18	0.438	1.360
3109X16X06	1.375	1-11-1/2	0.563	3/8-18	0.563	1.360
3109X16X08	1.375	1-11-1/2	0.703	1/2-14	0.703	1.360
3109X16X12	1.375	1-11-1/2	0.906	3/4-14	0.906	1.360
3109X20X04	1.750	1-1/4-11-1/2	0.438	1/4-18	0.438	1.470
3109X20X06	1.750	1-1/4-11-1/2	0.563	3/8-18	0.563	1.470
3109X20X08	1.750	1-1/4-11-1/2	0.703	1/2-14	0.703	1.470
3109X20X12	1.750	1-1/4-11-1/2	0.906	3/4-14	0.906	1.470
3109X20X16	1.750	1-1/4-11-1/2	1.141	1-11-1/2	1.141	1.470
3109X24X06	2.000	1-1/2-11-1/2	0.563	3/8-18	0.563	1.570
3109X24X08	2.000	1-1/2-11-1/2	0.703	1/2-14	0.703	1.570
3109X24X12	2.000	1-1/2-11-1/2	0.906	3/4-14	0.906	1.570
3109X24X16	2.000	1-1/2-11-1/2	1.141	1-11-1/2	1.141	1.570
3109X24X20	2.000	1-1/2-11-1/2	1.484	1-1/4-11-1/2	1.484	1.570
3109X32X20	2.500	2-11-1/2	1.484	1-1/4-11-1/2	1.484	1.750
3109X32X24	2.500	2-11-1/2	1.744	1-1/2-11-1/2	1.744	1.750

Description: **Hexagon Outside Head Pipe Plug**
WWF Part No.: **3159**
WWF Stainless Part No.: **5406-P-SS**
SAE: **130109E**

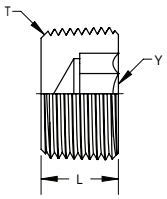
Air-Way: 5406-P
Parker: HP
Aeroquip: 2082
Gates: MP-PLUG



WWF	Y HEX	T	L
3159X02	0.438	1/8-27	0.568
3159X04	0.563	1/4-18	0.751
3159X06	0.688	3/8-18	0.782
3159X08	0.875	1/2-14	0.972
3159X12	1.063	3/4-14	1.064
3159X16	1.313	1-11-1/2	1.254
3159X20	1.750	1-1/4-11-1/2	1.469
3159X24	2.000	1-1/2-11-1/2	1.570
3159X32	2.500	2-11-1/2	1.750

Description: **Hex Socket Plug**
WWF Part No.: **3169**
WWF Stainless Part No.: **5406-HP-SS**
SAE: **130109**

Air-Way: 5406-HP
Parker: HHP
Aeroquip: 2222
Gates: /

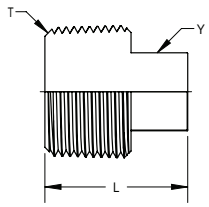


WWF	Y HEX	T	L
3169X01	0.156	1/16-27	0.300
3169X02	0.188	1/8-27	0.300
3169X04	0.250	1/4-18	0.460
3169X06	0.313	3/8-18	0.460
3169X08	0.375	1/2-14	0.610
3169X12	0.563	3/4-14	0.620
3169X16	0.625	1-11-1/2	0.770
3169X20	0.750	1-1/4-11-1/2	0.830
3169X24	1.000	1-1/2-11-1/2	0.830
3169X32	1.000	2-11-1/2	0.830

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Description: **Square Inside Head Pipe Plug**
WWF Part No.: **3179**
WWF Stainless Part No.: **5406-SHP-SS**
SAE: **130109A**

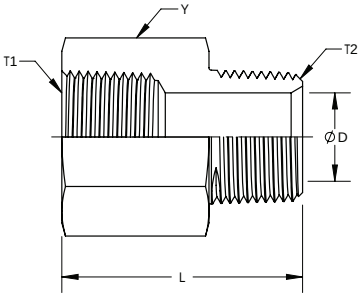
Air-Way: 5406-SHP
Parker: SHP-S
Aeroquip: /
Gates: /



WWF	Y HEX	T	L
3179X02	0.281	1/8-27	0.587
3179X04	0.375	1/4-18	0.800
3179X06	0.438	3/8-18	0.832
3179X08	0.563	1/2-14	1.075
3179X12	0.625	3/4-14	1.145
3179X16	0.813	1-11-1/2	1.370
3179X20	0.938	1-1/4-11-1/2	1.400

Description: **Adapter**
WWF Part No.: **3209** **Reversed**
WWF Stainless Part No.: **5405-SS** **Reversed**
SAE: **140139**

Air-Way: 5405
Parker: FG
Aeroquip: 2040
Gates: MP-FPL



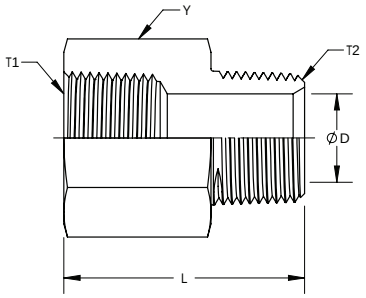
WWF	Y HEX	T1	D	T2	L
3209X02X02	0.625	1/8-27	0.188	1/8-27	1.040
3209X04X02	0.750	1/4-18	0.188	1/8-27	1.210
3209X04X04	0.750	1/4-18	0.281	1/4-18	1.390
3209X04X06	0.750	1/4-18	0.406	3/8-18	1.410
3209X06X04	0.875	3/8-18	0.281	1/4-18	1.440
3209X06X06	0.875	3/8-18	0.406	3/8-18	1.440
3209X06X08	1.125	3/8-18	0.531	1/2-14	1.870
3209X08X02	1.125	1/2-14	0.188	1/8-27	1.490
3209X08X04	1.125	1/2-14	0.281	1/4-18	1.680
3209X08X06	1.125	1/2-14	0.406	3/8-18	1.680
3209X08X08	1.125	1/2-14	0.531	1/2-14	1.870
3209X12X04	1.375	3/4-14	0.281	1/4-18	1.740
3209X12X06	1.375	3/4-14	0.406	3/8-18	1.740

Continued on page 25

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Description: **Adapter**
WWF Part No.: **3209** **Reversed**
WWF Stainless Part No.: **5405-SS** **Reversed**
SAE: **140139**

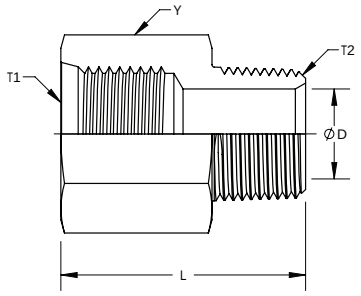
Air-Way: 5405
Parker: FG
Aeroquip: 2040
Gates: MP-FPL



WWF	Y HEX	T1	D	T2	L
3209X12X08	1.375	3/4-14	0.531	1/2-14	1.930
3209X12X12	1.375	3/4-14	0.719	3/4-14	1.930
3209X12X16	1.375	3/4-14	0.719	1-11-1/2	1.360
3209X16X12	1.625	1-11-1/2	0.719	3/4-14	2.180
3209X16X16	1.625	1-11-1/2	0.938	1-11-1/2	2.370
3209X16X20	1.750	1-11-1/2	0.938	1-1/4-11-1/2	2.490
3209X20X16	2.000	1-1/4-11-1/2	0.938	1-11-1/2	2.460
3209X24X20	2.375	1-1/2-11-1/2	1.250	1-1/4-11-1/2	2.500
3209X32X24	2.875	2-11-1/2	1.500	1-1/2-11-1/2	2.630

Description: **Female Straight to Male Pipe Adapter**
WWF Part No.: **3239**
WWF Stainless Part No.: **6404-SS**
SAE: ***I***

Air-Way: 6404
Parker: FHG5
Aeroquip: 2246-[R]
Gates: FB-MP

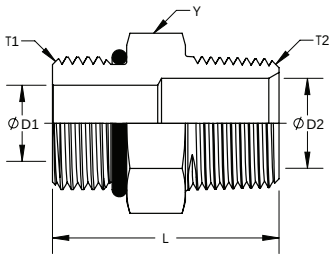


WWF	Y HEX	T1	D	T2	L
3239X04X02	0.688	7/16-20	0.188	1/8-27	1.130
3239X04X04	0.688	7/16-20	0.281	1/4-18	1.320
3239X05X02	0.750	1/2-20	0.188	1/8-27	1.370
3239X06X04	0.875	9/16-18	0.281	1/4-18	1.590
3239X06X06	0.875	9/16-18	0.406	3/8-18	1.400
3239X06X08	0.875	9/16-18	0.531	1/2-14	1.450
3239X08X06	1.000	3/4-16	0.406	3/8-18	1.500
3239X08X08	1.000	3/4-16	0.531	1/2-14	1.690
3239X10X08	1.125	7/8-14	0.531	1/2-14	1.820
3239X12X12	1.375	1-1/16-12	0.719	3/4-14	1.960
3239X16X16	1.625	1-5/16-12	0.938	1-11-1/2	2.220

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Description: **Male SAE to Male Pipe Adapter**
WWF Part No.: **3249**
WWF Stainless Part No.: **6401-SS**
SAE: **/**

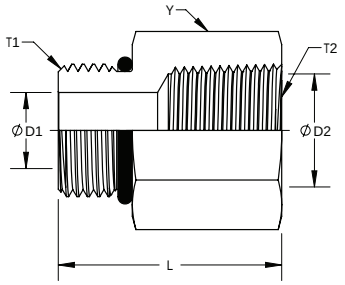
Air-Way: 6401
Parker: F5OF
Aeroquip: /
Gates: /



WWF	Y HEX	T1	D1	T2	D2	L
3249X04X02	0.563	7/16-20	0.172	1/8-27	0.188	1.040
3249X04X04	0.563	7/16-20	0.172	1/4-18	0.281	1.230
3249X05X04	0.625	1/2-20	0.234	1/4-18	0.281	1.230
3249X06X04	0.688	9/16-18	0.297	1/4-18	0.281	1.261
3249X06X06	0.750	9/16-18	0.297	3/8-18	0.406	1.261
3249X06X08	0.875	9/16-18	0.297	1/2-14	0.531	1.481
3249X08X06	0.875	3/4-16	0.391	3/8-18	0.406	1.338
3249X08X08	0.875	3/4-16	0.391	1/2-14	0.531	1.528
3249X08X12	1.125	3/4-16	0.391	3/4-14	0.719	1.760
3249X10X04	1.000	7/8-14	0.484	1/4-18	0.281	1.280
3249X10X06	1.000	7/8-14	0.484	3/8-18	0.406	1.460
3249X10X08	1.000	7/8-14	0.484	1/2-14	0.531	1.650
3249X10X12	1.125	7/8-14	0.484	3/4-14	0.719	1.650
3249X12X06	1.250	1-1/16-12	0.609	3/8-18	0.406	1.624
3249X12X08	1.250	1-1/16-12	0.609	1/2-14	0.531	1.814
3249X12X12	1.250	1-1/16-12	0.609	3/4-14	0.719	1.814
3249X16X12	1.500	1-5/16-12	0.844	3/4-14	0.719	1.844
3249X16X16	1.500	1-5/16-12	0.844	1-11-1/2	0.938	2.114
3249X20X20	1.875	1-5/8-12	1.078	1-1/4-11-1/2	1.250	2.144
3249X24X24	2.000	1-7/8-12	1.313	1-1/2-11-1/2	1.500	2.244
3249X32X32	2.750	2-1/2-12	1.781	2-11-1/2	1.938	2.434

Description: **Straight Thread "O" Ring Adapter**
WWF Part No.: **3269**
WWF Stainless Part No.: **6405-SS**
SAE: **/**

Air-Way: 6405
Parker: F5OG
Aeroquip: 2216-[R]
Gates: MB-FP



WWF	Y HEX	T1	D1	T2	D2	L
3269X04X02	0.563	7/16-20	0.172	1/8-27	0.332	1.000
3269X04X04	0.750	7/16-20	0.172	1/4-18	0.438	1.205
3269X04X06	0.875	7/16-20	0.172	3/8-18	0.563	1.351
3269X05X02	0.625	1/2-20	0.234	1/8-27	0.332	0.980
3269X05X04	0.750	1/2-20	0.234	1/4-18	0.438	1.205
3269X06X02	0.750	9/16-18	0.297	1/8-27	0.332	1.025
3269X06X04	0.750	9/16-18	0.297	1/4-18	0.438	1.235
3269X06X06	0.875	9/16-18	0.297	3/8-18	0.563	1.301
3269X06X08	1.125	9/16-18	0.297	1/2-14	0.703	1.642
3269X08X02	0.875	3/4-16	0.391	1/8-27	0.332	1.121
3269X08X04	0.875	3/4-16	0.391	1/4-18	0.438	1.331
3269X08X06	0.875	3/4-16	0.391	3/8-18	0.563	1.341
3269X08X08	1.125	3/4-16	0.391	1/2-14	0.703	1.710
3269X08X12	1.375	3/4-16	0.391	3/4-14	0.906	1.760
3269X10X04	1.000	7/8-14	0.484	1/4-18	0.438	1.402
3269X10X06	1.000	7/8-14	0.484	3/8-18	0.563	1.412
3269X10X08	1.125	7/8-14	0.484	1/2-14	0.703	1.632
3269X10X12	1.375	7/8-14	0.484	3/4-14	0.906	1.700
3269X12X04	1.250	1-1/16-12	0.609	1/4-18	0.438	1.550
3269X12X06	1.250	1-1/16-12	0.609	3/8-18	0.563	1.560
3269X12X08	1.250	1-1/16-12	0.609	1/2-14	0.703	1.780
3269X12X12	1.375	1-1/16-12	0.609	3/4-14	0.906	1.790
3269X12X16	1.625	1-1/16-12	0.609	1-11-1/2	1.141	2.033
3269X14X12	1.375	1-3/16-12	0.719	3/4-14	0.906	1.764
3269X16X06	1.500	1-5/16-12	0.844	3/8-18	0.563	1.573
3269X16X08	1.500	1-5/16-12	0.844	1/2-14	0.703	1.793
3269X16X12	1.500	1-5/16-12	0.844	3/4-14	0.906	1.803
3269X16X16	1.625	1-5/16-12	0.844	1-11-1/2	1.141	2.033
3269X16X20	2.000	1-5/16-12	0.844	1-1/4-11-1/2	1.484	2.286
3269X20X12	1.875	1-5/8-12	1.078	3/4-14	0.906	1.876
3269X20X16	1.875	1-5/8-12	1.078	1-11-1/2	1.141	2.106
3269X20X20	2.000	1-5/8-12	1.078	1-1/4-11-1/2	1.484	2.126
3269X20X24	2.375	1-5/8-12	1.078	1-1/2-11-1/2	1.744	2.291

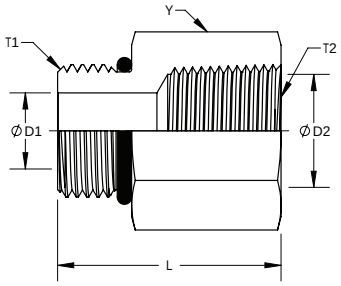
Continued on page 28

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A

Description: **Straight Thread "O" Ring Adapter**
WWF Part No.: **3269**
WWF Stainless Part No.: **6405-SS**
SAE: ***I***

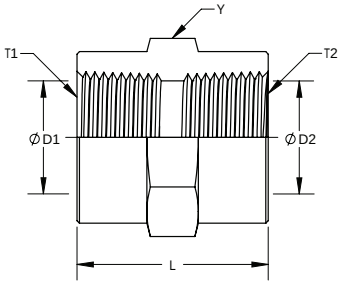
Air-Way: 6405
Parker: F5OG
Aeroquip: 2216-[R]
Gates: MB-FP



WWF	Y HEX	T1	D1	T2	D2	L
3269X24X12	2.125	1-7/8-12	1.313	3/4-14	0.906	1.881
3269X24X16	2.125	1-7/8-12	1.313	1-11-1/2	1.141	2.111
3269X24X20	2.125	1-7/8-12	1.313	1-1/4-11-1/2	1.484	2.131
3269X24X24	2.375	1-7/8-12	1.313	1-1/2-11-1/2	1.744	2.131
3269X32X32	2.875	2-1/2-12	1.781	2-11-1/2	2.213	2.231

Description: **Hexagon Pipe Coupling**
WWF Part No.: **3309**
WWF Stainless Part No.: **5000-SS**
SAE: **140138**

Air-Way: 5000
Parker: GG
Aeroquip: 2096
Gates: FP-FP



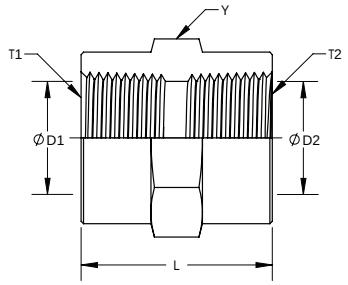
WWF	Y HEX	T1	D1	T2	D2	L
3309X02X02	0.625	1/8-27	0.332	1/8-27	0.332	0.750
3309X04X02	0.750	1/4-18	0.438	1/8-27	0.332	1.130
3309X04X04	0.750	1/4-18	0.438	1/4-18	0.438	1.130
3309X06X02	0.875	3/8-18	0.563	1/8-27	0.332	1.130
3309X06X04	0.875	3/8-18	0.563	1/4-18	0.438	1.130
3309X06X06	0.875	3/8-18	0.563	3/8-18	0.563	1.130
3309X08X04	1.125	1/2-14	0.703	1/4-18	0.438	1.500
3309X08X06	1.125	1/2-14	0.703	3/8-18	0.563	1.500
3309X08X08	1.125	1/2-14	0.703	1/2-14	0.703	1.500
3309X12X06	1.375	3/4-14	0.906	3/8-18	0.563	1.530
3309X12X08	1.375	3/4-14	0.906	1/2-14	0.703	1.530
3309X12X12	1.375	3/4-14	0.906	3/4-14	0.906	1.530
3309X16X08	1.625	1-11-1/2	1.141	1/2-14	0.703	1.890
3309X16X12	1.625	1-11-1/2	1.141	3/4-14	0.906	1.890
3309X16X16	1.625	1-11-1/2	1.141	1-11-1/2	1.141	1.890

Continued on page 29

Continued from page 28

Description: **Hexagon Pipe Coupling**
WWF Part No.: **3309**
WWF Stainless Part No.: **5000-SS**
SAE: **140138**

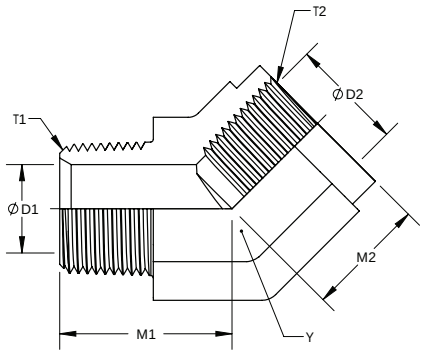
Air-Way: 5000
Parker: GG
Aeroquip: 2096
Gates: FP-FP



WWF	Y HEX	T1	D1	T2	D2	L
3309X20X16	2.000	1-1/4-11-1/2	1.484	1-11-1/2	1.141	1.930
3309X20X20	2.000	1-1/4-11-1/2	1.484	1-1/4-11-1/2	1.484	1.930
3309X24X20	2.375	1-1/2-11-1/2	1.744	1-1/4-11-1/2	1.484	1.930
3309X24X24	2.375	1-1/2-11-1/2	1.744	1-1/2-11-1/2	1.744	1.930
3309X32X24	2.875	2-11-1/2	2.213	1-1/2-11-1/2	1.744	1.960
3309X32X32	2.875	2-11-1/2	2.213	2-11-1/2	2.213	1.960

Description: **45° Street Elbow**
WWF Part No.: **F3359**
WWF Stainless Part No.: **5503-SS**
SAE: **140339**

Air-Way: 5503
Parker: CD45
Aeroquip: 2088
Gates: /

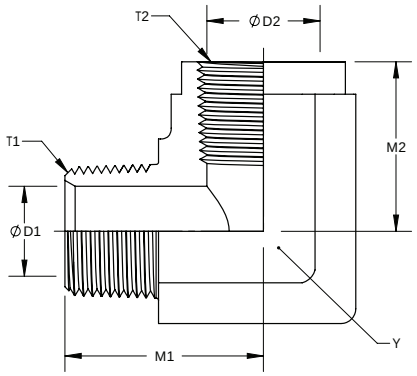


WWF	Y HEX	T1	M1	D1	T2	M2	D2
F3359X02X02	0.563	1/8-27	0.720	0.188	1/8-27	0.470	0.332
F3359X04X04	0.750	1/4-18	1.050	0.281	1/4-18	0.620	0.438
F3359X06X06	0.875	3/8-18	1.060	0.406	3/8-18	0.720	0.563
F3359X08X08	1.063	1/2-14	1.340	0.531	1/2-14	0.910	0.703
F3359X12X12	1.313	3/4-14	1.380	0.719	3/4-14	0.970	0.906
F3359X16X16	1.625	1-11-1/2	1.720	0.938	1-11-1/2	1.120	1.141
F3359X20X20	1.875	1-1/4-11-1/2	1.800	1.250	1-1/4-11-1/2	1.630	1.484
F3359X24X24	2.562	1-1/2-11-1/2	2.060	1.500	1-1/2-11-1/2	1.690	1.744
F3359X32X32	2.812	2-11-1/2	2.150	1.938	2-11-1/2	2.190	2.213

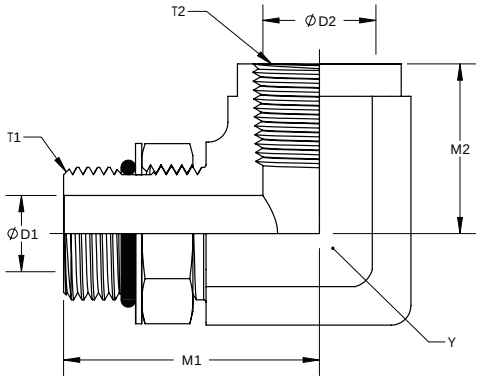
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Description: **90° Street Elbow**
WWF Part No.: **F3409**
WWF Stainless Part No.: **5502-SS**
SAE: **140239**

Air-Way: 5502
Parker: CD
Aeroquip: 2089
Gates: MP-FP90



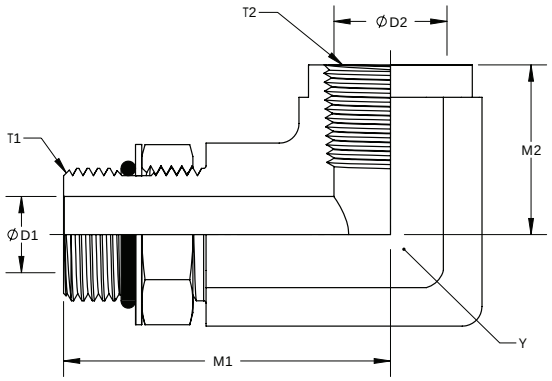
WWF	Y HEX	T1	M1	D1	T2	M2	D2
F3409X02X02	0.563	1/8-27	0.780	0.188	1/8-27	0.660	0.332
F3409X02X04	0.750	1/8-27	0.900	0.188	1/4-18	0.880	0.438
F3409X04X02	0.563	1/4-18	1.090	0.281	1/8-27	0.670	0.332
F3409X04X04	0.750	1/4-18	1.090	0.281	1/4-18	0.880	0.438
F3409X04X06	0.875	1/4-18	1.220	0.281	3/8-18	1.020	0.563
F3409X04X08	1.063	1/4-18	1.280	0.281	1/2-14	1.230	0.703
F3409X06X02	0.750	3/8-18	1.220	0.406	1/8-27	0.800	0.332
F3409X06X04	0.750	3/8-18	1.220	0.406	1/4-18	1.010	0.438
F3409X06X06	0.875	3/8-18	1.220	0.406	3/8-18	1.020	0.563
F3409X06X08	1.063	3/8-18	1.280	0.406	1/2-14	1.230	0.703
F3409X08X04	0.875	1/2-14	1.470	0.531	1/4-18	1.000	0.438
F3409X08X06	0.875	1/2-14	1.470	0.531	3/8-18	1.010	0.563
F3409X08X08	1.063	1/2-14	1.470	0.531	1/2-14	1.230	0.703
F3409X08X12	1.313	1/2-14	1.590	0.531	3/4-14	1.360	0.906
F3409X12X08	1.063	3/4-14	1.590	0.719	1/2-14	1.230	0.703
F3409X12X12	1.313	3/4-14	1.590	0.719	3/4-14	1.360	0.906
F3409X16X12	1.313	1-11-1/2	1.970	0.938	3/4-14	1.360	0.906
F3409X16X16	1.625	1-11-1/2	1.970	0.938	1-11-1/2	1.620	1.141
F3409X16X20	1.875	1-11-1/2	2.350	0.938	1-1/4-11-1/2	1.700	1.484
F3409X20X16	1.625	1-1/4-11-1/2	2.380	1.250	1-11-1/2	1.680	1.141
F3409X20X20	1.875	1-1/4-11-1/2	2.380	1.250	1-1/4-11-1/2	1.700	1.484
F3409X24X20	1.875	1-1/2-11-1/2	2.640	1.500	1-1/4-11-1/2	2.080	1.484
F3409X24X24	2.562	1-1/2-11-1/2	2.640	1.500	1-1/2-11-1/2	2.080	1.744
F3409X32X32	2.812	2-11-1/2	3.000	1.938	2-11-1/2	2.390	2.213



Description: **90° Straight Thread Elbow**
WWF Part No.: **F3459**
WWF Stainless Part No.: **6805-SS**
SAE: **/**

Air-Way: 6805
Parker: AOEG
Aeroquip: 206801-[R]
Gates: /

WWF	Y HEX	T1	M1	D1	T2	M2	D2
F3459X04X02	0.563	7/16-20	1.190	0.172	1/8-27	0.660	0.332
F3459X04X04	0.750	7/16-20	1.260	0.172	1/4-18	0.880	0.438
F3459X06X04	0.750	9/16-18	1.320	0.297	1/4-18	0.880	0.438
F3459X06X06	0.875	9/16-18	1.410	0.297	3/8-18	1.020	0.563
F3459X08X06	0.875	3/4-16	1.540	0.391	3/8-18	1.020	0.563
F3459X08X08	1.063	3/4-16	1.620	0.391	1/2-14	1.230	0.703
F3459X10X06	0.875	7/8-14	1.700	0.484	3/8-18	1.020	0.563
F3459X10X08	1.063	7/8-14	1.780	0.484	1/2-14	1.230	0.703
F3459X12X08	1.063	1-1/16-12	1.940	0.609	1/2-14	1.230	0.703
F3459X12X12	1.313	1-1/16-12	2.050	0.609	3/4-14	1.360	0.906
F3459X14X12	1.313	1-3/16-12	2.000	0.719	3/4-14	1.360	0.906
F3459X16X12	1.313	1-5/16-12	2.050	0.844	3/4-14	1.360	0.906
F3459X16X16	1.625	1-5/16-12	2.250	0.844	1-11-1/2	1.620	1.141
F3459X20X20	1.875	1-5/8-12	2.390	1.078	1-1/4-11-1/2	1.700	1.484
F3459X24X24	2.562	1-7/8-12	2.890	1.313	1-1/2-11-1/2	2.080	1.744



Description: **90° Straight Thread Elbow Long**
WWF Part No.: **F3469**
WWF Stainless Part No.: **6805-L-SS**
SAE: **/**

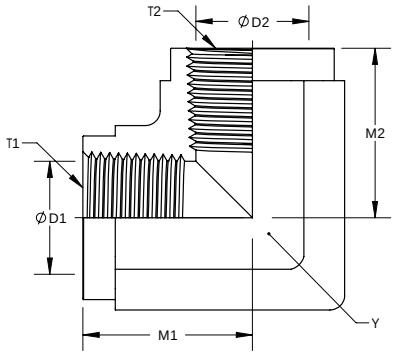
Air-Way: 6805-L
Parker: AOE4G
Aeroquip: 206804-[R]
Gates: /

WWF	Y HEX	T1	M1	D1	T2	M2	D2
F3469X08X08	1.063	3/4-16	2.100	0.391	1/2-14	1.230	0.703
F3469X10X08	1.063	7/8-14	2.260	0.484	1/2-14	1.230	0.703
F3469X12X12	1.313	1-1/16-12	2.620	0.609	3/4-14	1.360	0.906
F3469X16X16	1.625	1-5/16-12	3.060	0.844	1-11-1/2	1.620	1.141

A

Description: **90° Female Pipe Elbow**
WWF Part No.: **F3509**
WWF Stainless Part No.: **5504-SS**
SAE: **140238**

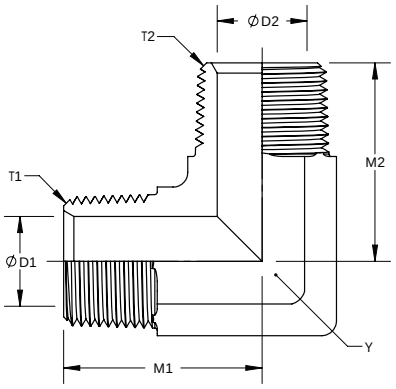
Air-Way: 5504
Parker: DD
Aeroquip: 2087
Gates: FP-FP90



WWF	Y HEX	T1	M1	D1	T2	M2	D2
F3509X02X02	0.563	1/8-27	0.660	0.332	1/8-27	0.660	0.332
F3509X04X02	0.750	1/4-18	0.880	0.438	1/8-27	0.670	0.332
F3509X04X04	0.750	1/4-18	0.880	0.438	1/4-18	0.880	0.438
F3509X06X04	0.875	3/8-18	1.020	0.563	1/4-18	1.010	0.438
F3509X06X06	0.875	3/8-18	1.020	0.563	3/8-18	1.020	0.563
F3509X08X04	1.063	1/2-14	1.230	0.703	1/4-18	1.000	0.438
F3509X08X06	1.063	1/2-14	1.230	0.703	3/8-18	1.010	0.563
F3509X08X08	1.063	1/2-14	1.230	0.703	1/2-14	1.230	0.703
F3509X12X08	1.313	3/4-14	1.360	0.906	1/2-14	1.350	0.703
F3509X12X12	1.313	3/4-14	1.360	0.906	3/4-14	1.360	0.906
F3509X16X12	1.625	1-11-1/2	1.620	1.141	3/4-14	1.390	0.906
F3509X16X16	1.625	1-11-1/2	1.620	1.141	1-11-1/2	1.620	1.141
F3509X20X20	1.875	1-1/4-11-1/2	1.700	1.484	1-1/4-11-1/2	1.700	1.484
F3509X24X24	2.562	1-1/2-11-1/2	2.080	1.744	1-1/2-11-1/2	2.080	1.744

Description: **90° Male Pipe Elbow**
WWF Part No.: **F3529**
WWF Stainless Part No.: **5500-SS**
SAE: **140237**

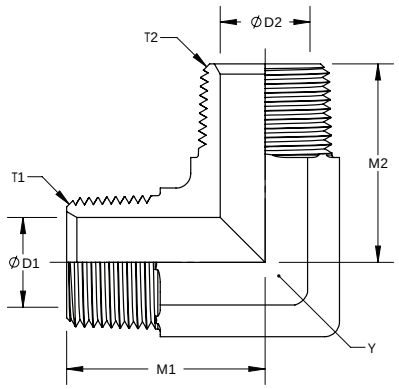
Air-Way: 5500
Parker: CR
Aeroquip: 2085
Gates: MP-MP90



WWF	Y HEX	T1	M1	D1	T2	M2	D2
F3529X02X02	0.438	1/8-27	0.780	0.188	1/8-27	0.780	0.188
F3529X04X02	0.563	1/4-18	1.090	0.281	1/8-27	0.900	0.188
F3529X04X04	0.563	1/4-18	1.090	0.281	1/4-18	1.090	0.281
F3529X06X04	0.750	3/8-18	1.220	0.406	1/4-18	1.220	0.281
F3529X06X06	0.750	3/8-18	1.220	0.406	3/8-18	1.220	0.406
F3529X08X04	0.875	1/2-14	1.470	0.531	1/4-18	1.280	0.281

Continued on page 33

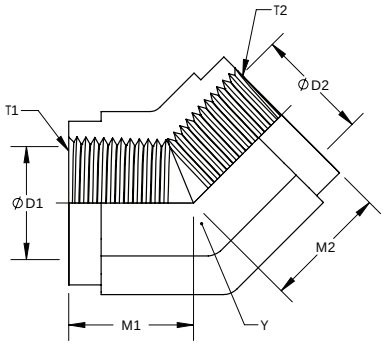
Continued from page 32



Description: **90° Male Pipe Elbow**
WWF Part No.: **F3529**
WWF Stainless Part No.: **5500-SS**
SAE: **140237**

Air-Way: 5500
Parker: CR
Aeroquip: 2085
Gates: MP-MP90

WWF	Y HEX	T1	M1	D1	T2	M2	D2
F3529X08X06	0.875	1/2-14	1.470	0.531	3/8-18	1.280	0.406
F3529X08X08	0.875	1/2-14	1.470	0.531	1/2-14	1.470	0.531
F3529X12X08	1.063	3/4-14	1.590	0.719	1/2-14	1.590	0.531
F3529X12X12	1.063	3/4-14	1.590	0.719	3/4-14	1.590	0.719
F3529X16X08	1.313	1-11-1/2	1.970	0.938	1/2-14	1.780	0.531
F3529X16X12	1.313	1-11-1/2	1.970	0.938	3/4-14	1.780	0.719
F3529X16X16	1.313	1-11-1/2	1.970	0.938	1-11-1/2	1.970	0.938
F3529X20X20	1.625	1-1/4-11-1/2	2.380	1.250	1-1/4-11-1/2	2.380	1.250
F3529X24X24	1.875	1-1/2-11-1/2	2.640	1.500	1-1/2-11-1/2	2.640	1.500



Description: **45° Female Pipe Elbow**
WWF Part No.: **F3559**
WWF Stainless Part No.: **5505-SS**
SAE: **140338**

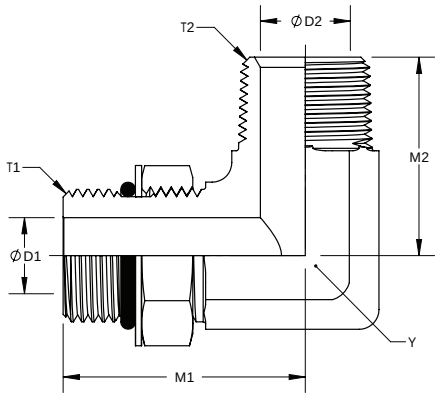
Air-Way: 5505
Parker: DD45
Aeroquip: /
Gates: /

WWF	Y HEX	T1	M1	D1	T2	M2	D2
F3559X02X02	0.563	1/8-27	0.500	0.332	1/8-27	0.500	0.332
F3559X04X04	0.750	1/4-18	0.690	0.438	1/4-18	0.690	0.438
F3559X06X06	0.875	3/8-18	0.750	0.563	3/8-18	0.750	0.563
F3559X08X08	1.063	1/2-14	0.940	0.703	1/2-14	0.940	0.703
F3559X12X12	1.313	3/4-14	1.000	0.906	3/4-14	1.000	0.906
F3559X16X16	1.625	1-11-1/2	1.190	1.141	1-11-1/2	1.190	1.141

A

Description: **90° Straight Thread Male to Male Pipe Elbow**
WWF Part No.: **F3569**
WWF Stainless Part No.: **6806-SS**
SAE: **/**

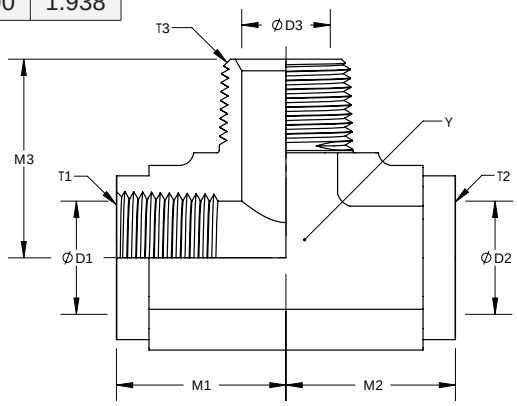
Air-Way: 6806
Parker: /
Aeroquip: /
Gates: /



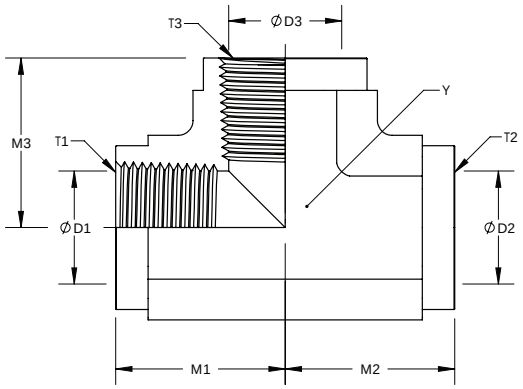
WWF	Y HEX	T1	M1	D1	T2	M2	D2
F3569X04X02	0.438	7/16-20	1.030	0.172	1/8-27	0.780	0.188
F3569X04X04	0.563	7/16-20	1.190	0.172	1/4-18	1.090	0.281
F3569X05X02	0.563	1/2-20	1.130	0.234	1/8-27	0.780	0.188
F3569X06X04	0.563	9/16-18	1.250	0.297	1/4-18	1.090	0.281
F3569X06X06	0.750	9/16-18	1.320	0.297	3/8-18	1.220	0.406
F3569X06X08	0.875	9/16-18	1.410	0.297	1/2-14	1.470	0.531
F3569X08X06	0.750	3/4-16	1.450	0.391	3/8-18	1.220	0.406
F3569X08X08	0.875	3/4-16	1.540	0.391	1/2-14	1.470	0.531
F3569X10X08	0.875	7/8-14	1.700	0.484	1/2-14	1.470	0.531
F3569X12X12	1.063	1-1/16-12	1.940	0.609	3/4-14	1.590	0.719
F3569X14X12	1.313	1-3/16-12	2.000	0.719	3/4-14	1.690	0.719
F3569X16X12	1.313	1-5/16-12	2.050	0.844	3/4-14	1.780	0.719
F3569X16X16	1.313	1-5/16-12	2.050	0.844	1-11-1/2	1.970	0.938
F3569X20X20	1.625	1-5/8-12	2.250	1.078	1-1/4-11-1/2	2.380	1.250
F3569X24X24	1.875	1-7/8-12	2.390	1.313	1-1/2-11-1/2	2.640	1.500
F3569X32X32	2.500	2-1/2-12	2.890	1.781	2-11-1/2	3.000	1.938

Description: **Male Branch Tee**
WWF Part No.: **F3609**
WWF Stainless Part No.: **5604-SS**
SAE: **140425**

Air-Way: 5604
Parker: MMS
Aeroquip: 2091
Gates: FP-FP-MP



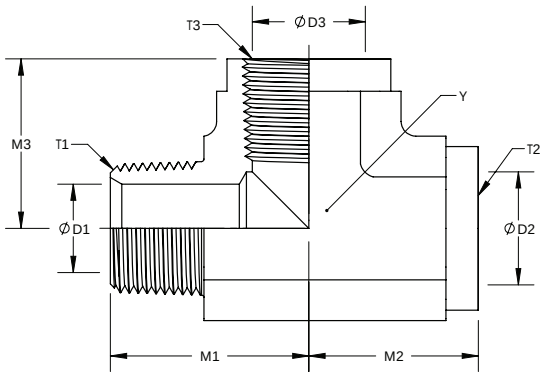
WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
F3609X02X02X02	0.563	1/8-27	0.660	0.332	1/8-27	0.660	0.332	1/8-27	0.780	0.188
F3609X04X04X04	0.750	1/4-18	0.880	0.438	1/4-18	0.880	0.438	1/4-18	1.090	0.281
F3609X06X06X06	0.875	3/8-18	1.020	0.563	3/8-18	1.020	0.563	3/8-18	1.220	0.406
F3609X08X08X08	1.063	1/2-14	1.230	0.703	1/2-14	1.230	0.703	1/2-14	1.470	0.531
F3609X12X12X12	1.313	3/4-14	1.360	0.906	3/4-14	1.360	0.906	3/4-14	1.590	0.719
F3609X16X16X16	1.625	1-11-1/2	1.620	1.141	1-11-1/2	1.620	1.141	1-11-1/2	1.970	0.938
F3609X20X20X20	1.875	1-1/4-11-1/2	1.700	1.484	1-1/4-11-1/2	1.700	1.484	1-1/4-11-1/2	2.380	1.250
F3609X24X24X24	2.562	1-1/2-11-1/2	2.080	1.744	1-1/2-11-1/2	2.080	1.744	1-1/2-11-1/2	2.640	1.500



Description: **Female Pipe Tee**
WWF Part No.: **F3709**
WWF Stainless Part No.: **5605-SS**
SAE: **140438**

Air-Way: 5605
Parker: MMO
Aeroquip: 2090
Gates: FP-FP-FP

WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
F3709X02X02X02	0.563	1/8-27	0.660	0.332	1/8-27	0.660	0.332	1/8-27	0.660	0.332
F3709X04X04X04	0.750	1/4-18	0.880	0.438	1/4-18	0.880	0.438	1/4-18	0.880	0.438
F3709X06X04X06	0.875	3/8-18	1.020	0.563	1/4-18	1.010	0.438	3/8-18	1.020	0.563
F3709X06X06X06	0.875	3/8-18	1.020	0.563	3/8-18	1.020	0.563	3/8-18	1.020	0.563
F3709X08X08X08	1.063	1/2-14	1.230	0.703	1/2-14	1.230	0.703	1/2-14	1.230	0.703
F3709X12X12X12	1.313	3/4-14	1.360	0.906	3/4-14	1.360	0.906	3/4-14	1.360	0.906
F3709X16X16X16	1.625	1-11-1/2	1.620	1.141	1-11-1/2	1.620	1.141	1-11-1/2	1.620	1.141
F3709X20X20X20	1.875	1-1/4-11-1/2	1.700	1.484	1-1/4-11-1/2	1.700	1.484	1-1/4-11-1/2	1.700	1.484
F3709X24X24X24	2.562	1-1/2-11-1/2	2.080	1.744	1-1/2-11-1/2	2.080	1.744	1-1/2-11-1/2	2.080	1.744
F3709X32X32X32	2.812	2-11-1/2	2.390	2.213	2-11-1/2	2.390	2.213	2-11-1/2	2.390	2.213

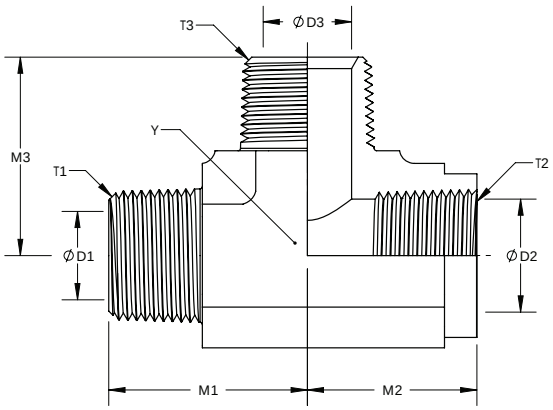


Description: **Male Run Tee**
WWF Part No.: **F3759**
WWF Stainless Part No.: **5602-SS**
SAE: **140424**

Air-Way: 5602
Parker: MRO
Aeroquip: 2092
Gates: /

WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
F3759X02X02X02	0.563	1/8-27	0.780	0.188	1/8-27	0.660	0.332	1/8-27	0.660	0.332
F3759X04X04X04	0.750	1/4-18	1.090	0.281	1/4-18	0.880	0.438	1/4-18	0.880	0.438
F3759X06X06X06	0.875	3/8-18	1.220	0.406	3/8-18	1.020	0.563	3/8-18	1.020	0.563
F3759X08X08X08	1.063	1/2-14	1.470	0.531	1/2-14	1.230	0.703	1/2-14	1.230	0.703
F3759X12X12X12	1.313	3/4-14	1.590	0.719	3/4-14	1.360	0.906	3/4-14	1.360	0.906
F3759X16X16X16	1.625	1-11-1/2	1.970	0.938	1-11-1/2	1.620	1.141	1-11-1/2	1.620	1.141
F3759X20X20X20	1.875	1-1/4-11-1/2	2.380	1.250	1-1/4-11-1/2	1.700	1.484	1-1/4-11-1/2	1.700	1.484
F3759X24X24X24	2.562	1-1/2-11-1/2	2.640	1.500	1-1/2-11-1/2	2.080	1.744	1-1/2-11-1/2	2.080	1.744

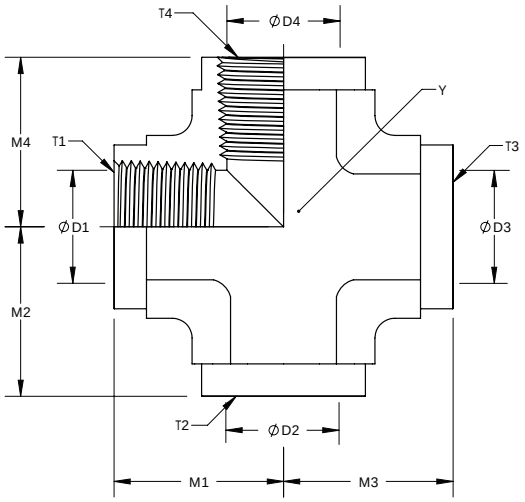
A



Description: **Female Run Tee**
WWF Part No.: **F3809**
WWF Stainless Part No.: **5603-SS**
SAE: **/**

Air-Way: 5603
Parker: /
Aeroquip: 2093
Gates: /

WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
F3809X02X02X02	0.563	1/8-27	0.780	0.188	1/8-27	0.660	0.332	1/8-27	0.780	0.188
F3809X04X04X04	0.750	1/4-18	1.090	0.281	1/4-18	0.880	0.438	1/4-18	1.090	0.281
F3809X06X06X06	0.875	3/8-18	1.220	0.406	3/8-18	1.020	0.563	3/8-18	1.220	0.406
F3809X08X08X08	1.063	1/2-14	1.470	0.531	1/2-14	1.230	0.703	1/2-14	1.470	0.531
F3809X12X12X12	1.313	3/4-14	1.590	0.719	3/4-14	1.360	0.906	3/4-14	1.590	0.719
F3809X16X16X16	1.625	1-11-1/2	1.970	0.938	1-11-1/2	1.620	1.141	1-11-1/2	1.970	0.938
F3809X20X20X20	1.875	1-1/4-11-1/2	2.380	1.250	1-1/4-11-1/2	1.700	1.484	1-1/4-11-1/2	2.380	1.250
F3809X24X24X24	2.562	1-1/2-11-1/2	2.640	1.500	1-1/2-11-1/2	2.080	1.744	1-1/2-11-1/2	2.640	1.500



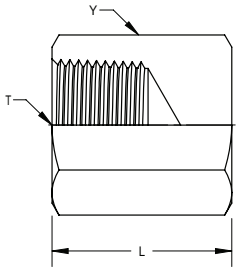
Description: **Female Pipe Cross**
WWF Part No.: **F3959**
WWF Stainless Part No.: **5652-SS**
SAE: **140538**

Air-Way: 5652
Parker: KMMOO
Aeroquip: 2080
Gates: /

WWF	Y HEX	T1 / T3	M1 / M3	D1 / D3	T2 / T4	M2 / M4	D2 / D4
F3959X02X02X02X02	0.563	1/8-27	0.660	0.332	1/8-27	0.660	0.332
F3959X04X04X04X04	0.750	1/4-18	0.880	0.438	1/4-18	0.880	0.438
F3959X06X06X06X06	0.875	3/8-18	1.020	0.563	3/8-18	1.020	0.563
F3959X08X08X08X08	1.063	1/2-14	1.230	0.703	1/2-14	1.230	0.703
F3959X12X12X12X12	1.313	3/4-14	1.360	0.906	3/4-14	1.360	0.906
F3959X16X16X16X16	1.625	1-11-1/2	1.620	1.141	1-11-1/2	1.620	1.141
F3959X20X20X20X20	1.875	1-1/4-11-1/2	1.700	1.484	1-1/4-11-1/2	1.700	1.484
F3959X24X24X24X24	2.562	1-1/2-11-1/2	2.080	1.744	1-1/2-11-1/2	2.080	1.744
F3959X32X32X32X32	2.812	2-11-1/2	2.390	2.213	2-11-1/2	2.390	2.213

Description: **Pipe Cap**
WWF Part No.: **5406C**
WWF Stainless Part No.: **/**
SAE: **/**

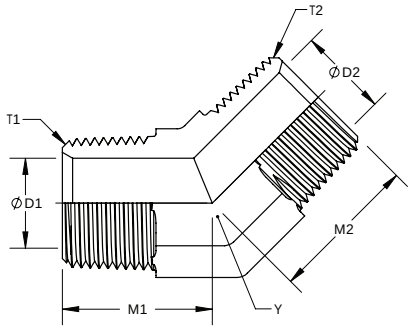
Air-Way: 5406-C
Parker: /
Aeroquip: /
Gates: /



WWF	Y HEX	T	L
5406CX04	0.750	1/4-18	0.910
5406CX06	0.875	3/8-18	1.030
5406CX08	1.063	1/2-14	1.340
5406CX12	1.250	3/4-14	1.440
5406CX16	1.625	1-11-1/2	1.610

Description: **45° Male Pipe Elbow**
WWF Part No.: **5501**
WWF Stainless Part No.: **5501-SS**
SAE: **/**

Air-Way: 5501
Parker: /
Aeroquip: 2247
Gates: /

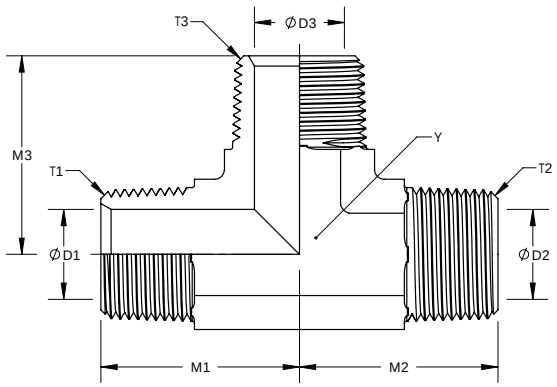


WWF	Y HEX	T1	M1	D1	T2	M2	D2
5501X04X04	0.563	1/4-18	0.860	0.281	1/4-18	0.860	0.281
5501X06X06	0.750	3/8-18	0.950	0.406	3/8-18	0.950	0.406
5501X08X08	0.875	1/2-14	1.170	0.531	1/2-14	1.170	0.531
5501X12X12	1.063	3/4-14	1.200	0.719	3/4-14	1.200	0.719
5501X16X16	1.313	1-11-1/2	1.480	0.938	1-11-1/2	1.480	0.938
5501X20X20	1.625	1-1/4-11-1/2	1.670	1.250	1-1/4-11-1/2	1.670	1.250
5501X24X24	1.875	1-1/2-11-1/2	1.770	1.500	1-1/2-11-1/2	1.770	1.500

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Description: **Male Pipe Tee**
WWF Part No.: **5600**
WWF Stainless Part No.: **5600-SS**
SAE: **140437**

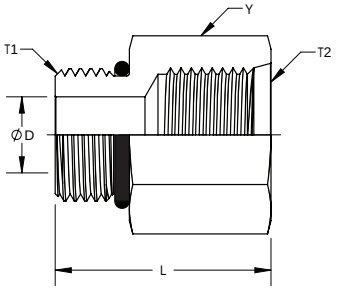
Air-Way: 5600
Parker: RRS
Aeroquip: 2257
Gates: /



WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
5600X02X02X02	0.438	1/8-27	0.780	0.188	1/8-27	0.780	0.188	1/8-27	0.780	0.188
5600X04X04X04	0.563	1/4-18	1.090	0.281	1/4-18	1.090	0.281	1/4-18	1.090	0.281
5600X06X06X06	0.750	3/8-18	1.220	0.406	3/8-18	1.220	0.406	3/8-18	1.220	0.406
5600X08X08X08	0.875	1/2-14	1.470	0.531	1/2-14	1.470	0.531	1/2-14	1.470	0.531
5600X12X12X12	1.063	3/4-14	1.590	0.719	3/4-14	1.590	0.719	3/4-14	1.590	0.719
5600X16X16X16	1.313	1-11-1/2	1.970	0.938	1-11-1/2	1.970	0.938	1-11-1/2	1.970	0.938

Description: **Male SAE to Female SAE Adapter**
WWF Part No.: **6410**
WWF Stainless Part No.: **6410-SS**
SAE: ***/***

Air-Way: 6410
Parker: F50G5
Aeroquip: FF1010
Gates: /



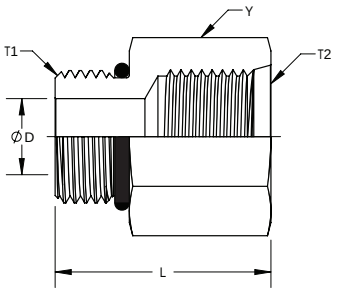
WWF	Y HEX	T1	D	T2	L
6410X02X04	0.688	5/16-24	0.063	7/16-20	1.130
6410X04X02	0.563	7/16-20	0.172	5/16-24	1.080
6410X04X04	0.688	7/16-20	0.172	7/16-20	1.080
6410X04X06	0.813	7/16-20	0.172	9/16-18	1.240
6410X04X08	1.063	7/16-20	0.172	3/4-16	1.350
6410X05X04	0.688	1/2-20	0.234	7/16-20	1.080
6410X05X06	0.813	1/2-20	0.234	9/16-18	1.240
6410X06X04	0.688	9/16-18	0.297	7/16-20	1.120
6410X06X06	0.813	9/16-18	0.297	9/16-18	1.160
6410X06X08	1.063	9/16-18	0.297	3/4-16	1.380
6410X08X04	0.875	3/4-16	0.391	7/16-20	1.160
6410X08X06	0.875	3/4-16	0.391	9/16-18	1.160
6410X08X08	1.063	3/4-16	0.391	3/4-16	1.470
6410X08X10	1.125	3/4-16	0.391	7/8-14	1.560

Continued on page 39

Continued from page 38

Description: **Male SAE to Female SAE Adapter**
WWF Part No.: **6410**
WWF Stainless Part No.: **6410-SS**
SAE: **/**

Air-Way: 6410
Parker: F50G5
Aeroquip: FF1010
Gates: /

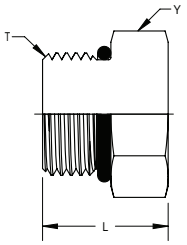


WWF	Y HEX	T1	D	T2	L
6410X08X12	1.375	3/4-16	0.391	1-1/16-12	1.730
6410X10X04	1.000	7/8-14	0.484	7/16-20	0.910
6410X10X06	1.000	7/8-14	0.484	9/16-18	1.270
6410X10X08	1.063	7/8-14	0.484	3/4-16	1.380
6410X10X10	1.125	7/8-14	0.484	7/8-14	1.690
6410X10X12	1.375	7/8-14	0.484	1-1/16-12	1.790
6410X12X06	1.250	1-1/16-12	0.609	9/16-18	1.000
6410X12X08	1.250	1-1/16-12	0.609	3/4-16	1.480
6410X12X10	1.250	1-1/16-12	0.609	7/8-14	1.570
6410X12X12	1.375	1-1/16-12	0.609	1-1/16-12	1.730
6410X12X16	1.625	1-1/16-12	0.609	1-5/16-12	1.880
6410X14X12	1.375	1-3/16-12	0.719	1-1/16-12	1.730
6410X16X08	1.500	1-5/16-12	0.844	3/4-16	1.000
6410X16X10	1.500	1-5/16-12	0.844	7/8-14	1.570
6410X16X12	1.500	1-5/16-12	0.844	1-1/16-12	1.730
6410X16X14	1.625	1-5/16-12	0.844	1-3/16-12	1.730
6410X16X16	1.625	1-5/16-12	0.844	1-5/16-12	1.730
6410X16X20	2.125	1-5/16-12	0.844	1-5/8-12	1.970
6410X20X06	1.875	1-5/8-12	1.078	9/16-18	1.000
6410X20X08	1.875	1-5/8-12	1.078	3/4-16	1.000
6410X20X10	1.875	1-5/8-12	1.078	7/8-14	1.000
6410X20X12	1.875	1-5/8-12	1.078	1-1/16-12	1.000
6410X20X16	1.875	1-5/8-12	1.078	1-5/16-12	1.730
6410X20X24	2.250	1-5/8-12	1.078	1-7/8-12	1.980
6410X24X12	2.125	1-7/8-12	1.313	1-1/16-12	1.000
6410X24X16	2.125	1-7/8-12	1.313	1-5/16-12	1.730
6410X24X20	2.125	1-7/8-12	1.313	1-5/8-12	1.790
6410X32X20	2.750	2-1/2-12	1.781	1-5/8-12	1.000
6410X32X24	2.750	2-1/2-12	1.781	1-7/8-12	1.800

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Description: **External Hex Port Plug**
WWF Part No.: **7237S**
WWF Stainless Part No.: **6408-SS**
SAE: **090109A**

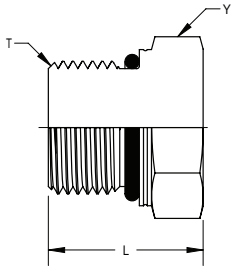
Air-Way: 6408
Parker: P5ON
Aeroquip: 900598
Gates: MB-PLUG



WWF	Y HEX	T	L
7237X02S	0.438	5/16-24	0.600
7237X03S	0.500	3/8-24	0.600
7237X04S	0.563	7/16-20	0.670
7237X05S	0.625	1/2-20	0.670
7237X06S	0.688	9/16-18	0.730
7237X08S	0.875	3/4-16	0.800
7237X10S	1.000	7/8-14	0.930
7237X12S	1.250	1-1/16-12	1.090
7237X14S	1.375	1-3/16-12	1.090
7237X16S	1.500	1-5/16-12	1.120
7237X20S	1.875	1-5/8-12	1.200
7237X24S	2.125	1-7/8-12	1.270
7237X32S	2.750	2-1/2-12	1.430

Description: **External Hex Port Plug - Metric**
WWF Part No.: **7237M**
WWF Stainless Part No.: **8555-P-SS**
SAE: **62M0109A**

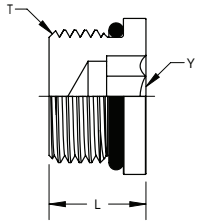
Air-Way: 8555-P
Parker: P87OMN
Aeroquip: /
Gates: /



WWF	Y HEX	T	L
7237XM10	0.551	M10X1.0	0.669
7237XM12	0.669	M12X1.5	0.728
7237XM14	0.748	M14X1.5	0.768
7237XM16	0.866	M16X1.5	0.866
7237XM18	0.945	M18X1.5	0.945
7237XM22	1.063	M22X1.5	1.024
7237XM27	1.260	M27X2.0	1.240
7237XM33	1.614	M33X2.0	1.338
7237XM42	1.969	M42X2.0	1.438

Description: **Internal Hex Port Plug**
WWF Part No.: **7238**
WWF Stainless Part No.: **6408-H-SS**
SAE: **090109B**

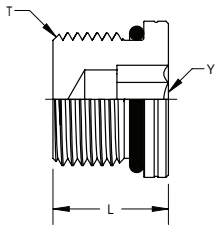
Air-Way: 6408-H
Parker: HP5ON
Aeroquip: FF2138
Gates: /



WWF	Y HEX	T	L
7238X02	0.125	5/16-24	0.405
7238X03	0.156	3/8-24	0.405
7238X04	0.188	7/16-20	0.472
7238X05	0.219	1/2-20	0.472
7238X06	0.250	9/16-18	0.508
7238X08	0.313	3/4-16	0.587
7238X10	0.375	7/8-14	0.657
7238X12	0.563	1-1/16-12	0.776
7238X14	0.563	1-3/16-12	0.776
7238X16	0.625	1-5/16-12	0.776
7238X20	0.750	1-5/8-12	0.776
7238X24	0.750	1-7/8-12	0.776
7238X32	0.750	2-1/2-12	0.776

Description: **Internal Hex Port Plug - Metric**
WWF Part No.: **7238M**
WWF Stainless Part No.: ***/***
SAE: **62M0109B**

Air-Way: /
Parker: VSTI M-OR
Aeroquip: /
Gates: /

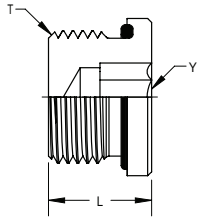


WWF	Y HEX	T	L
7238XM08	0.157	M8X1.0	0.512
7238XM10	0.197	M10X1.0	0.531
7238XM12	0.236	M12X1.5	0.610
7238XM14	0.236	M14X1.5	0.630
7238XM16	0.315	M16X1.5	0.689
7238XM18	0.315	M18X1.5	0.748
7238XM22	0.394	M22X1.5	0.787
7238XM27	0.472	M27X2.0	0.925
7238XM33	0.551	M33X2.0	0.964
7238XM42	0.669	M42X2.0	0.984

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Description: **DIN BSP Plug**
WWF Part No.: **7240G**
WWF Stainless Part No.: **8555-H-SS**
SAE: **/**

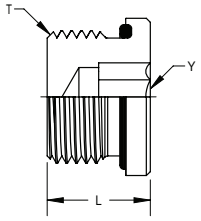
Air-Way: 8555-H
Parker: VSTI R-ED
Aeroquip: /
Gates: /



WWF	Y HEX	T	L
7240X02G	0.197	G 1/8A	0.472
7240X04G	0.236	G 1/4A	0.669
7240X06G	0.315	G 3/8A	0.669
7240X08G	0.394	G 1/2A	0.748
7240X12G	0.472	G 3/4A	0.827
7240X16G	0.669	G1 A	0.886
7240X20G	0.866	G1 1/4A	0.886
7240X24G	0.945	G1 1/2A	0.886

Description: **DIN Metric Plug**
WWF Part No.: **7240M**
WWF Stainless Part No.: **9522-H-SS**
SAE: **/**

Air-Way: 9522-H
Parker: VSTI M-ED
Aeroquip: /
Gates: /



WWF	Y HEX	T	L
7240XM10	0.197	M10X1.0	0.472
7240XM12	0.236	M12X1.5	0.669
7240XM14	0.236	M14X1.5	0.669
7240XM16	0.315	M16X1.5	0.669
7240XM18	0.315	M18X1.5	0.669
7240XM22	0.394	M22X1.5	0.748
7240XM27	0.472	M27X2.0	0.827
7240XM33	0.669	M33X2.0	0.886
7240XM42	0.866	M42X2.0	0.886
7240XM48	0.945	M48X2.0	0.886

NOTES

NOTES

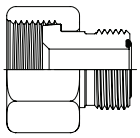
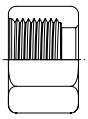
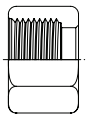
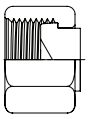
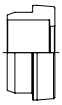
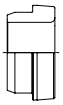
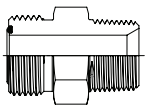
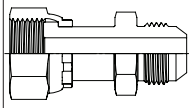
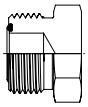
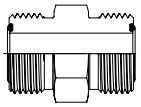
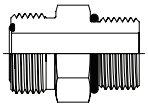
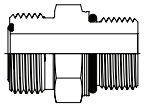
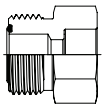
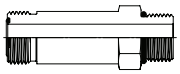
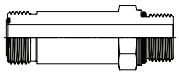
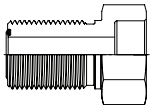
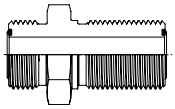
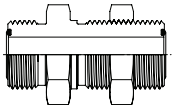
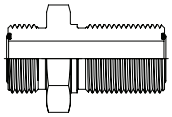
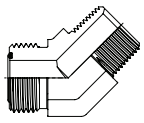
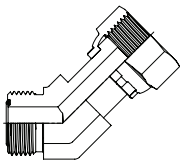
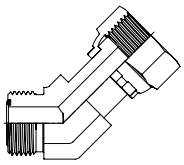
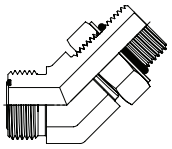
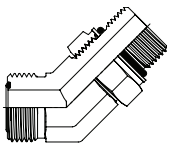
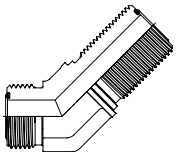
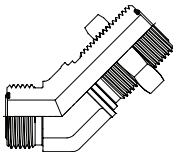
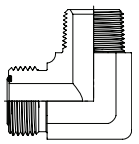
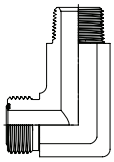
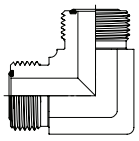
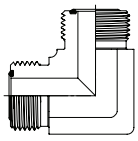
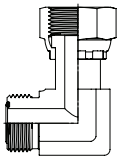
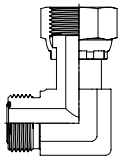
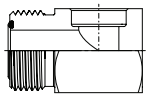
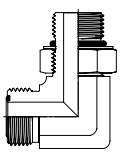
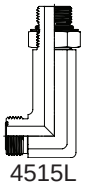
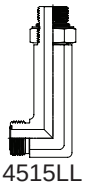
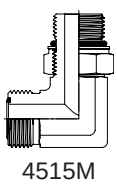
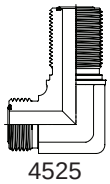
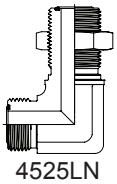
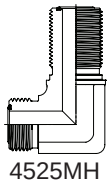


Steel “O” Ring Face Seal Fittings

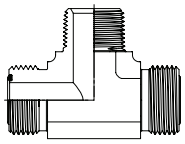
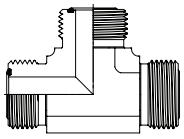
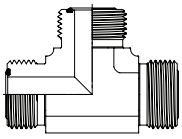
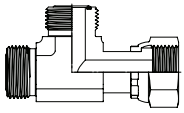
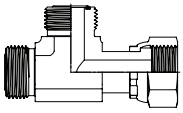
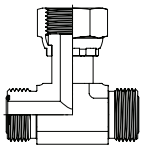
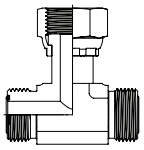
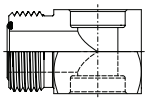
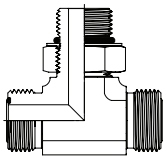
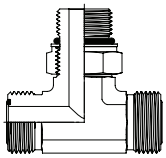
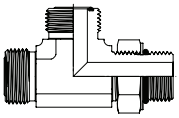
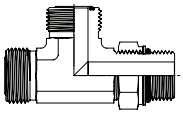
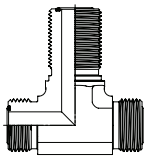
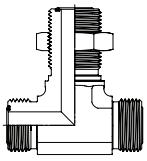
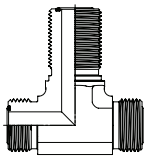
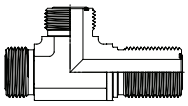
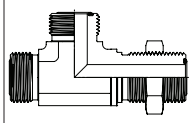
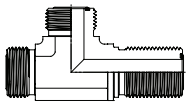
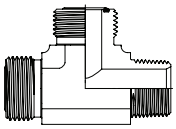
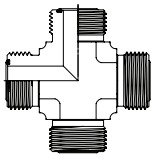
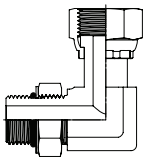
4000 SERIES

4000 SERIES - STEEL "O" RING FACE SEAL FITTINGS

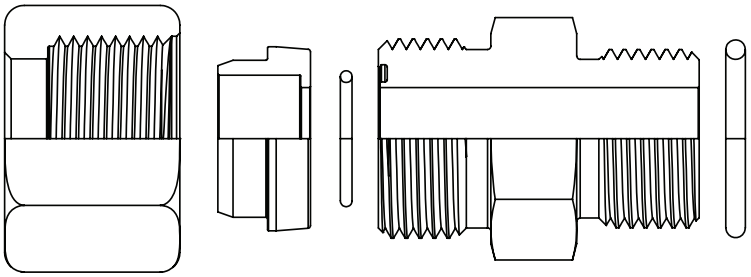
B

FS2406 Page 52	POR	**FS0318** Page 53	**MFS0318** Page 53	**FS0304-C** Page 54	**FS0319** Page 54	Page 55
						
4015	4100	4105	4105MH	4129	4165	4165PF
Reducer	Male Weld Spud	Standard Nut	Metric Hex Nut	Cap Assembly	Sleeve	Mechanical Sleeve
FS2404 Page 55	**FS6504** Page 56	**FS2408** Page 57	POR	**FS2403** Page 57	**FS6400** Page 58	**FS7640** Page 59
						
4205	4213	4229	4300	4305	4314	4314M
Male Connector	Female Swivel to Male JIC	Plug	Male Braze Spud	Union Straight	Stud Straight	Stud Straight - Metric
FS0403 Page 60	**FS6400-L** Page 61	**FS7640-L** Page 61	POR	**FS2700** Page 62	**FS2700-LN** Page 62	**FS2700-MH** Page 63
						
4315	4316	4316M	4324	4325	4325LN	4325MH
Braze-On Straight	Stud Straight Long	Stud Straight Long Metric	Male Braze Bulkhead Connector	Bulkhead Straight	Bulkhead Straight With Locknut	Bulkhead Straight Metric Hex
FS2503 Page 63	**FS6502** Page 64	**FS6502-MH** Page 64	**FS6802** Page 65	**FS7300** Page 66	**FS2702** Page 66	**FS2702-LN** Page 67
						
4355	4356	4356MH	4365	4365M	4375	4375LN
45º Male Elbow	45º Swivel Elbow	45º Swivel Elbow Metric Hex	45º Adjustable Stud Elbow	45º Adjustable Stud Elbow - Metric	45º Bulkhead Elbow	45º Bulkhead Elbow With Locknut
FS2501 Page 67	**FS2501-L** Page 68	**FS2500** Page 69	**FS2500-MH** Page 69	**FS6500** Page 70	**FS6500-MH** Page 70	POR
						
4405	4405L	4505	4505MH	4506	4506MH	4514
90º Male Elbow	90º Male Elbow Long	90º Union Elbow	90º Union Elbow Metric Hex	90º Swivel Elbow	90º Swivel Elbow Metric Hex	Male Braze 90º Elbow
FS6801 Page 71	**FS6801-L** Page 72	**FS6801-LL** Page 72	**FS7205** Page 73	**FS2701** Page 74	**FS2701-LN** Page 74	**FS2701-MH** Page 75
						
4515	4515L	4515LL	4515M	4525	4525LN	4525MH
90º Adjustable Stud Elbow	90º Adjustable Stud Elbow - Long	90º Adjustable Stud Elbow - Extra Long	90º Adjustable Stud Elbow - Metric	90º Bulkhead Elbow	90º Bulkhead Elbow With Locknut	90º Bulkhead Elbow Metric Hex

4000 SERIES - STEEL "O" RING FACE SEAL FITTINGS

FS2601 Page 75	**FS4000** Page 76	**FS2603** Page 76	**FS2603-MH** Page 77	**FS6602** Page 78	**FS6602-MH** Page 78	**FS6600** Page 79
						
4605	4629	4705	4705MH	4706	4706MH	4707
Male Branch Tee	"O" Ring	Union Tee	Union Tee Metric Hex	Swivel Run Tee	Swivel Run Tee Metric Hex	Swivel Branch Tee
FS6600-MH Page 79	POR	**FS6803** Page 80	**FS7210** Page 81	**FS6804** Page 82	**FS7215** Page 83	**FS2703** Page 84
						
4707MH	4714	4715	4715M	4716	4716M	4725
Swivel Branch Tee Metric Hex	Male Braze Branch Tee	Adjustable Stud Branch Tee	Adjustable Stud Branch Tee - Metric	Adjustable Stud Run Tee	Adjustable Stud Run Tee - Metric	Bulkhead Branch Tee
FS2703-LN Page 84	**FS2703-MH** Page 85	**FS2704** Page 85	**FS2704-LN** Page 86	**FS2704-MH** Page 86	Page 87	Page 87
						
4725LN	4725MH	4726	4726LN	4726MH	4755	4924
Bulkhead Branch Tee With Locknut	Bulkhead Branch Tee - Metric Hex	Bulkhead Run Tee	Bulkhead Run Tee With Locknut	Bulkhead Run Tee Metric Hex	Male Run Tee	Straight Thread Locknut
FS0306 Page 88	**FS2650** Page 88	**FS6809** Page 89	Page 165	Page 166		
						
4925	4955	FS6809	7629	7269M		
Bulkhead Locknut	Union Cross	Swivel 90º Adjustable Stud Elbow	90 Durometer "O" Ring	90 Durometer Metric "O" Ring		

4000 SERIES - STEEL “O” RING FACE SEAL FITTINGS



4000 Series Assembly

CONSTRUCTION
4000 Series "O" Ring Face Seal Fittings consist of four main components: Bodies, "O" Rings, Nuts, and Sleeves.
Bodies - Straight bodies are machined from bar stock. Shape fittings (elbows, tees, & crosses) are made from forgings.
"O" Rings - Buna-N, 90 Durometer
Nuts - "O" Ring Face Seal Tube Nuts in sizes 1/4”, 3/8", 1/2", 3/4”, 5/8", and 1” are Cold Formed in 1010 steel.
"O" Ring Face Seal Tube Nuts in sizes 1-1/4", 1-1/2", & 2" are hot forged from 1045.
Sleeves - "O" Ring Face Seal Sleeves are machined from 12L14 bar stock.

APPLICATIONS
For use with most high pressure applications. Applications containing continuous mechanical shock.

PRESSURE RATINGS
Working pressures up to 6000 PSI - depending on tube and fitting size. (For applications using extreme pressures at 5000 PSI or above, contact World Wide Fittings.)

MATERIAL
Steel - 12L14, 1045.
"O" Ring - Buna-N 90 Durometer, Viton.

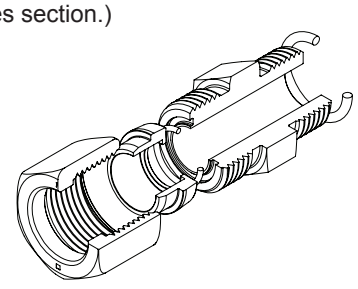
PLATING
Clear Zinc Trivalent.

TEMPERATURE RANGE
-30° F to 275° F
(Viton "O" Rings available upon request for high temperature applications. Contact World Wide Fittings for details.)

HOW TO ORDER
Tubing sizes are measured in sixteenths of an inch. When ordering, the tube end of the fitting must be specified first followed by the pipe thread or straight thread end. All fittings in this section are ordered as bodies only unless specified by customers when ordering.
(Contact World Wide when ordering fittings as assemblies or configurations which are non-standard.)

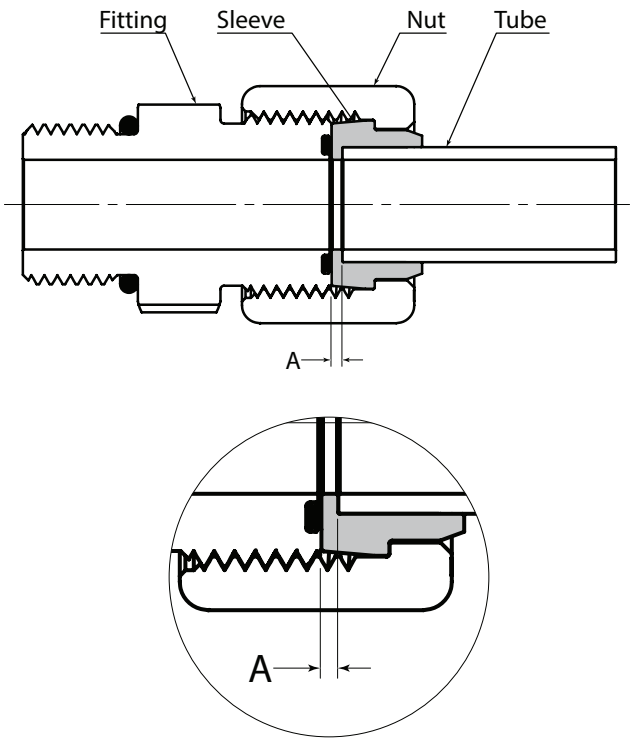
CONFORMANCE
4000 Series fittings meet SAE J1453 Specifications.

ASSEMBLY INSTRUCTIONS
1. Measure the needed length of tubing to be cut. When measuring be sure to leave room at the end of your tube for the sleeve which will be brazed on to the end of the tubing.
2. Cut the length of tubing making sure the ends of the tubes are square. Remove all burrs and foreign matter from the ends of the tubing where brazing is to be done.
3. Clamp the tube to be brazed in a vise and slide the tube nut on to the tube with the open end of the nut facing the tube end. Apply flux to the outside of the tube end. When applying flux to the tail end of the sleeve, be sure to coat the OD, ID, & braze ring.
4. Slide the sleeve with the brazing ring on to the tube end and apply heat uniformly around the sleeve and the tube end. As the flux reaches the proper brazing temperature it will become clear in color. When the proper brazing temperature is maintained the braze ring will melt and the sleeve will settle down on the end of the tube. Should the sleeve not settle on to the tube apply a slight pressure to the sleeve to force the sleeve down onto the tube.
5. After the tube cools, remove the assembly from the vise and inspect the braze joint. The braze material should have formed a continuous fillet completely around the tube. Should visible gaps be noticeable, the braze joint may not be complete and would fail if put into service. Re-brazing is recommended to correct the problem.
6. Remove any excess flux & residue from the brazed assembly.
7. Install the "O" Ring Face Seal fitting body to the piece of equipment. Line the ends of your tube assembly up with the fitting bodies. Visually inspect the ends of the fitting bodies to make sure the "O" Ring seals are in place. Bring the nut at each end up to the fitting body and tighten to the finger-tight position. Using a torque wrench, tighten the Face Seal tube nuts to the proper torque.
   (Refer to the assembly torque charts during installation of 4000 series fittings from the port and thread assemblies section.)



4000 SERIES - STEEL "O" RING FACE SEAL FITTINGS

Correct assembly

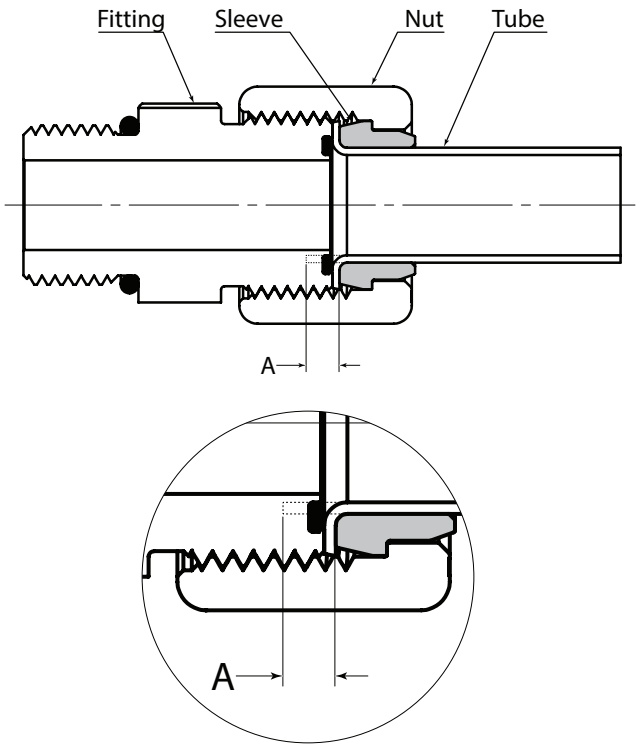


Tube length allowance

(See table below)

Nominal Tube O.D.		A (in.)
Inch	Metric	
1/4	6	0.04
3/8	8, 10	0.04
1/2	12	0.04
5/8	14, 15, 16	0.06
3/4	18, 20	0.06
1	22, 25	0.06
1-1/4	28, 30, 32	0.06
1-1/2	35, 38	0.06

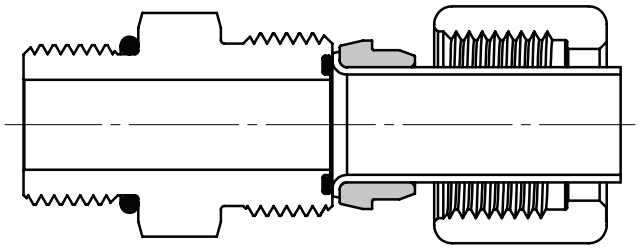
Correct assembly



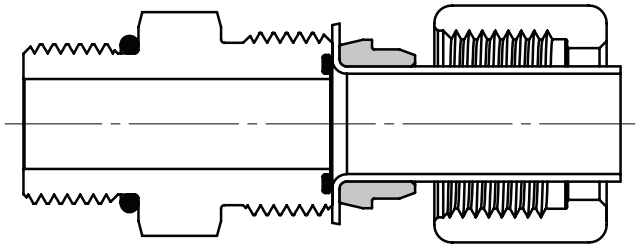
Tube length allowance

(See page 50 for extra cut-off length)

Incorrect assembly

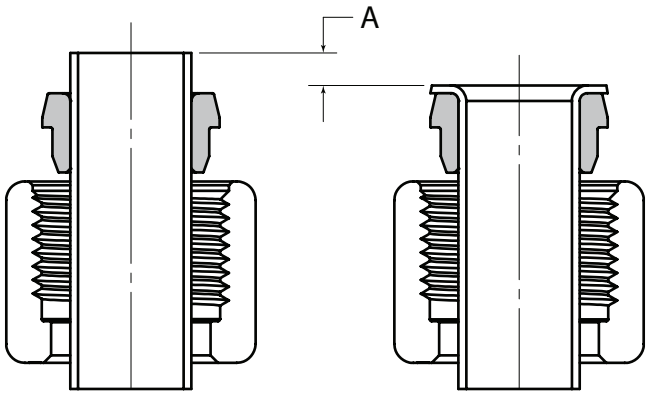


Underflanged assembly



Overflanged assembly

4000 SERIES - STEEL “O” RING FACE SEAL FITTINGS

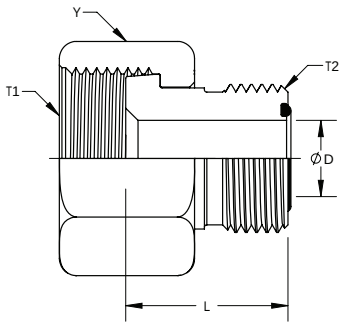


Extra cut-off length - “A”

Extra tube cut-off length guide for inch tube

Tube O.D. (inch)	Tube Wall Thickness - inch										
	.028	.035	.049	.065	.083	.095	.109	.120	.134	.156	.188
1/4	3/16	13/16	5/32								
3/8		9/16	9/64	5/32	5/32	5/32					
1/2		5/32	9/64	9/64	9/64	9/64					
5/8			5/32	5/32	7/64	11/64	5/32	11/64			
3/4		5/32	5/32	5/32	1/8	7/64	9/64	5/32	11/64		
1		9/64	9/64	9/64	9/64	7/64	11/64	11/64	3/16		
1-1/4					5/32	7/64	7/64	1/8	5/32	11/64	11/64
1-1/2				11/64	11/64	3/16	3/16	3/16	3/16	15/64	7/32

NOTES



Description: **Reducer**
WWF Part No.: **4015**
WWF Stainless Part No.: **/**
SAE: **520123**

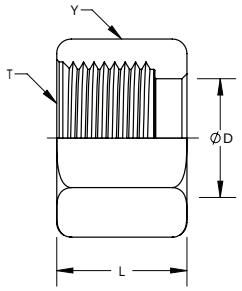
B

Air-Way: FS2406
Parker: TRLON
Aeroquip: FF2281T
Gates: /

WWF	Y HEX	D	T1	T2	L
4015X06X04	0.813	0.177	11/16-16	9/16-18	0.768
4015X08X04	0.938	0.177	13/16-16	9/16-18	0.866
4015X08X06	0.938	0.256	13/16-16	11/16-16	0.886
4015X10X04	1.125	0.177	1-14	9/16-18	0.906
4015X10X06	1.125	0.256	1-14	11-16-16	0.945
4015X10X08	1.125	0.374	1-14	13/16-16	1.004
4015X12X04	1.375	0.177	1-3/16-12	9/16-18	0.984
4015X12X06	1.375	0.256	1-3/16-12	11/16-16	1.024
4015X12X08	1.375	0.374	1-3/16-12	13/16-16	1.083
4015X12X10	1.375	0.492	1-3/16-12	1-14	1.161
4015X12X16	1.375	0.610	1-3/16-12	1-7/16-12	1.239
4015X16X08	1.625	0.374	1-7/16-12	13/16-16	1.150
4015X16X10	1.625	0.492	1-7/16-12	1-14	1.260
4015X16X12	1.625	0.610	1-7/16-12	1-3/16-12	1.299
4015X20X12	1.875	0.610	1-11/16-12	1-3/16-12	1.319
4015X20X16	1.875	0.807	1-11/16-12	1-7/16-12	1.338
4015X20X24	1.875	1.024	1-11/16-12	2-12	1.514
4015X24X12	2.250	0.610	2-12	1-3/16-12	1.321
4015X24X16	2.250	0.807	2-12	1-7/16-12	1.338
4015X24X20	2.250	1.024	2-12	1-11/16-12	1.338

Description: **Standard Nut**
WWF Part No.: **4105**
WWF Stainless Part No.: **/**
SAE: **520110**

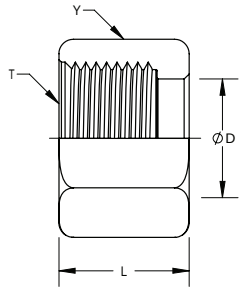
Air-Way: FS0318
Parker: BL
Aeroquip: FC2326
Gates: /



WWF	Y HEX	T	D	L
4105X04	0.688	9/16-18	0.413	0.590
4105X06	0.813	11/16-16	0.533	0.669
4105X08	0.938	13/16-16	0.653	0.787
4105X10	1.125	1-14	0.831	0.945
4105X12	1.375	1-3/16-12	0.951	1.043
4105X16	1.625	1-7/16-12	1.146	1.083
4105X20	1.875	1-11/16-12	1.417	1.083
4105X24	2.250	2-12	1.732	1.083

Description: **Metric Hex Nut**
WWF Part No.: **4105MH**
WWF Stainless Part No.: **/**
SAE: **52M0110A**

Air-Way: MFS0318
Parker: BML
Aeroquip: /
Gates: /

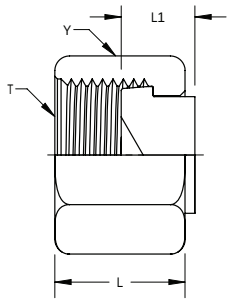


WWF	Y HEX	T	D	L
4105X04MH	0.669	9/16-18	0.413	0.590
4105X06MH	0.866	11/16-16	0.533	0.669
4105X08MH	0.945	13/16-16	0.653	0.787
4105X10MH	1.181	1-14	0.831	0.945
4105X12MH	1.417	1-3/16-12	0.951	1.043
4105X16MH	1.614	1-7/16-12	1.146	1.083
4105X20MH	1.969	1-11/16-12	1.417	1.083
4105X24MH	2.362	2-12	1.732	1.083

B

Description: **Cap Assembly**
WWF Part No.: **4129**
WWF Stainless Part No.: **/**
SAE: **520112**

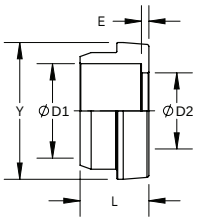
Air-Way: FS0304-C
Parker: FNL
Aeroquip: FF9863
Gates: /



WWF	Y HEX	L1	T	L
4129X04	0.688	0.354	9/16-18	0.661
4129X06	0.813	0.413	11/16-16	0.740
4129X08	0.938	0.472	13/16-16	0.866
4129X10	1.125	0.531	1-14	1.024
4129X12	1.375	0.590	1-3/16-12	1.122
4129X16	1.625	0.630	1-7/16-12	1.161
4129X20	1.875	0.630	1-11/16-12	1.161
4129X24	2.250	0.630	2-12	1.161

Description: **Sleeve**
WWF Part No.: **4165**
WWF Stainless Part No.: **/**
SAE: **520115**

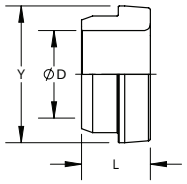
Air-Way: FS0319
Parker: TL
Aeroquip: FC1229
Gates: /



WWF	Y	D1	D2	E	L
4165X04	0.502	0.256	0.177	0.039	0.374
4165X06X04	0.620	0.256	0.177	0.079	0.413
4165X06X05	0.620	0.318	0.216	0.079	0.413
4165X06	0.620	0.381	0.256	0.039	0.374
4165X08X06	0.744	0.381	0.256	0.138	0.472
4165X08	0.744	0.506	0.374	0.039	0.374
4165X10	0.923	0.631	0.492	0.059	0.413
4165X12X10	1.096	0.631	0.492	0.216	0.571
4165X12	1.096	0.757	0.610	0.059	0.551
4165X16X12	1.346	0.757	0.610	0.177	0.669
4165X16	1.346	1.007	0.807	0.059	0.610
4165X20X16	1.596	1.007	0.807	0.059	0.610
4165X20	1.596	1.258	1.024	0.059	0.610
4165X24	1.909	1.508	1.260	0.059	0.610

Description: **Mechanical Sleeve**
WWF Part No.: **4165PF**
WWF Stainless Part No.: **/**
SAE: **/**

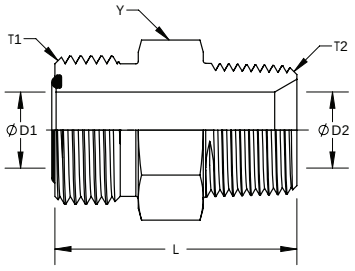
Air-Way: /
Parker: TPL
Aeroquip: /
Gates: /



WWF	Y	D	L
4165X04PF	0.502	0.256	0.295
4165X06PF	0.620	0.381	0.332
4165X08PF	0.744	0.506	0.415
4165X10PF	0.923	0.631	0.415
4165X12PF	1.096	0.757	0.475
4165X16PF	1.346	1.007	0.529
4165X20PF	1.596	1.258	0.551
4165X24PF	1.909	1.508	0.532

Description: **Male Connector**
WWF Part No.: **4205**
WWF Stainless Part No.: **/**
SAE: **/**

Air-Way: FS2404
Parker: FLO
Aeroquip: FF2031T
Gates: MFFOR-MP



WWF	Y HEX	T1	D1	T2	D2	L
4205X04X02	0.625	9/16-18	0.177	1/8-27	0.188	1.080
4205X04X04	0.625	9/16-18	0.177	1/4-18	0.281	1.260
4205X04X06	0.750	9/16-18	0.177	3/8-18	0.406	1.320
4205X04X08	0.875	9/16-18	0.177	1/2-14	0.531	1.520
4205X06X02	0.750	11/16-16	0.256	1/8-27	0.188	1.160
4205X06X04	0.750	11/16-16	0.256	1/4-18	0.281	1.340
4205X06X06	0.750	11/16-16	0.256	3/8-18	0.406	1.340
4205X06X08	0.875	11/16-16	0.256	1/2-14	0.531	1.540
4205X08X04	0.875	13/16-16	0.374	1/4-18	0.281	1.450
4205X08X06	0.875	13/16-16	0.374	3/8-18	0.406	1.450
4205X08X08	0.875	13/16-16	0.374	1/2-14	0.531	1.640
4205X08X12	1.125	13/16-16	0.374	3/4-14	0.719	1.690

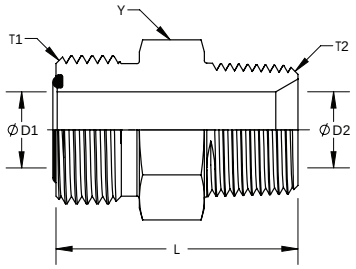
Continued on page 56

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B

Description: **Male Connector**
WWF Part No.: **4205**
WWF Stainless Part No.: **/**
SAE: **/**

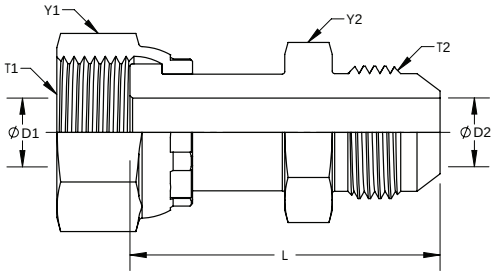
Air-Way: FS2404
Parker: FLO
Aeroquip: FF2031T
Gates: MFFOR-MP



WWF	Y HEX	T1	D1	T2	D2	L
4205X08X16	1.375	13/16-16	0.374	1-11-1/2	0.938	1.900
4205X10X08	1.063	1-14	0.492	1/2-14	0.531	1.820
4205X10X12	1.125	1-14	0.492	3/4-14	0.719	1.850
4205X12X08	1.250	1-3/16-12	0.610	1/2-14	0.531	1.930
4205X12X12	1.250	1-3/16-12	0.610	3/4-14	0.719	1.940
4205X12X16	1.375	1-3/16-12	0.610	1-11-1/2	0.938	2.060
4205X16X12	1.500	1-7/16-12	0.807	3/4-14	0.719	2.000
4205X16X16	1.500	1-7/16-12	0.807	1-11-1/2	0.938	2.190
4205X16X20	1.688	1-7/16-12	0.807	1-1/4-11-1/2	1.250	2.244
4205X20X12	1.750	1-11/16-12	1.024	3/4-14	0.719	2.080
4205X20X16	1.750	1-11/16-12	1.024	1-11-1/2	0.938	2.270
4205X20X20	1.750	1-11/16-12	1.024	1-1/4-11-1/2	1.250	2.300
4205X24X24	2.125	2-12	1.260	1-1/2-11-1/2	1.500	2.440

Description: **Female Swivel to Male JIC**
WWF Part No.: **4213**
WWF Stainless Part No.: **/**
SAE: **/**

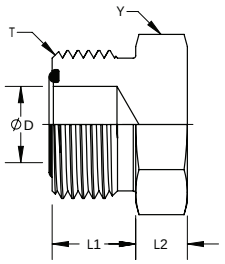
Air-Way: FS6504
Parker: XHL6
Aeroquip: FF2209T
Gates: FFORX-MJ



WWF	Y1 HEX	Y2 HEX	T1	D1	T2	D2	L
4213X04X04	0.688	0.625	9/16-18	0.157	7/16-20	0.172	1.574
4213X06X06	0.813	0.750	11/16-16	0.256	9/16-18	0.297	1.658
4213X08X08	0.938	0.875	13/16-16	0.354	3/4-16	0.391	2.055
4213X10X10	1.125	1.063	1-14	0.453	7/8-14	0.484	2.254
4213X12X12	1.375	1.250	1-3/16-12	0.551	1-1/16-12	0.609	2.478
4213X16X16	1.625	1.500	1-7/16-12	0.787	1-5/16-12	0.844	2.840
4213X20X20	1.875	1.875	1-11/16-12	1.024	1-5/8-12	1.078	2.887

Description: **Plug**
WWF Part No.: **4229**
WWF Stainless Part No.: **/**
SAE: **520109**

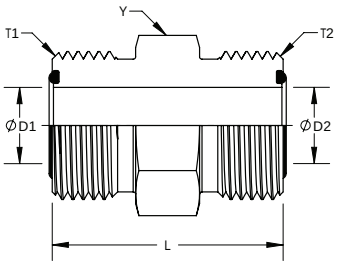
Air-Way: FS2408
Parker: PNLO
Aeroquip: FF9767
Gates: MFFOR-PLUG



WWF	Y HEX	T	D	L1	L2
4229X04	0.625	9/16-18	0.177	0.394	0.256
4229X06	0.750	11/16-16	0.256	0.433	0.315
4229X08	0.875	13/16-16	0.374	0.512	0.354
4229X10	1.063	1-14	0.492	0.610	0.413
4229X12	1.250	1-3/16-12	0.610	0.669	0.413
4229X16	1.500	1-7/16-12	0.807	0.689	0.413
4229X20	1.750	1-11/16-12	1.024	0.689	0.413
4229X24	2.125	2-12	1.260	0.689	0.413

Description: **Union Straight**
WWF Part No.: **4305**
WWF Stainless Part No.: **/**
SAE: **520101**

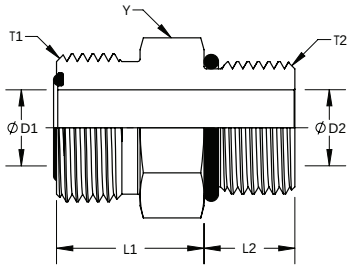
Air-Way: FS2403
Parker: HLO
Aeroquip: FF2000T
Gates: /



WWF	Y HEX	T1	D1	T2	D2	L
4305X04X04	0.625	9/16-18	0.177	9/16-18	0.177	1.083
4305X06X04	0.750	11/16-16	0.256	9/16-18	0.177	1.181
4305X06X06	0.750	11/16-16	0.256	11/16-16	0.256	1.220
4305X08X06	0.875	13/16-16	0.374	11/16-16	0.256	1.319
4305X08X08	0.875	13/16-16	0.374	13/16-16	0.374	1.398
4305X10X08	1.063	1-14	0.492	13/16-16	0.374	1.575
4305X10X10	1.063	1-14	0.492	1-14	0.492	1.673
4305X12X08	1.250	1-3/16-12	0.610	13/16-16	0.374	1.693
4305X12X10	1.250	1-3/16-12	0.610	1-14	0.492	1.791
4305X12X12	1.250	1-3/16-12	0.610	1-3/16-12	0.610	1.850
4305X16X12	1.500	1-7/16-12	0.807	1-3/16-12	0.610	1.929
4305X16X16	1.500	1-7/16-12	0.807	1-7/16-12	0.807	1.949
4305X20X16	1.750	1-11/16-12	1.024	1-7/16-12	0.807	2.027
4305X20X20	1.750	1-11/16-12	1.024	1-11/16-12	1.024	2.027
4305X24X20	2.125	2-12	1.260	1-11/16-12	1.024	2.087
4305X24X24	2.125	2-12	1.260	2-12	1.260	2.087

Description: **Stud Straight**
WWF Part No.: **4314**
WWF Stainless Part No.: **/**
SAE: **520120**

Air-Way: FS6400
Parker: F5OLO
Aeroquip: FF1852T
Gates: MFFOR-MB

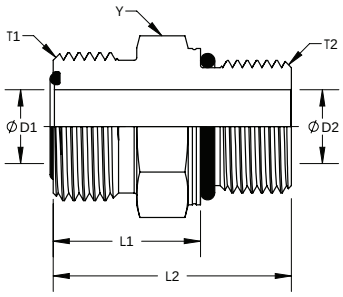


B

WWF	Y HEX	T1	L1	D1	T2	L2	D2
4314X04X04	0.625	9/16-18	0.709	0.177	7/16-20	0.433	0.177
4314X04X05	0.625	9/16-18	0.728	0.177	1/2-20	0.433	0.236
4314X04X06	0.750	9/16-18	0.748	0.177	9/16-18	0.472	0.295
4314X04X08	0.875	9/16-18	0.768	0.177	3/4-16	0.551	0.394
4314X06X04	0.750	11/16-16	0.905	0.256	7/16-20	0.433	0.177
4314X06X05	0.750	11/16-16	0.787	0.256	1/2-20	0.433	0.236
4314X06X06	0.750	11/16-16	0.787	0.256	9/16-18	0.472	0.295
4314X06X08	0.875	11/16-16	0.807	0.256	3/4-16	0.551	0.394
4314X06X10	1.063	11/16-16	0.886	0.256	7/8-14	0.630	0.492
4314X06X12	1.250	11/16-16	0.945	0.256	1-1/16-12	0.728	0.610
4314X08X04	0.875	13/16-16	1.004	0.374	7/16-20	0.433	0.177
4314X08X06	0.875	13/16-16	1.004	0.374	9/16-18	0.472	0.295
4314X08X08	0.875	13/16-16	0.886	0.374	3/4-16	0.551	0.394
4314X08X10	1.063	13/16-16	0.964	0.374	7/8-14	0.630	0.492
4314X08X12	1.250	13/16-16	1.024	0.374	1-1/16-12	0.728	0.610
4314X08X16	1.500	13/16-16	1.063	0.374	1-5/16-12	0.728	0.846
4314X10X06	1.063	1-14	1.161	0.492	9/16-18	0.472	0.295
4314X10X08	1.063	1-14	1.220	0.492	3/4-16	0.551	0.394
4314X10X10	1.063	1-14	1.063	0.492	7/8-14	0.630	0.492
4314X10X12	1.250	1-14	1.122	0.492	1-1/16-12	0.728	0.610
4314X10X16	1.500	1-14	1.181	0.492	1-5/16-12	0.728	0.846
4314X12X06	1.250	1-3/16-12	1.299	0.610	9/16-18	0.472	0.295
4314X12X08	1.250	1-3/16-12	1.358	0.610	3/4-16	0.551	0.394
4314X12X10	1.250	1-3/16-12	1.358	0.610	7/8-14	0.630	0.492
4314X12X12	1.250	1-3/16-12	1.191	0.610	1-1/16-12	0.728	0.610
4314X12X16	1.500	1-3/16-12	1.220	0.610	1-5/16-12	0.728	0.846
4314X16X08	1.500	1-7/16-12	1.398	0.807	3/4-16	0.551	0.394
4314X16X10	1.500	1-7/16-12	1.398	0.807	7/8-14	0.630	0.492
4314X16X12	1.500	1-7/16-12	1.417	0.807	1-1/16-12	0.728	0.610
4314X16X16	1.500	1-7/16-12	1.260	0.807	1-5/16-12	0.728	0.846
4314X16X20	1.875	1-7/16-12	1.338	0.807	1-5/8-12	0.728	1.083
4314X16X24	2.125	1-7/16-12	1.398	0.807	1-7/8-12	0.728	1.319
4314X20X16	1.875	1-11/16-12	1.555	1.024	1-5/16-12	0.728	0.846
4314X20X20	1.875	1-11/16-12	1.338	1.024	1-5/8-12	0.728	1.083
4314X20X24	2.125	1-11/16-12	1.398	1.024	1-7/8-12	0.728	1.319
4314X24X20	2.125	2-12	1.614	1.260	1-5/8-12	0.728	1.083
4314X24X24	2.125	2-12	1.398	1.260	1-7/8-12	0.728	1.319

Description: **Stud Straight - Metric**
WWF Part No.: **4314M**
WWF Stainless Part No.: **/**
SAE: **52M0187**

Air-Way: FS7640
Parker: F87OMLO
Aeroquip: /
Gates: /

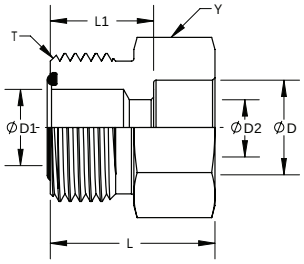


B

WWF	Y HEX	T1	L1	D1	T2	L2	D2
4314X04XM12	0.669	9/16-18	0.688	0.177	M12X1.5	1.122	0.157
4314X04XM14	0.748	9/16-18	0.728	0.177	M14X1.5	1.161	0.236
4314X06XM12	0.748	11/16-16	0.826	0.256	M12X1.5	1.260	0.157
4314X06XM14	0.748	11/16-16	0.826	0.256	M14X1.5	1.260	0.236
4314X06XM16	0.866	11/16-16	0.826	0.256	M16X1.5	1.318	0.275
4314X06XM18	0.944	11/16-16	0.866	0.256	M18X1.5	1.417	0.354
4314X06XM22	1.063	11/16-16	0.886	0.256	M22X1.5	1.476	0.472
4314X08XM14	0.866	13/16-16	0.944	0.374	M14X1.5	1.378	0.236
4314X08XM16	0.866	13/16-16	0.944	0.374	M16X1.5	1.438	0.275
4314X08XM18	0.944	13/16-16	0.944	0.374	M18X1.5	1.496	0.354
4314X08XM22	1.063	13/16-16	0.964	0.374	M22X1.5	1.555	0.472
4314X08XM27	1.260	13/16-16	1.024	0.374	M27X2.0	1.752	0.590
4314X10XM16	1.063	1-14	1.063	0.492	M16X1.5	1.555	0.275
4314X10XM18	1.063	1-14	1.063	0.492	M18X1.5	1.614	0.354
4314X10XM22	1.063	1-14	1.063	0.492	M22X1.5	1.653	0.472
4314X10XM27	1.260	1-14	1.122	0.492	M27X2.0	1.850	0.590
4314X12XM22	1.260	1-3/16-12	1.181	0.610	M22X1.5	1.771	0.472
4314X12XM27	1.260	1-3/16-12	1.181	0.610	M27X2.0	1.909	0.590
4314X12XM33	1.614	1-3/16-12	1.299	0.610	M33X2.0	2.027	0.787
4314X16XM27	1.614	1-7/16-12	1.318	0.807	M27X2.0	2.047	0.590
4314X16XM33	1.614	1-7/16-12	1.318	0.807	M33X2.0	2.047	0.787
4314X16XM42	1.969	1-7/16-12	1.417	0.807	M42X2.0	2.145	1.024
4314X20XM33	1.811	1-11/16-12	1.397	1.024	M33X2.0	2.126	0.787
4314X20XM42	1.969	1-11/16-12	1.397	1.024	M42X2.0	2.145	1.024
4314X24XM42	1.969	2-12	1.397	1.260	M42X2.0	2.145	1.024
4314X24XM48	2.165	2-12	1.397	1.260	M48X2.0	2.244	1.260

Description: **Braze-On Straight**
WWF Part No.: **4315**
WWF Stainless Part No.: **/**
SAE: **520104**

Air-Way: FS0403
Parker: LOHB3
Aeroquip: FF1851T
Gates: /

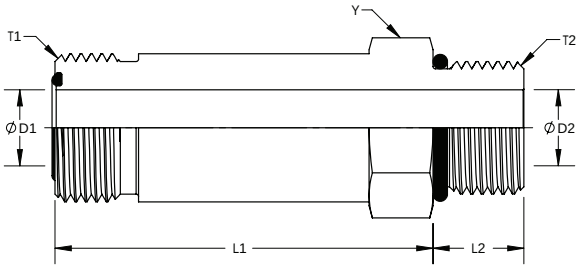


B

WWF	Y HEX	T	D	D1	D2	L1	L
4315X04X04	0.625	9/16-18	0.256	0.177	0.177	0.531	0.866
4315X04X05	0.625	9/16-18	0.318	0.177	0.177	0.531	0.866
4315X04X06	0.625	9/16-18	0.381	0.177	0.177	0.531	0.866
4315X06X04	0.750	11/16-16	0.256	0.177	0.177	0.571	0.905
4315X06X06	0.750	11/16-16	0.381	0.256	0.256	0.571	0.905
4315X06X08	0.750	11/16-16	0.506	0.256	0.256	0.571	0.905
4315X08X06	0.875	13/16-16	0.381	0.256	0.256	0.630	0.964
4315X08X08	0.875	13/16-16	0.506	0.374	0.374	0.630	0.964
4315X08X10	0.875	13/16-16	0.631	0.374	0.374	0.630	0.964
4315X08X12	1.063	13/16-16	0.757	0.374	0.374	0.630	1.130
4315X10X10	1.063	1-14	0.631	0.492	0.492	0.748	1.102
4315X10X12	1.063	1-14	0.757	0.492	0.492	0.748	1.240
4315X12X10	1.250	1-3/16-12	0.631	0.610	0.492	0.827	1.181
4315X12X12	1.250	1-3/16-12	0.757	0.610	0.610	0.827	1.319
4315X12X14	1.375	1-3/16-12	0.882	0.610	0.610	0.827	1.322
4315X12X16	1.250	1-3/16-12	1.007	0.610	0.610	0.827	1.378
4315X16X12	1.500	1-7/16-12	0.757	0.807	0.610	0.964	1.457
4315X16X16	1.500	1-7/16-12	1.007	0.807	0.807	0.964	1.516
4315X16X20	1.750	1-7/16-12	1.258	0.807	0.807	0.964	1.516
4315X20X16	1.750	1-11/16-12	1.007	1.024	0.807	0.964	1.516
4315X20X20	1.750	1-11/16-12	1.258	1.024	1.024	0.964	1.516
4315X20X24	2.125	1-11/16-12	1.508	1.024	1.024	0.964	1.516
4315X24X24	2.125	2-12	1.508	1.260	1.260	0.964	1.516

Description: **Stud Straight Long**
WWF Part No.: **4316**
WWF Stainless Part No.: **/**
SAE: **521720**

Air-Way: FS6400-L
Parker: FF5OLO
Aeroquip: FF1854T
Gates: MFFOR-MBL

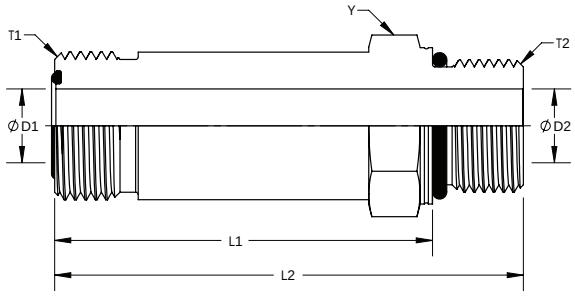


B

WWF	Y HEX	T1	L1	D1	T2	L2	D2
4316X04X04	0.625	9/16-18	1.634	0.177	7/16-20	0.433	0.177
4316X06X04	0.750	11/16-16	1.791	0.256	7/16-20	0.433	0.177
4316X06X06	0.750	11/16-16	1.791	0.256	9/16-18	0.472	0.295
4316X06X08	0.875	11/16-16	2.047	0.256	3/4-16	0.551	0.394
4316X08X08	0.875	13/16-16	2.126	0.374	3/4-16	0.551	0.394
4316X08X12	1.250	13/16-16	2.854	0.374	1-1/16-12	0.728	0.610
4316X10X10	1.063	1-14	2.500	0.492	7/8-14	0.630	0.492
4316X10X12	1.250	1-14	2.972	0.492	1-1/16-12	0.728	0.610
4316X12X10	1.250	1-3/16-12	3.031	0.610	7/8-14	0.630	0.492
4316X12X12	1.250	1-3/16-12	3.031	0.610	1-1/16-12	0.728	0.610
4316X12X16	1.500	1-3/16-12	3.386	0.610	1-5/16-12	0.728	0.846
4316X16X12	1.500	1-7/16-12	3.405	0.807	1-1/16-12	0.728	0.610
4316X16X16	1.500	1-7/16-12	3.405	0.807	1-5/16-12	0.728	0.846

Description: **Stud Straight Long - Metric**
WWF Part No.: **4316M**
WWF Stainless Part No.: **/**
SAE: **52M1787**

Air-Way: FS7640-L
Parker: /
Aeroquip: /
Gates: /

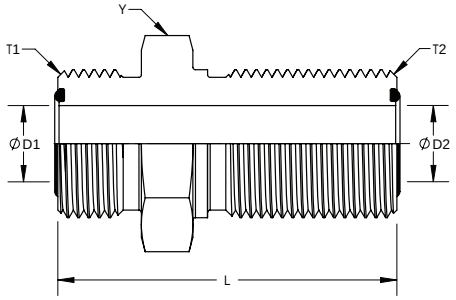


WWF	Y HEX	T1	L1	D1	T2	L2	D2
4316X04XM12	0.669	9/16-18	1.634	0.177	M12X1.5	2.067	0.157
4316X06XM12	0.748	11/16-16	1.791	0.256	M12X1.5	2.224	0.157
4316X06XM16	0.866	11/16-16	1.791	0.256	M16X1.5	2.283	0.276
4316X10XM22	1.063	1-14	2.500	0.492	M22X1.5	3.090	0.472
4316X12XM27	1.260	1-3/16-12	3.031	0.610	M27X2.0	3.760	0.590

B

Description: **Bulkhead Straight**
WWF Part No.: **4325**
WWF Stainless Part No.: **/**
SAE: **520601**

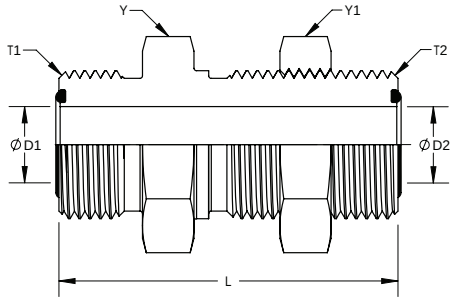
Air-Way: FS2700
Parker: WLO
Aeroquip: /
Gates: /



WWF	Y HEX	T1	D1	T2	D2	L
4325X04X04	0.813	9/16-18	0.177	9/16-18	0.177	1.890
4325X06X06	1.000	11/16-16	0.256	11/16-16	0.256	2.087
4325X06X08	1.125	11/16-16	0.256	13/16-16	0.374	2.224
4325X08X08	1.125	13/16-16	0.374	13/16-16	0.374	2.303
4325X08X10	1.313	13/16-16	0.374	1-14	0.492	2.520
4325X10X08	1.313	1-14	0.492	13/16-16	0.374	2.461
4325X10X10	1.313	1-14	0.492	1-14	0.492	2.618
4325X12X12	1.500	1-3/16-12	0.610	1-3/16-12	0.610	2.716
4325X16X12	1.750	1-7/16-12	0.807	1-3/16-12	0.610	2.736
4325X16X16	1.750	1-7/16-12	0.807	1-7/16-12	0.807	2.756
4325X20X20	2.000	1-11/16-12	1.024	1-11/16-12	1.024	2.756
4325X24X24	2.375	2-12	1.260	2-12	1.260	2.756

Description: **Bulkhead Straight With Locknut**
WWF Part No.: **4325LN**
WWF Stainless Part No.: **/**
SAE: **520601**

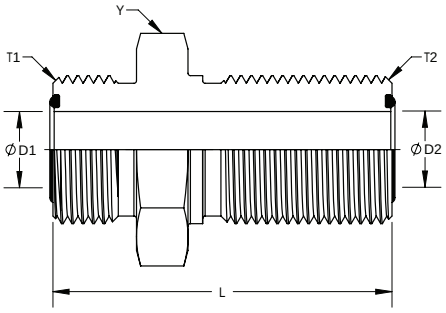
Air-Way: FS2700-LN
Parker: WF5OLO-WLN
Aeroquip: FF1994T
Gates: /



WWF	Y HEX	Y1 HEX	T1	D1	T2	D2	L
4325X04X04LN	0.813	0.813	9/16-18	0.177	9/16-18	0.177	1.890
4325X06X06LN	1.000	1.000	11/16-16	0.256	11/16-16	0.256	2.087
4325X08X08LN	1.125	1.125	13/16-16	0.374	13/16-16	0.374	2.303
4325X10X10LN	1.313	1.313	1-14	0.492	1-14	0.492	2.618
4325X12X12LN	1.500	1.500	1-3/16-12	0.610	1-3/16-12	0.610	2.716
4325X16X16LN	1.750	1.750	1-7/16-12	0.807	1-7/16-12	0.807	2.756
4325X20X20LN	2.000	2.000	1-11/16-12	1.024	1-11/16-12	1.024	2.756
4325X24X24LN	2.375	2.375	2-12	1.260	2-12	1.260	2.756

Description: **Bulkhead Straight Metric Hex**
WWF Part No.: **4325MH**
WWF Stainless Part No.: **/**
SAE: **52M0601**

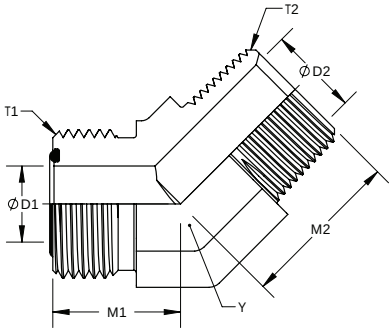
Air-Way: FS2700-MH
Parker: WMLO
Aeroquip: /
Gates: /



WWF	Y HEX	T1	D1	T2	D2	L
4325X04X04MH	0.866	9/16-18	0.177	9/16-18	0.177	1.890
4325X06X06MH	1.063	11/16-16	0.256	11/16-16	0.256	2.087
4325X08X08MH	1.181	13/16-16	0.374	13/16-16	0.374	2.303
4325X10X10MH	1.417	1-14	0.492	1-14	0.492	2.618
4325X12X12MH	1.614	1-3/16-12	0.610	1-3/16-12	0.610	2.716
4325X16X16MH	1.811	1-7/16-12	0.807	1-7/16-12	0.807	2.756
4325X20X20MH	1.969	1-11/16-12	1.024	1-11/16-12	1.024	2.756

Description: **45° Male Elbow**
WWF Part No.: **4355**
WWF Stainless Part No.: **/**
SAE: **/**

Air-Way: FS2503
Parker: VLO
Aeroquip: FF2093T
Gates: /

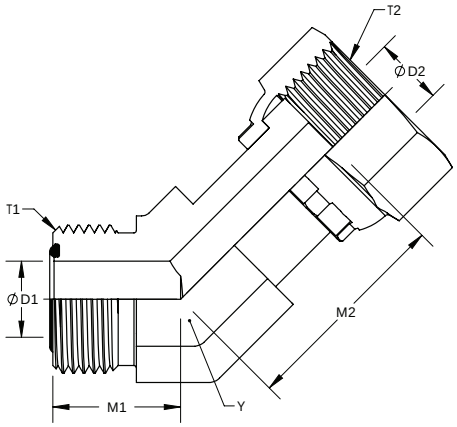


WWF	Y HEX	T1	M1	D1	T2	M2	D2
4355X04X02	0.563	9/16-18	0.630	0.177	1/8-27	0.640	0.188
4355X04X04	0.563	9/16-18	0.630	0.177	1/4-18	0.860	0.281
4355X06X04	0.669	11/16-16	0.748	0.256	1/4-18	0.860	0.281
4355X06X06	0.669	11/16-16	0.748	0.256	3/8-18	0.950	0.406
4355X06X08	0.750	11/16-16	0.748	0.256	1/2-14	1.170	0.531
4355X08X06	0.750	13/16-16	0.800	0.374	3/8-18	0.950	0.406
4355X08X08	0.875	13/16-16	0.860	0.374	1/2-14	1.170	0.531
4355X08X12	1.063	13/16-16	0.860	0.374	3/4-14	1.300	0.719
4355X10X08	1.063	1-14	0.925	0.492	1/2-14	1.170	0.531
4355X12X08	1.188	1-3/16-12	1.024	0.610	1/2-14	1.170	0.531
4355X12X12	1.188	1-3/16-12	1.024	0.610	3/4-14	1.300	0.719
4355X16X16	1.438	1-7/16-12	1.181	0.807	1-11-1/2	1.480	0.938
4355X20X20	1.625	1-11/16-12	1.260	1.024	1-1/4-11-1/2	1.670	1.250

B

Description: **45° Swivel Elbow**
WWF Part No.: **4356**
WWF Stainless Part No.: **/**
SAE: **/**

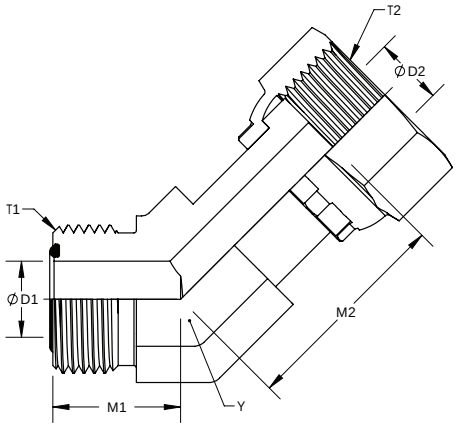
Air-Way: FS6502
Parker: V6LO
Aeroquip: FF2133T
Gates: /



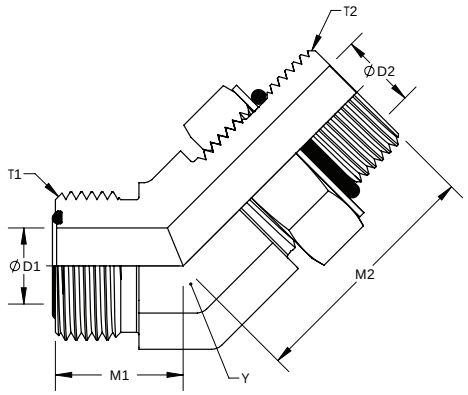
WWF	Y HEX	T1	M1	D1	T2	M2	D2
4356X04X04	0.563	9/16-18	0.630	0.177	9/16-18	0.990	0.157
4356X06X06	0.669	11/16-16	0.748	0.256	11/16-16	1.120	0.256
4356X08X08	0.750	13/16-16	0.807	0.374	13/16-16	1.320	0.354
4356X10X10	1.063	1-14	0.925	0.492	1-14	1.440	0.453
4356X12X12	1.188	1-3/16-12	1.024	0.610	1-3/16-12	1.730	0.551
4356X16X16	1.438	1-7/16-12	1.181	0.807	1-7/16-12	1.870	0.787

Description: **45° Swivel Elbow Metric Hex**
WWF Part No.: **4356MH**
WWF Stainless Part No.: **/**
SAE: **/**

Air-Way: FS6502-MH
Parker: /
Aeroquip: /
Gates: /



WWF	Y HEX	T1	M1	D1	T2	M2	D2
4356X06X06MH	0.669	11/16-16	0.748	0.256	11/16-16	1.102	0.256



Description: **45° Adjustable Stud Elbow**
WWF Part No.: **4365**
WWF Stainless Part No.: **/**
SAE: **520320**

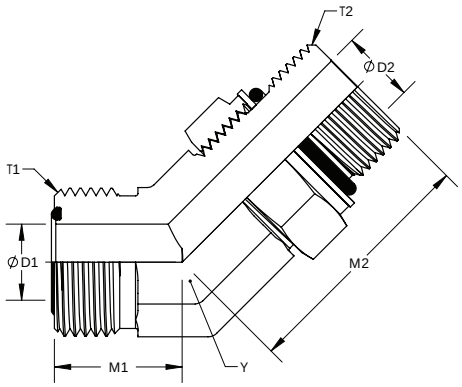
Air-Way: FS6802
Parker: V5OLO
Aeroquip: FF2068T
Gates: MFFOR-MB45

WWF	Y HEX	T1	M1	D1	T2	M2	D2
4365X04X03	0.563	9/16-18	0.630	0.177	3/8-24	1.102	0.118
4365X04X04	0.563	9/16-18	0.630	0.177	7/16-20	1.181	0.177
4365X04X06	0.669	9/16-18	0.689	0.177	9/16-18	1.300	0.295
4365X06X04	0.669	11/16-16	0.748	0.256	7/16-20	1.220	0.177
4365X06X06	0.669	11/16-16	0.748	0.256	9/16-18	1.300	0.295
4365X06X08	0.750	11/16-16	0.748	0.256	3/4-16	1.438	0.394
4365X06X10	1.063	11/16-16	0.787	0.256	7/8-14	1.752	0.492
4365X08X06	0.750	13/16-16	0.807	0.374	9/16-18	1.280	0.295
4365X08X08	0.750	13/16-16	0.807	0.374	3/4-16	1.438	0.394
4365X08X10	1.063	13/16-16	0.846	0.374	7/8-14	1.752	0.492
4365X08X12	1.188	13/16-16	0.886	0.374	1-1/16-12	1.969	0.610
4365X10X08	1.063	1-14	0.925	0.492	3/4-16	1.575	0.394
4365X10X10	1.063	1-14	0.925	0.492	7/8-14	1.752	0.492
4365X10X12	1.188	1-14	0.964	0.492	1-1/16-12	1.969	0.610
4365X12X08	1.188	1-3/16-12	1.024	0.610	3/4-16	1.634	0.394
4365X12X10	1.188	1-3/16-12	1.024	0.610	7/8-14	1.811	0.492
4365X12X12	1.188	1-3/16-12	1.024	0.610	1-1/16-12	1.969	0.610
4365X12X16	1.438	1-3/16-12	1.161	0.610	1-5/16-12	2.067	0.846
4365X16X12	1.438	1-7/16-12	1.181	0.807	1-1/16-12	2.028	0.610
4365X16X16	1.438	1-7/16-12	1.181	0.807	1-5/16-12	2.067	0.846
4365X16X20	1.625	1-7/16-12	1.260	0.807	1-5/8-12	2.106	1.082
4365X20X16	1.625	1-11/16-12	1.260	1.024	1-5/16-12	2.106	0.846
4365X20X20	1.625	1-11/16-12	1.260	1.024	1-5/8-12	2.106	1.082
4365X24X24	1.875	2-12	1.457	1.260	1-7/8-12	2.106	1.319

B

Description: **45° Adjustable Stud Elbow - Metric**
WWF Part No.: **4365M**
WWF Stainless Part No.: **/**
SAE: **52M0387**

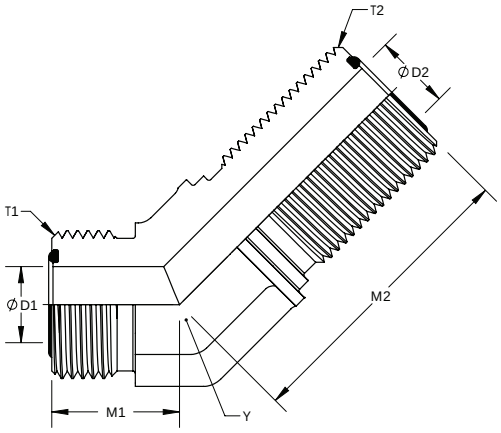
Air-Way: FS7300
Parker: V87OMLO
Aeroquip: /
Gates: /



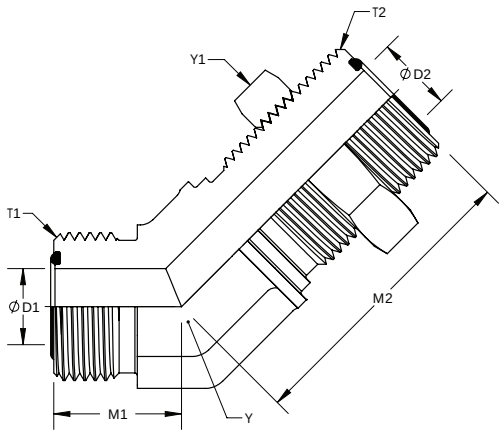
WWF	Y HEX	T1	M1	D1	T2	M2	D2
4365X04XM14	0.669	9/16-18	0.689	0.177	M14X1.5	1.240	0.236
4365X06XM14	0.669	11/16-16	0.748	0.256	M14X1.5	1.240	0.236
4365X06XM16	0.669	11/16-16	0.748	0.256	M16X1.5	1.319	0.276
4365X06XM18	0.748	11/16-16	0.748	0.256	M18X1.5	1.457	0.354
4365X08XM18	0.748	13/16-16	0.807	0.374	M18X1.5	1.457	0.354
4365X10XM22	0.945	1-14	0.925	0.492	M22X1.5	1.732	0.472
4365X16XM33	1.417	1-7/16-12	1.181	0.807	M33X2.0	2.067	0.787
4365X20XM42	1.614	1-11/16-12	1.260	1.024	M42X2.0	2.126	1.024

Description: **45° Bulkhead Elbow**
WWF Part No.: **4375**
WWF Stainless Part No.: **/**
SAE: **520801**

Air-Way: FS2702
Parker: WNLO
Aeroquip: /
Gates: /



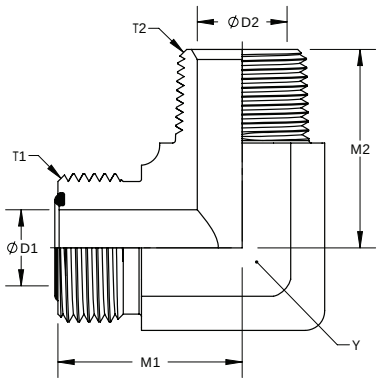
WWF	Y HEX	T1	M1	D1	T2	M2	D2
4375X04X04	0.563	9/16-18	0.630	0.177	9/16-18	1.732	0.177
4375X06X06	0.669	11/16-16	0.748	0.256	11/16-16	1.909	0.256
4375X08X08	0.750	13/16-16	0.807	0.374	13/16-16	2.008	0.374
4375X10X08	1.063	1-14	0.925	0.492	13/16-16	2.126	0.374
4375X10X10	1.063	1-14	0.925	0.492	1-14	2.224	0.492
4375X12X12	1.188	1-3/16-12	1.024	0.610	1-3/16-12	2.382	0.610
4375X16X16	1.438	1-7/16-12	1.181	0.807	1-7/16-12	2.560	0.807
4375X20X20	1.625	1-11/16-12	1.260	1.024	1-11/16-12	2.638	1.024
4375X24X24	1.875	2-12	1.457	1.260	2-12	2.638	1.260



Description: **45° Bulkhead Elbow With Locknut**
WWF Part No.: **4375LN**
WWF Stainless Part No.: ***/***
SAE: **520801**

Air-Way: FS2702-LN
Parker: WNLO-WLN
Aeroquip: FF2144T
Gates: /

WWF	Y HEX	Y1 HEX	T1	M1	D1	T2	M2	D2
4375X04X04LN	0.563	0.813	9/16-18	0.630	0.177	9/16-18	1.732	0.177
4375X06X06LN	0.669	1.000	11/16-16	0.748	0.256	11/16-16	1.909	0.256
4375X08X08LN	0.750	1.125	13/16-16	0.807	0.374	13/16-16	2.008	0.374
4375X10X08LN	1.063	1.125	1-14	0.925	0.492	13/16-16	2.126	0.374
4375X10X10LN	1.063	1.313	1-14	0.925	0.492	1-14	2.224	0.492
4375X12X12LN	1.188	1.500	1-3/16-12	1.024	0.610	1-3/16-12	2.382	0.610
4375X16X16LN	1.438	1.750	1-7/16-12	1.181	0.807	1-7/16-12	2.560	0.807
4375X20X20LN	1.625	2.000	1-11/16-12	1.260	1.024	1-11/16-12	2.638	1.024
4375X24X24LN	1.875	2.375	2-12	1.457	1.260	2-12	2.638	1.260



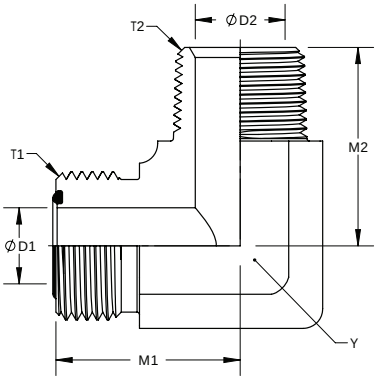
Description: **90° Male Elbow**
WWF Part No.: **4405**
WWF Stainless Part No.: ***/***
SAE: ***/***

Air-Way: FS2501
Parker: CLO
Aeroquip: FF2032T
Gates: /

WWF	Y HEX	T1	M1	D1	T2	M2	D2
4405X04X02	0.563	9/16-18	0.846	0.177	1/8-27	0.800	0.188
4405X04X04	0.563	9/16-18	0.846	0.177	1/4-18	1.120	0.281
4405X04X06	0.750	9/16-18	0.972	0.177	3/8-18	1.220	0.406
4405X04X08	0.875	9/16-18	1.070	0.177	1/2-14	1.470	0.531
4405X06X04	0.669	11/16-16	0.984	0.256	1/4-18	1.090	0.281
4405X06X06	0.750	11/16-16	0.984	0.256	3/8-18	1.220	0.406
4405X06X08	0.875	11/16-16	1.150	0.256	1/2-14	1.470	0.531
4405X08X04	0.750	13/16-16	1.102	0.374	1/4-18	1.220	0.281
4405X08X06	0.750	13/16-16	1.102	0.374	3/8-18	1.220	0.406
4405X08X08	0.875	13/16-16	1.102	0.374	1/2-14	1.470	0.531

Continued on page 68

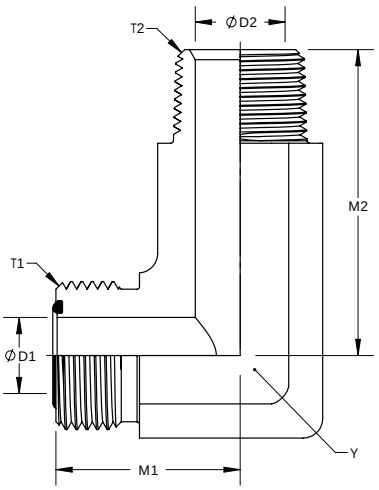
Continued from page 67



Description: **90° Male Elbow**
WWF Part No.: **4405**
WWF Stainless Part No.: **/**
SAE: **/**

Air-Way: FS2501
Parker: CLO
Aeroquip: FF2032T
Gates: /

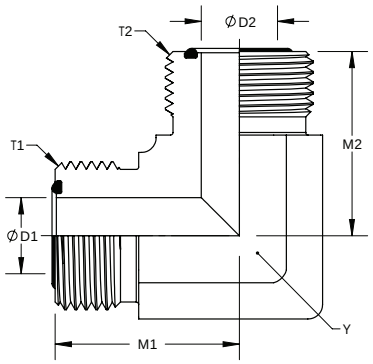
WWF	Y HEX	T1	M1	D1	T2	M2	D2
4405X08X12	1.063	13/16-16	1.327	0.374	3/4-14	1.590	0.719
4405X10X08	1.063	1-14	1.319	0.492	1/2-14	1.470	0.531
4405X10X12	1.188	1-14	1.410	0.492	3/4-14	1.590	0.719
4405X10X16	1.313	1-14	1.555	0.492	1-11-1/2	1.970	0.938
4405X12X08	1.188	1-3/16-12	1.476	0.610	1/2-14	1.590	0.531
4405X12X12	1.188	1-3/16-12	1.476	0.610	3/4-14	1.590	0.719
4405X12X16	1.313	1-3/16-12	1.620	0.610	1-11-1/2	1.970	0.938
4405X16X12	1.438	1-7/16-12	1.634	0.807	3/4-14	1.780	0.719
4405X16X16	1.438	1-7/16-12	1.634	0.807	1-11-1/2	1.970	0.938
4405X20X16	1.625	1-11/16-12	1.752	1.024	1-11-1/2	2.350	0.938
4405X20X20	1.625	1-11/16-12	1.752	1.024	1-1/4-11-1/2	2.380	1.250



Description: **90° Male Elbow Long**
WWF Part No.: **4405L**
WWF Stainless Part No.: **/**
SAE: **/**

Air-Way: FS2501-L
Parker: /
Aeroquip: /
Gates: /

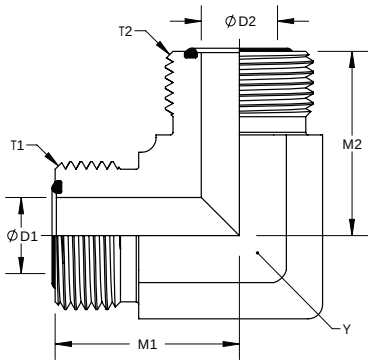
WWF	Y HEX	T1	M1	D1	T2	M2	D2
4405X08X08L	0.875	13/16-16	1.102	0.374	1/2-14	1.820	0.531
4405X12X12L	1.188	1-3/16-12	1.476	0.610	3/4-14	2.440	0.719



Description: **90° Union Elbow**
WWF Part No.: **4505**
WWF Stainless Part No.: **/**
SAE: **520201**

Air-Way: FS2500
Parker: ELO
Aeroquip: FF2035T
Gates: /

WWF	Y HEX	T1	M1	D1	T2	M2	D2
4505X04X04	0.563	9/16-18	0.846	0.177	9/16-18	0.846	0.177
4505X06X04	0.669	11/16-16	0.984	0.256	9/16-18	0.925	0.177
4505X06X06	0.669	11/16-16	0.984	0.256	11/16-16	0.984	0.256
4505X08X08	0.750	13/16-16	1.102	0.374	13/16-16	1.102	0.374
4505X10X10	1.063	1-14	1.319	0.492	1-14	1.319	0.492
4505X12X08	1.188	1-3/16-12	1.476	0.610	13/16-16	1.338	0.374
4505X12X12	1.188	1-3/16-12	1.476	0.610	1-3/16-12	1.476	0.610
4505X16X16	1.438	1-7/16-12	1.634	0.807	1-7/16-12	1.634	0.807
4505X20X20	1.625	1-11/16-12	1.752	1.024	1-11/16-12	1.752	1.024
4505X24X24	1.875	2-12	1.929	1.260	2-12	1.929	1.260

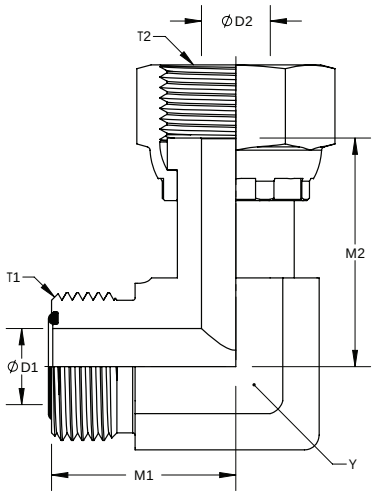


Description: **90° Union Elbow Metric Hex**
WWF Part No.: **4505MH**
WWF Stainless Part No.: **/**
SAE: **52M0201**

Air-Way: FS2500-MH
Parker: EMLO
Aeroquip: /
Gates: /

WWF	Y HEX	T1	M1	D1	T2	M2	D2
4505X10X10MH	0.945	1-14	1.319	0.492	1-14	1.319	0.492

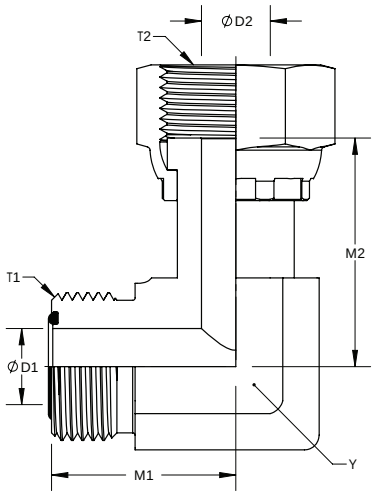
B



Description: **90° Swivel Elbow**
WWF Part No.: **4506**
WWF Stainless Part No.: **/**
SAE: **520221**

Air-Way: FS6500
Parker: C6LO
Aeroquip: FF2098T
Gates: MFFOR-FFORX90

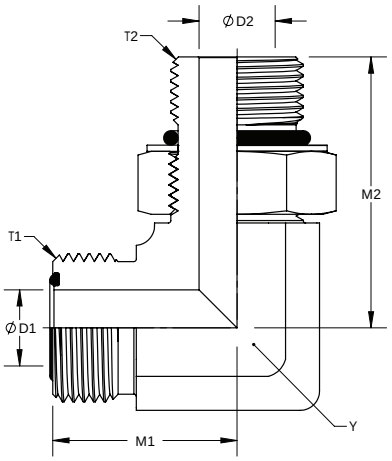
WWF	Y HEX	T1	M1	D1	T2	M2	D2
4506X04X04	0.563	9/16-18	0.846	0.177	9/16-18	1.043	0.157
4506X04X06	0.669	9/16-18	0.925	0.177	11/16-16	1.142	0.256
4506X06X06	0.669	11/16-16	0.984	0.256	11/16-16	1.142	0.256
4506X08X06	0.750	13/16-16	1.102	0.374	11/16-16	1.378	0.256
4506X08X08	0.750	13/16-16	1.102	0.374	13/16-16	1.496	0.354
4506X08X12	1.188	13/16-16	1.338	0.374	1-3/16-16	1.831	0.551
4506X10X10	1.063	1-14	1.319	0.492	1-14	1.614	0.453
4506X12X12	1.188	1-3/16-12	1.476	0.610	1-3/16-12	1.831	0.551
4506X16X16	1.438	1-7/16-12	1.634	0.807	1-7/16-12	2.106	0.787
4506X20X20	1.625	1-11/16-12	1.752	1.024	1-11/16-12	2.283	1.024
4506X24X20	1.875	2-12	1.929	1.260	1-11/16-12	2.401	1.024
4506X24X24	1.875	2-12	1.929	1.260	2-12	2.401	1.260



Description: **90° Swivel Elbow Metric Hex**
WWF Part No.: **4506MH**
WWF Stainless Part No.: **/**
SAE: **52M0221**

Air-Way: FS6500-MH
Parker: C6MLO
Aeroquip: /
Gates: /

WWF	Y HEX	T1	M1	D1	T2	M2	D2
4506X04X04MH	0.551	9/16-18	0.846	0.177	9/16-18	1.043	0.157
4506X06X06MH	0.669	11/16-16	0.984	0.256	11/16-16	1.142	0.256
4506X10X10MH	0.945	1-14	1.319	0.492	1-14	1.614	0.453
4506X12X12MH	1.063	1-3/16-12	1.476	0.610	1-3/16-12	1.831	0.551
4506X16X16MH	1.417	1-7/16-12	1.634	0.807	1-7/16-12	2.106	0.787

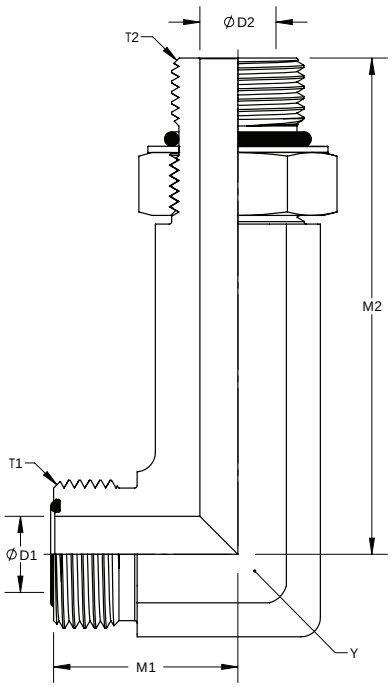


Description: **90° Adjustable Stud Elbow**
WWF Part No.: **4515**
WWF Stainless Part No.: **/**
SAE: **520220**

Air-Way: FS6801
Parker: C5OLO
Aeroquip: FF1868T
Gates: MFFOR-MB90

WWF	Y HEX	T1	M1	D1	T2	M2	D2
4515X04X04	0.563	9/16-18	0.846	0.177	7/16-20	1.299	0.177
4515X04X05	0.669	9/16-18	0.925	0.177	1/2-20	1.398	0.236
4515X04X06	0.669	9/16-18	0.925	0.177	9/16-18	1.457	0.295
4515X04X08	0.750	9/16-18	0.984	0.177	3/4-16	1.594	0.394
4515X06X04	0.669	11/16-16	0.984	0.256	7/16-20	1.378	0.177
4515X06X05	0.669	11/16-16	0.984	0.256	1/2-20	1.378	0.236
4515X06X06	0.669	11/16-16	0.984	0.256	9/16-18	1.457	0.295
4515X06X08	0.750	11/16-16	1.043	0.256	3/4-16	1.594	0.394
4515X06X10	1.063	11/16-16	1.181	0.256	7/8-14	1.969	0.492
4515X06X12	1.188	11/16-16	1.280	0.256	1-1/16-12	2.165	0.610
4515X06X16	1.438	11/16-16	1.417	0.256	1-5/16-12	2.342	0.846
4515X08X04	0.750	13/16-16	1.102	0.374	7/16-20	1.358	0.177
4515X08X06	0.750	13/16-16	1.102	0.374	9/16-18	1.438	0.295
4515X08X08	0.750	13/16-16	1.102	0.374	3/4-16	1.594	0.394
4515X08X10	1.063	13/16-16	1.240	0.374	7/8-14	1.969	0.492
4515X08X12	1.188	13/16-16	1.338	0.374	1-1/16-12	2.165	0.610
4515X08X16	1.438	13/16-16	1.476	0.374	1-5/16-12	2.342	0.846
4515X10X08	1.063	1-14	1.319	0.492	3/4-16	1.811	0.394
4515X10X10	1.063	1-14	1.319	0.492	7/8-14	1.969	0.492
4515X10X12	1.188	1-14	1.417	0.492	1-1/16-12	2.165	0.610
4515X12X08	1.188	1-3/16-12	1.476	0.610	3/4-16	1.831	0.394
4515X12X10	1.188	1-3/16-12	1.476	0.610	7/8-14	2.008	0.492
4515X12X12	1.188	1-3/16-12	1.476	0.610	1-1/16-12	2.165	0.610
4515X12X16	1.438	1-3/16-12	1.614	0.610	1-5/16-12	2.342	0.846
4515X16X12	1.438	1-7/16-12	1.634	0.807	1-1/16-12	2.303	0.610
4515X16X14	1.438	1-7/16-12	1.634	0.807	1-3/16-12	2.303	0.669
4515X16X16	1.438	1-7/16-12	1.634	0.807	1-5/16-12	2.342	0.846
4515X16X20	1.625	1-7/16-12	1.752	0.807	1-5/8-12	2.441	1.083
4515X20X12	1.625	1-11/16-12	1.752	1.024	1-1/16-12	2.402	0.610
4515X20X16	1.625	1-11/16-12	1.752	1.024	1-5/16-12	2.441	0.846
4515X20X20	1.625	1-11/16-12	1.752	1.024	1-5/8-12	2.441	1.083
4515X20X24	1.875	1-11/16-12	1.929	1.024	1-7/8-12	2.598	1.319
4515X24X20	1.875	2-12	1.929	1.260	1-5/8-12	2.598	1.083
4515X24X24	1.875	2-12	1.929	1.260	1-7/8-12	2.598	1.319

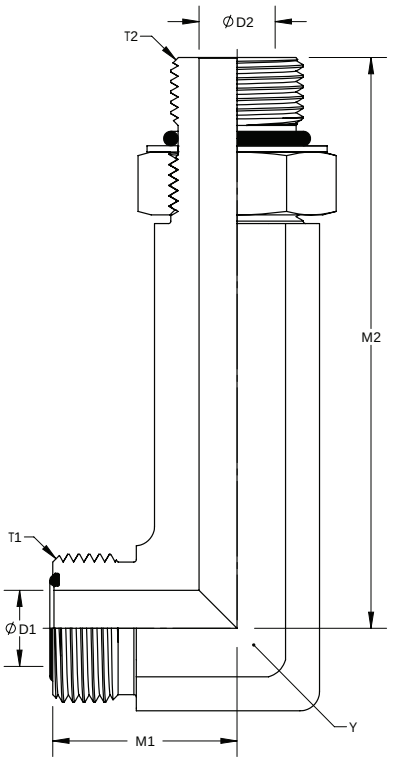
B



Description: **90° Adjustable Stud Elbow Long**
WWF Part No.: **4515L**
WWF Stainless Part No.: **/**
SAE: **521520**

Air-Way: FS6801-L
Parker: CC5OLO
Aeroquip: FF2227T
Gates: /

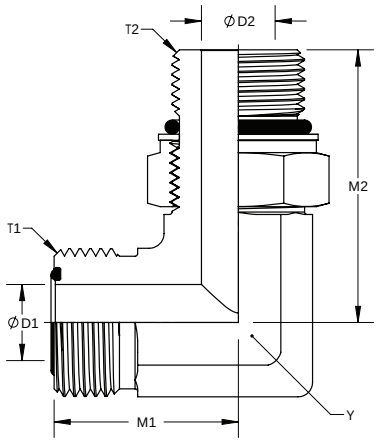
WWF	Y HEX	T1	M1	D1	T2	M2	D2
4515X04X04L	0.563	9/16-18	0.846	0.177	7/16-20	2.224	0.177
4515X06X06L	0.669	11/16-16	0.984	0.256	9/16-18	2.618	0.295
4515X08X08L	0.750	13/16-16	1.102	0.374	3/4-16	2.953	0.394
4515X10X10L	1.063	1-14	1.319	0.492	7/8-14	3.504	0.492
4515X12X12L	1.188	1-3/16-12	1.476	0.610	1-1/16-12	3.976	0.610
4515X16X16L	1.438	1-7/16-12	1.634	0.807	1-5/16-12	4.508	0.846
4515X20X20L	1.625	1-11/16-12	1.752	1.024	1-5/8-12	4.980	1.083



Description: **90° Adjustable Stud Elbow Extra Long**
WWF Part No.: **4515LL**
WWF Stainless Part No.: **/**
SAE: **/**

Air-Way: FS6801-LL
Parker: /
Aeroquip: /
Gates: /

WWF	Y HEX	T1	M1	D1	T2	M2	D2
4515X10X10LL	1.063	1-14	1.319	0.492	7/8-14	3.990	0.492



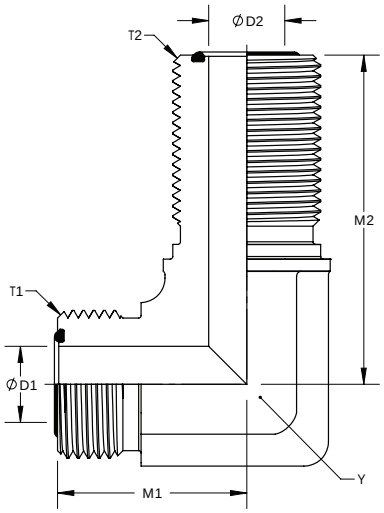
B

Description: **90° Adjustable Stud Elbow - Metric**
WWF Part No.: **4515M**
WWF Stainless Part No.: **/**
SAE: **52M0287**

Air-Way: FS7205
Parker: C87OMLO
Aeroquip: /
Gates: /

WWF	Y HEX	T1	M1	D1	T2	M2	D2
4515X04XM12	0.551	9/16-18	0.846	0.177	M12X1.5	1.299	0.157
4515X04XM14	0.669	9/16-18	0.925	0.177	M14X1.5	1.398	0.236
4515X06XM12	0.669	11/16-16	0.984	0.256	M12X1.5	1.398	0.157
4515X06XM14	0.669	11/16-16	0.984	0.256	M14X1.5	1.398	0.236
4515X06XM16	0.669	11/16-16	0.984	0.256	M16X1.5	1.476	0.276
4515X06XM18	0.748	11/16-16	1.043	0.256	M18X1.5	1.614	0.354
4515X08XM14	0.748	13/16-16	1.102	0.374	M14X1.5	1.417	0.236
4515X08XM16	0.748	13/16-16	1.102	0.374	M16X1.5	1.496	0.276
4515X08XM18	0.748	13/16-16	1.102	0.374	M18X1.5	1.614	0.354
4515X08XM22	0.945	13/16-16	1.240	0.374	M22X1.5	1.929	0.472
4515X08XM30	1.417	13/16-16	1.476	0.374	M30X2.0	2.342	0.669
4515X10XM18	0.945	1-14	1.319	0.492	M18X1.5	1.870	0.354
4515X10XM22	0.945	1-14	1.319	0.492	M22X1.5	1.929	0.472
4515X10XM27	1.063	1-14	1.417	0.492	M27X2.0	2.185	0.590
4515X12XM22	1.063	1-3/16-12	1.476	0.610	M22X1.5	1.929	0.472
4515X12XM27	1.063	1-3/16-12	1.476	0.610	M27X2.0	2.185	0.590
4515X16XM33	1.417	1-7/16-12	1.634	0.807	M33X2.0	2.342	0.787
4515X20XM33	1.614	1-11/16-12	1.752	1.024	M33X2.0	2.441	0.787
4515X20XM42	1.614	1-11/16-12	1.752	1.024	M42X2.0	2.480	1.024
4515X20XM48	1.969	1-11/16-12	1.929	1.024	M48X2.0	2.815	1.260

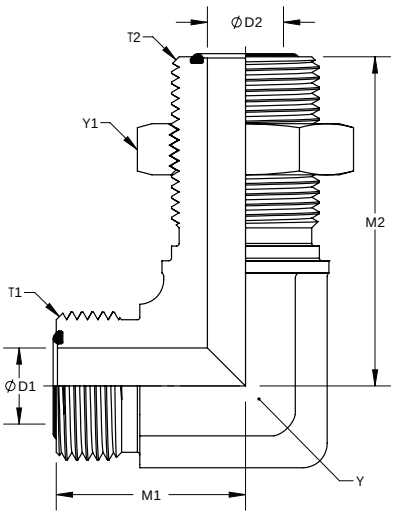
B



Description: **90° Bulkhead Elbow**
WWF Part No.: **4525**
WWF Stainless Part No.: **/**
SAE: **520701**

Air-Way: FS2701
Parker: WELO
Aeroquip: /
Gates: /

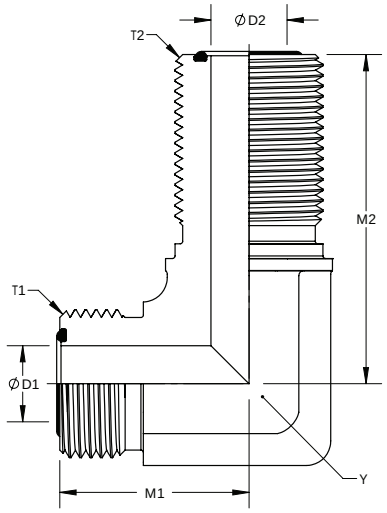
WWF	Y HEX	T1	M1	D1	T2	M2	D2
4525X04X04	0.563	9/16-18	0.886	0.177	9/16-18	1.850	0.177
4525X06X06	0.669	11/16-16	1.023	0.256	11/16-16	2.047	0.256
4525X08X08	0.750	13/16-16	1.142	0.374	13/16-16	2.185	0.374
4525X10X10	1.063	1-14	1.358	0.492	1-14	2.480	0.492
4525X12X12	1.188	1-3/16-12	1.516	0.610	1-3/16-12	2.638	0.610
4525X16X16	1.438	1-7/16-12	1.673	0.807	1-7/16-12	2.795	0.807
4525X20X20	1.625	1-11/16-12	1.791	1.024	1-11/16-12	2.972	1.024
4525X24X24	1.875	2-12	1.949	1.260	2-12	3.130	1.260



Description: **90° Bulkhead Elbow With Locknut**
WWF Part No.: **4525LN**
WWF Stainless Part No.: **/**
SAE: **520701**

Air-Way: FS2701-LN
Parker: WELO-WLN
Aeroquip: FF2030T
Gates: /

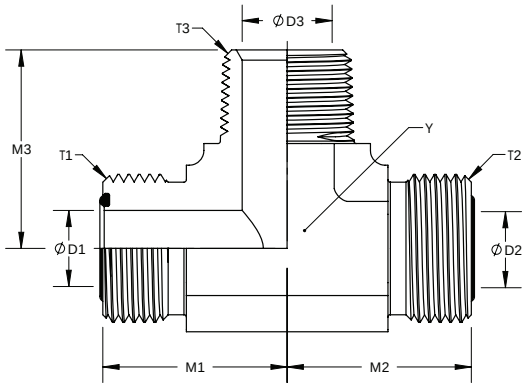
WWF	Y HEX	Y1 HEX	T1	M1	D1	T2	M2	D2
4525X04X04LN	0.563	0.813	9/16-18	0.886	0.177	9/16-18	1.850	0.177
4525X06X06LN	0.669	1.000	11/16-16	1.023	0.256	11/16-16	2.047	0.256
4525X08X08LN	0.750	1.125	13/16-16	1.142	0.374	13/16-16	2.185	0.374
4525X10X10LN	1.063	1.313	1-14	1.358	0.492	1-14	2.480	0.492
4525X12X12LN	1.188	1.500	1-3/16-12	1.516	0.610	1-3/16-12	2.638	0.610
4525X16X16LN	1.438	1.750	1-7/16-12	1.673	0.807	1-7/16-12	2.795	0.807
4525X20X20LN	1.625	2.000	1-11/16-12	1.791	1.024	1-11/16-12	2.972	1.024
4525X24X24LN	1.875	2.375	2-12	1.949	1.260	2-12	3.130	1.260



Description: **90° Bulkhead Elbow Metric Hex**
WWF Part No.: **4525MH**
WWF Stainless Part No.: **/**
SAE: **52M0701**

Air-Way: FS2701-MH
Parker: WEMLO
Aeroquip: /
Gates: /

WWF	Y HEX	T1	M1	D1	T2	M2	D2
4525X10X10MH	0.945	1-14	1.358	0.492	1-14	2.480	0.492
4525X12X12MH	1.063	1-3/16-12	1.516	0.610	1-3/16-12	2.638	0.610
4525X16X16MH	1.417	1-7/16-12	1.673	0.807	1-7/16-12	2.795	0.807



Description: **Male Branch Tee**
WWF Part No.: **4605**
WWF Stainless Part No.: **/**
SAE: **520425**

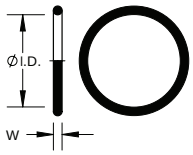
Air-Way: FS2601
Parker: SLO
Aeroquip: FF2001T
Gates: /

WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
4605X04X04X04	0.563	9/16-18	0.846	0.177	9/16-18	0.846	0.177	1/4-18	1.090	0.281
4605X06X06X04	0.669	11/16-16	0.984	0.256	11/16-16	0.984	0.256	1/4-18	1.090	0.281
4605X06X06X06	0.750	11/16-16	0.984	0.256	11/16-16	0.984	0.256	3/8-18	1.220	0.406
4605X08X08X06	0.750	13/16-16	1.102	0.374	13/16-16	1.102	0.374	3/8-18	1.220	0.406
4605X08X08X08	0.875	13/16-16	1.102	0.374	13/16-16	1.102	0.374	1/2-14	1.470	0.531
4605X12X12X12	1.188	1-3/16-12	1.476	0.610	1-3/16-12	1.476	0.610	3/4-14	1.590	0.719
4605X16X16X16	1.438	1-7/16-12	1.634	0.807	1-7/16-12	1.634	0.807	1-11-1/2	1.970	0.938
4605X20X20X20	1.625	1-11/16-12	1.752	1.024	1-11/16-12	1.752	1.024	1-1/4-11-1/2	2.380	1.250

B

Description: **"O" Ring**
WWF Part No.: **4629**
WWF Stainless Part No.: **/**
SAE: **/**

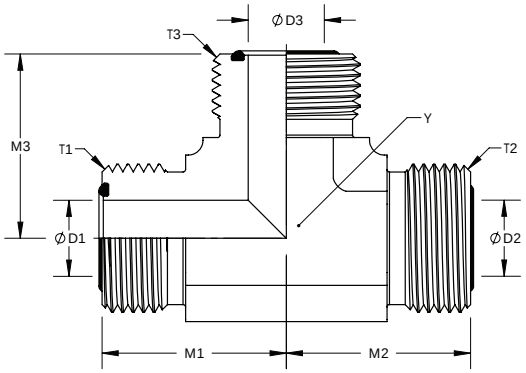
Air-Way: FS4000
Parker: "O" Ring
Aeroquip: /
Gates: ORFF



WWF	I.D.	W
4629X04	0.301	0.070
4629X06	0.364	0.070
4629X08	0.489	0.070
4629X10	0.614	0.070
4629X12	0.739	0.070
4629X16	0.926	0.070
4629X20	1.176	0.070
4629X24	1.489	0.070

Description: **Union Tee**
WWF Part No.: **4705**
WWF Stainless Part No.: **/**
SAE: **520401**

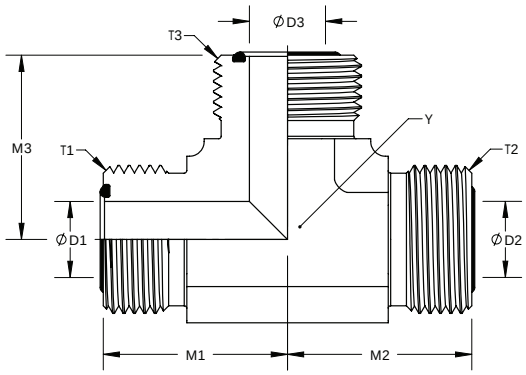
Air-Way: FS2603
Parker: JLO
Aeroquip: FF1898T
Gates: /



WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
4705X04X04X04	0.563	9/16-18	0.846	0.177	9/16-18	0.846	0.177	9/18-18	0.846	0.177
4705X06X06X06	0.669	11/16-16	0.984	0.256	11/16-16	0.984	0.256	11/16-16	0.984	0.256
4705X06X06X08	0.750	11/16-16	1.043	0.256	11/16-16	1.043	0.256	13/16-16	1.102	0.374
4705X08X06X08	0.750	13/16-16	1.102	0.374	11-16-16	1.043	0.256	13/16-16	1.102	0.374
4705X08X08X06	0.750	13/16-16	1.102	0.374	13/16-16	1.102	0.374	11/16-16	1.043	0.256
4705X08X08X08	0.750	13/16-16	1.102	0.374	13/16-16	1.102	0.374	13/16-16	1.102	0.374
4705X10X10X10	1.063	1-14	1.319	0.492	1-14	1.319	0.492	1-14	1.319	0.492
4705X10X10X12	1.188	1-14	1.417	0.492	1-14	1.417	0.492	1-3/16-12	1.476	0.610
4705X12X12X04	1.188	1-3/16-12	1.476	0.610	1-3/16-12	1.476	0.610	9/16-18	1.201	0.177
4705X12X12X06	1.188	1-3/16-12	1.476	0.610	1-3/16-12	1.476	0.610	11/16-16	1.280	0.256
4705X12X12X12	1.188	1-3/16-12	1.476	0.610	1-3/16-12	1.476	0.610	1-3/16-12	1.476	0.610
4705X12X12X16	1.438	1-3/16-12	1.614	0.610	1-3/16-12	1.614	0.610	1-7/16-12	1.634	0.807

Continued on page 77

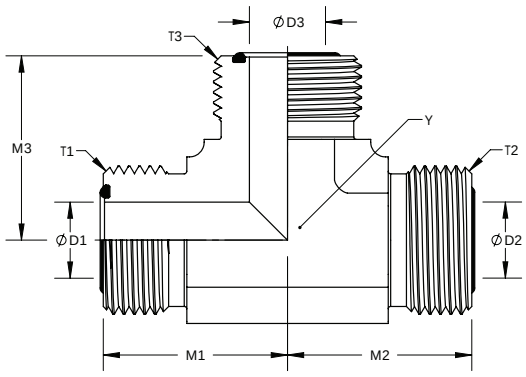
Continued from page 76



Description: **Union Tee**
WWF Part No.: **4705**
WWF Stainless Part No.: ***/***
SAE: **520401**

Air-Way: FS2603
Parker: JLO
Aeroquip: FF1898T
Gates: /

WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
4705X16X16X12	1.438	1-7/16-12	1.634	0.807	1-7/16-12	1.634	0.807	1-3/16-12	1.614	0.610
4705X16X16X16	1.438	1-7/16-12	1.634	0.807	1-7/16-12	1.634	0.807	1-7/16-12	1.634	0.807
4705X20X20X16	1.625	1-11/16-12	1.752	1.024	1-11/16-12	1.752	1.024	1-7/16-12	1.752	0.807
4705X20X20X20	1.625	1-11/16-12	1.752	1.024	1-11/16-12	1.752	1.024	1-11/16-12	1.752	1.024
4705X24X24X24	1.875	2-12	1.929	1.260	2-12	1.929	1.260	2-12	1.929	1.260



Description: **Union Tee Metric Hex**
WWF Part No.: **4705MH**
WWF Stainless Part No.: ***/***
SAE: **52M0401**

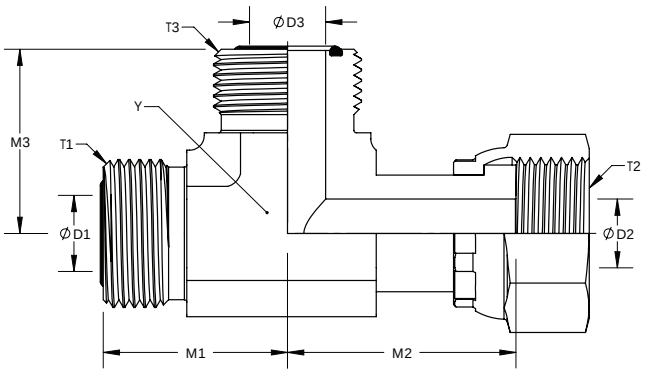
Air-Way: FS2603-MH
Parker: JMLO
Aeroquip: /
Gates: /

WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
4705X16X16X16MH	1.417	1-7/16-12	1.634	0.807	1-7/16-12	1.634	0.807	1-7/16-12	1.634	0.807
4705X20X20X20MH	1.614	1-11/16-12	1.752	1.024	1-11/16-12	1.752	1.024	1-11/16-12	1.752	1.024

B

Description: **Swivel Run Tee**
WWF Part No.: **4706**
WWF Stainless Part No.: **/**
SAE: **520432**

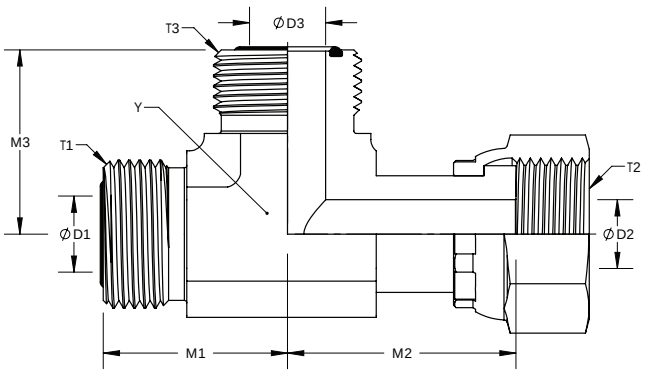
Air-Way: FS6602
Parker: R6LO
Aeroquip: FF2114T
Gates: /



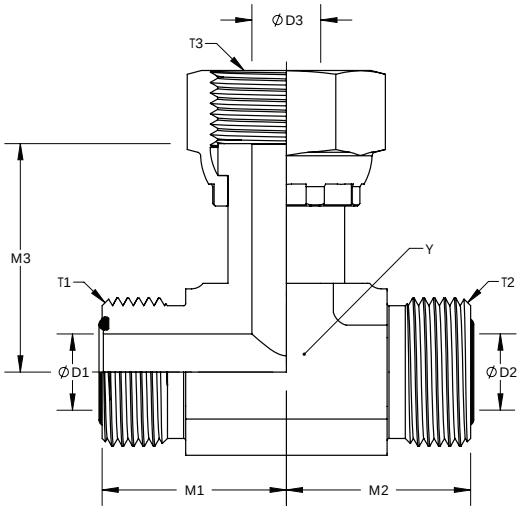
WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
4706X04X04X04	0.563	9/16-18	0.846	0.177	9/16-18	1.043	0.157	9/16-18	0.846	0.177
4706X06X06X06	0.669	11/16-16	0.984	0.256	11/16-16	1.142	0.256	11/16-16	0.984	0.256
4706X06X06X08	0.750	11/16-16	1.043	0.256	11/16-16	1.378	0.256	13/16-16	1.102	0.374
4706X08X08X08	0.750	13/16-16	1.102	0.374	13/16-16	1.496	0.354	13/16-16	1.102	0.374
4706X10X10X10	1.063	1-14	1.319	0.492	1-14	1.614	0.453	1-14	1.319	0.492
4706X12X10X10	1.188	1-3/16-12	1.476	0.610	1-14	1.732	0.453	1-14	1.417	0.492
4706X12X12X10	1.188	1-3/16-12	1.476	0.610	1-3/16-12	1.831	0.551	1-14	1.417	0.492
4706X12X12X12	1.188	1-3/16-12	1.476	0.610	1-3/16-12	1.831	0.551	1-3/16-12	1.476	0.610
4706X16X16X16	1.438	1-7/16-12	1.634	0.807	1-7/16-12	2.106	0.787	1-7/16-12	1.634	0.807
4706X20X20X20	1.625	1-11/16-12	1.752	1.024	1-11/16-12	2.283	1.024	1-11/16-12	1.752	1.024
4706X24X24X24	1.875	2-12	1.929	1.260	2-12	2.401	1.260	2-12	1.929	1.260

Description: **Swivel Run Tee Metric Hex**
WWF Part No.: **4706MH**
WWF Stainless Part No.: **/**
SAE: **52M0432**

Air-Way: FS6602-MH
Parker: R6MLO
Aeroquip: /
Gates: /



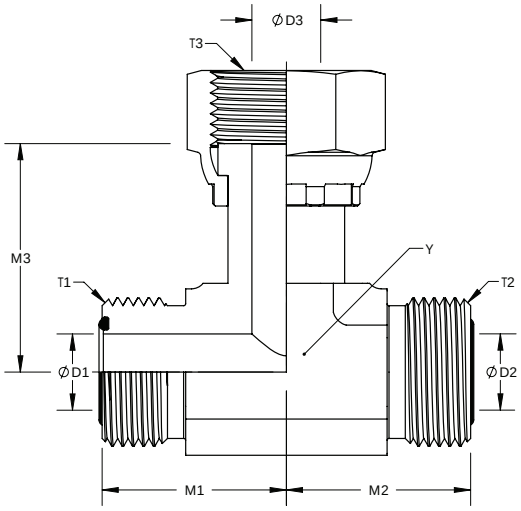
WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
4706X04X04X04MH	0.551	9/16-18	0.846	0.177	9/16-18	1.043	0.157	9/16-18	0.846	0.177
4706X06X06X06MH	0.669	11/16-16	0.984	0.256	11/16-16	1.142	0.256	11/16-16	0.984	0.256
4706X10X10X10MH	0.945	1-14	1.319	0.492	1-14	1.614	0.453	1-14	1.319	0.492
4706X12X12X12MH	1.063	1-3/16-12	1.476	0.610	1-3/16-12	1.831	0.551	1-3/16-12	1.476	0.610
4706X16X16X16MH	1.417	1-7/16-12	1.634	0.807	1-7/16-12	2.106	0.787	1-7/16-12	1.634	0.807
4706X20X20X20MH	1.614	1-11/16-12	1.752	1.024	1-11/16-12	2.283	1.024	1-11/16-12	1.752	1.024



Description: **Swivel Branch Tee**
WWF Part No.: **4707**
WWF Stainless Part No.: **/**
SAE: **520433**

Air-Way: FS6600
Parker: S6LO
Aeroquip: FF1857T
Gates: MFFOR-MFFOR-FFORX

WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
4707X04X04X04	0.563	9/16-18	0.846	0.177	9/16-18	0.846	0.177	9/18-18	1.043	0.157
4707X06X06X06	0.669	11/16-16	0.984	0.256	11/16-16	0.984	0.256	11/16-16	1.142	0.256
4707X08X08X08	0.750	13/16-16	1.102	0.374	13/16-16	1.102	0.374	13/16-16	1.496	0.354
4707X10X10X10	1.063	1-14	1.319	0.492	1-14	1.319	0.492	1-14	1.614	0.453
4707X12X12X12	1.188	1-3/16-12	1.476	0.610	1-3/16-12	1.476	0.610	1-3/16-12	1.831	0.551
4707X16X16X16	1.438	1-7/16-12	1.634	0.807	1-7/16-12	1.634	0.807	1-7/16-12	2.106	0.787
4707X20X20X20	1.625	1-11/16-12	1.752	1.024	1-11/16-12	1.752	1.024	1-11/16-12	2.283	1.024
4707X24X24X24	1.875	2-12	1.929	1.260	2-12	1.929	1.260	2-12	2.401	1.260



Description: **Swivel Branch Tee Metric Hex**
WWF Part No.: **4707MH**
WWF Stainless Part No.: **/**
SAE: **52M0433**

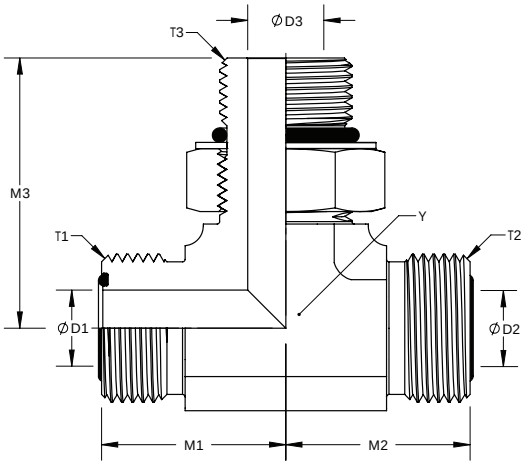
Air-Way: FS6600-MH
Parker: S6MLO
Aeroquip: /
Gates: /

WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
4707X10X10X10MH	0.945	1-14	1.319	0.492	1-14	1.319	0.492	1-14	1.614	0.453
4707X12X12X12MH	1.063	1-3/16-12	1.476	0.610	1-3/16-12	1.476	0.610	1-3/16-12	1.831	0.551
4707X20X20X20MH	1.614	1-11/16-12	1.752	1.024	1-11/16-12	1.752	1.024	1-11/16-12	2.283	1.024

B

Description: **Adjustable Stud Branch Tee**
WWF Part No.: **4715**
WWF Stainless Part No.: **/**
SAE: **520429**

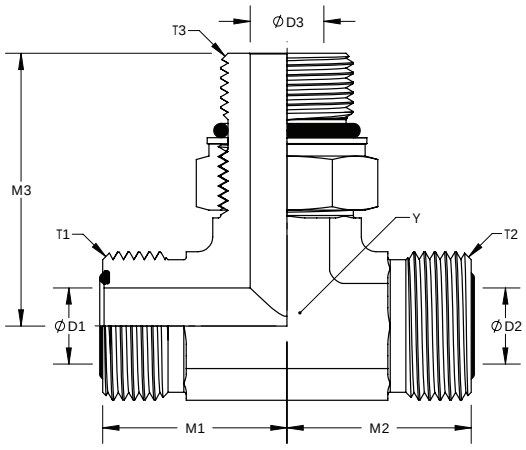
Air-Way: FS6803
Parker: S5OLO
Aeroquip: FF1861T
Gates: MFFOR-MFFOR-MB



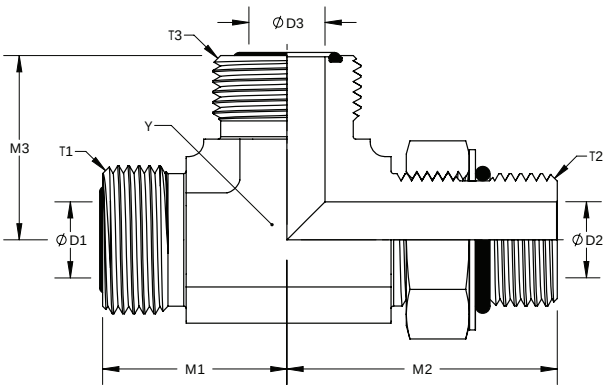
WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
4715X04X04X04	0.563	9/16-18	0.846	0.177	9/16-18	0.846	0.177	7/16-20	1.299	0.177
4715X06X06X06	0.669	11/16-16	0.984	0.256	11/16-16	0.984	0.256	9/16-18	1.457	0.295
4715X06X06X08	0.750	11/16-16	1.043	0.256	11/16-16	1.043	0.256	3/4-16	1.594	0.393
4715X08X08X06	0.750	13/16-16	1.102	0.374	13/16-16	1.102	0.374	9/16-18	1.438	0.295
4715X08X08X08	0.750	13/16-16	1.102	0.374	13/16-16	1.102	0.374	3/4-16	1.594	0.393
4715X10X10X10	1.063	1-14	1.319	0.492	1-14	1.319	0.492	7/8-14	1.969	0.492
4715X12X12X10	1.188	1-3/16-12	1.476	0.610	1-3/16-12	1.476	0.610	7/8-14	2.008	0.492
4715X12X12X12	1.188	1-3/16-12	1.476	0.610	1-3/16-12	1.476	0.610	1-1/16-12	2.165	0.610
4715X12X12X16	1.438	1-3/16-12	1.614	0.610	1-3/16-12	1.614	0.610	1-5/16-12	2.342	0.846
4715X16X16X16	1.438	1-7/16-12	1.634	0.807	1-7/16-12	1.634	0.807	1-5/16-12	2.342	0.846
4715X16X16X20	1.625	1-7/16-12	1.752	0.807	1-7/16-12	1.752	0.807	1-5/8-12	2.441	1.083
4715X20X20X20	1.625	1-11/16-12	1.752	1.024	1-11/16-12	1.752	1.024	1-5/8-12	2.441	1.083
4715X24X24X24	1.875	2-12	1.929	1.260	2-12	1.929	1.260	1-7/8-12	2.598	1.319

Description: **Adjustable Stud Branch Tee - Metric**
WWF Part No.: **4715M**
WWF Stainless Part No.: **/**
SAE: **52M0489**

Air-Way: FS7210
Parker: S87OMLO
Aeroquip: /
Gates: /



WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
4715X04X04XM12	0.551	9/16-18	0.846	0.177	9/16-18	0.846	0.177	M12X1.5	1.299	0.157
4715X04X04XM14	0.669	9/16-18	0.925	0.177	9/16-18	0.925	0.177	M14X1.5	1.397	0.236
4715X06X06XM14	0.669	11/16-16	0.984	0.256	11/16-16	0.984	0.256	M14X1.5	1.397	0.236
4715X06X06XM16	0.669	11/16-16	0.984	0.256	11/16-16	0.984	0.256	M16X1.5	1.476	0.276
4715X08X08XM14	0.748	13/16-16	1.102	0.374	13/16-16	1.102	0.374	M14X1.5	1.417	0.236
4715X08X08XM18	0.748	13/16-16	1.102	0.374	13/16-16	1.102	0.374	M18X1.5	1.614	0.354
4715X08X08XM22	0.945	13/16-16	1.240	0.374	13/16-16	1.240	0.374	M22X1.5	1.929	0.472
4715X10X10XM22	0.945	1-14	1.319	0.492	1-14	1.319	0.492	M22X1.5	1.929	0.472
4715X12X12XM27	1.063	1-3/16-12	1.476	0.610	1-3/16-12	1.476	0.610	M27X2.0	2.185	0.590
4715X16X16XM33	1.417	1-7/16-12	1.634	0.807	1-7/16-12	1.634	0.807	M33X2.0	2.342	0.787
4715X20X20XM42	1.614	1-11/16-12	1.752	1.024	1-11/16-12	1.752	1.024	M42X2.0	2.480	1.024
4715X24X24XM48	1.969	2-12	1.929	1.260	2-12	1.929	1.260	M48X2.0	2.815	1.260



Description: **Adjustable Stud Run Tee**
WWF Part No.: **4716**
WWF Stainless Part No.: **/**
SAE: **520428**

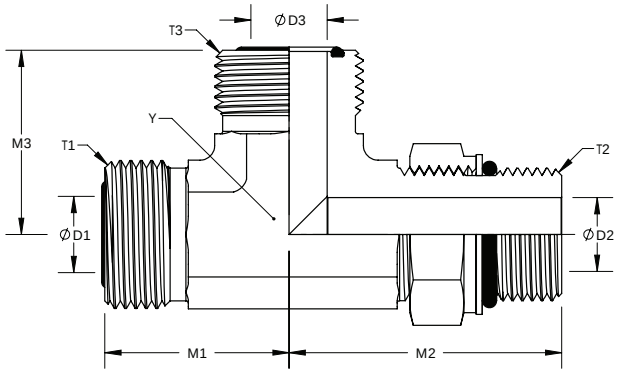
Air-Way: FS6804
Parker: R5OLO
Aeroquip: FF1865T
Gates: MFFOR-MB-MFFOR

B

WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
4716X04X04X04	0.563	9/16-18	0.846	0.177	7/16-20	1.299	0.177	9/18-18	0.846	0.177
4716X04X04X06	0.669	9/16-18	0.925	0.177	7/16-20	1.378	0.177	11/16-16	0.984	0.256
4716X04X06X04	0.669	9/16-18	0.925	0.177	9/16-18	1.457	0.295	9/18-18	0.925	0.177
4716X06X04X06	0.669	11/16-16	0.984	0.256	7/16-20	1.378	0.177	11/16-16	0.984	0.256
4716X06X06X06	0.669	11/16-16	0.984	0.256	9/16-18	1.457	0.295	11/16-16	0.984	0.256
4716X08X06X08	0.750	13/16-16	1.102	0.374	9/16-18	1.438	0.295	13/16-16	1.102	0.374
4716X08X08X08	0.750	13/16-16	1.102	0.374	3/4-16	1.594	0.394	13/16-16	1.102	0.374
4716X08X08X12	1.188	13/16-16	1.338	0.374	3/4-16	1.831	0.394	1-3/16-12	1.476	0.610
4716X08X10X08	1.063	13/16-16	1.240	0.374	7/8-14	1.969	0.492	13/16-16	1.240	0.374
4716X08X12X08	1.188	13/16-16	1.338	0.374	1-1/16-12	2.165	0.610	13/16-16	1.338	0.374
4716X08X16X08	1.438	13/16-16	1.476	0.374	1-5/16-12	2.342	0.846	13/16-16	1.476	0.374
4716X10X10X08	1.063	1-14	1.319	0.492	7/8-14	1.969	0.492	13/16-16	1.240	0.374
4716X10X10X10	1.063	1-14	1.319	0.492	7/8-14	1.969	0.492	1-14	1.319	0.492
4716X10X12X10	1.188	1-14	1.417	0.492	1-1/16-12	2.165	0.610	1-14	1.417	0.492
4716X10X12X12	1.188	1-14	1.417	0.492	1-1/16-12	2.165	0.610	1-3/16-12	1.476	0.610
4716X12X12X12	1.188	1-3/16-12	1.476	0.610	1-1/16-12	2.165	0.610	1-3/16-12	1.476	0.610
4716X12X12X16	1.438	1-3/16-12	1.614	0.610	1-1/16-12	2.303	0.610	1-7/16-12	1.634	0.807
4716X12X16X12	1.438	1-3/16-12	1.614	0.610	1-5/16-12	2.342	0.846	1-3/16-12	1.614	0.610
4716X12X16X16	1.438	1-3/16-12	1.614	0.610	1-5/16-12	2.342	0.846	1-7/16-12	1.634	0.807
4716X16X12X10	1.438	1-7/16-12	1.634	0.807	1-1/16-12	2.303	0.610	1-14	1.555	0.492
4716X16X16X12	1.438	1-7/16-12	1.634	0.807	1-5/16-12	2.342	0.846	1-3/16-12	1.614	0.610
4716X16X16X16	1.438	1-7/16-12	1.634	0.807	1-5/16-12	2.342	0.846	1-7/16-12	1.634	0.807
4716X16X16X20	1.625	1-7/16-12	1.752	0.807	1-5/16-12	2.441	0.846	1-11/16-12	1.752	1.024
4716X16X20X08	1.625	1-7/16-12	1.752	0.807	1-5/8-12	2.441	1.083	13/16-16	1.594	0.374
4716X20X20X20	1.625	1-11/16-12	1.752	1.024	1-5/8-12	2.441	1.083	1-11/16-12	1.752	1.024
4716X24X24X24	1.875	2-12	1.929	1.260	1-7/8-12	2.598	1.319	2-12	1.929	1.260

Description: **Adjustable Stud Run Tee - Metric**
WWF Part No.: **4716M**
WWF Stainless Part No.: **/**
SAE: **52M0488**

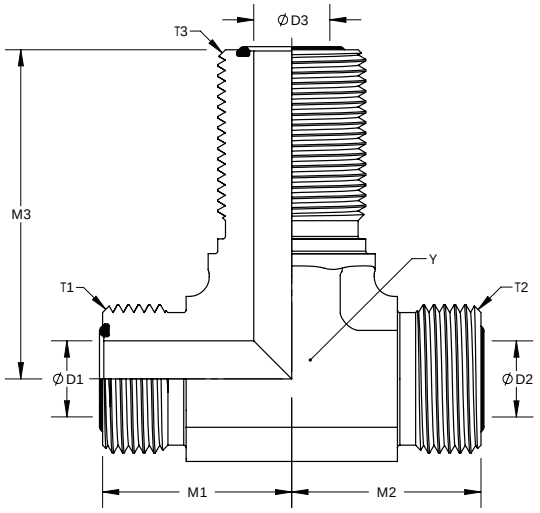
Air-Way: FS7215
Parker: R87OMLO
Aeroquip: /
Gates: /



B

WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
4716X04XM12X04	0.551	9/16-18	0.846	0.177	M12X1.5	1.299	0.157	9/16-18	0.846	0.177
4716X04XM14X04	0.669	9/16-18	0.945	0.177	M14X1.5	1.398	0.236	9/16-18	0.945	0.177
4716X06XM14X06	0.669	11/16-16	0.984	0.256	M14X1.5	1.398	0.236	11/16-16	0.984	0.256
4716X06XM16X06	0.669	11/16-16	0.984	0.256	M16X1.5	1.476	0.275	11/16-16	0.984	0.256
4716X08XM14X08	0.748	13/16-16	1.102	0.374	M14X1.5	1.417	0.236	13/16-16	1.102	0.374
4716X08XM18X08	0.748	13/16-16	1.102	0.374	M18X1.5	1.614	0.354	13/16-16	1.102	0.374
4716X08XM22X08	0.945	13/16-16	1.240	0.374	M22X1.5	1.929	0.472	13/16-16	1.240	0.374
4716X08XM33X20	1.614	13/16-16	1.752	0.374	M33X2.0	2.480	0.787	1-11/16-12	1.752	1.024
4716X10XM22X10	0.945	1-14	1.319	0.492	M22X1.5	1.929	0.472	1-14	1.319	0.492
4716X12XM27X12	1.063	1-3/16-12	1.476	0.610	M27X2.0	2.185	0.590	1-3/16-12	1.476	0.610
4716X16XM33X16	1.417	1-7/16-12	1.634	0.807	M33X2.0	2.342	0.787	1-7/16-12	1.634	0.807
4716X20XM42X20	1.614	1-11/16-12	1.752	1.024	M42X2.0	2.480	1.024	1-11/16-12	1.752	1.024
4716X24XM48X24	1.969	2-12	1.929	1.260	M48X2.0	2.815	1.260	2-12	1.929	1.260

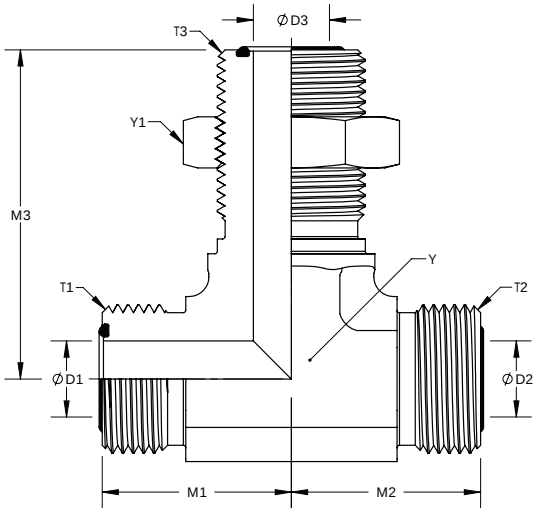
B



Description: **Bulkhead Branch Tee**
WWF Part No.: **4725**
WWF Stainless Part No.: **/**
SAE: **520959**

Air-Way: FS2703
Parker: WJLO
Aeroquip: /
Gates: /

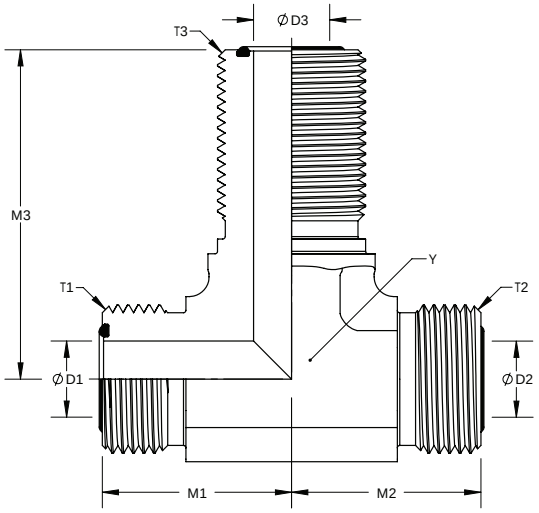
WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
4725X04X04X04	0.563	9/16-18	0.886	0.177	9/16-18	0.886	0.177	9/16-18	1.850	0.177
4725X06X06X06	0.669	11/16-16	1.024	0.256	11/16-16	1.024	0.256	11/16-16	2.047	0.256
4725X08X08X08	0.750	13/16-16	1.142	0.374	13/16-16	1.142	0.374	13/16-16	2.185	0.374
4725X10X10X10	1.063	1-14	1.358	0.492	1-14	1.358	0.492	1-14	2.480	0.492
4725X12X12X12	1.188	1-3/16-12	1.516	0.610	1-3/16-12	1.516	0.610	1-3/16-12	2.637	0.610
4725X16X16X16	1.438	1-7/16-12	1.673	0.807	1-7/16-12	1.673	0.807	1-7/16-12	2.795	0.807
4725X20X20X20	1.625	1-11/16-12	1.791	1.024	1-11/16-12	1.791	1.024	1-11/16-12	2.972	1.024
4725X24X24X24	1.875	2-12	1.949	1.260	2-12	1.949	1.260	2-12	3.130	1.260



Description: **Bulkhead Branch Tee With Locknut**
WWF Part No.: **4725LN**
WWF Stainless Part No.: **/**
SAE: **520959**

Air-Way: FS2703-LN
Parker: WJLO-WLN
Aeroquip: FF2033T
Gates: /

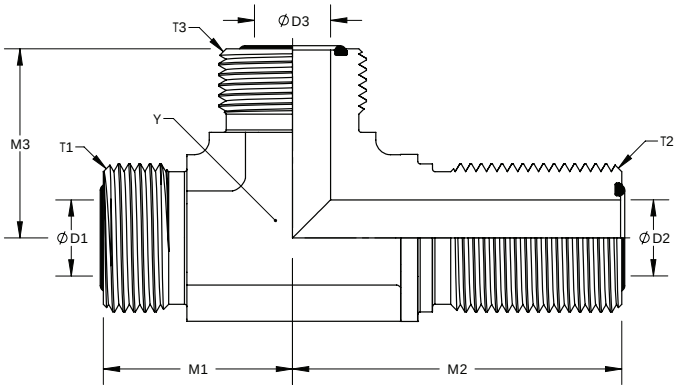
WWF	Y HEX	Y1 HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
4725X04X04X04LN	0.563	0.813	9/16-18	0.886	0.177	9/16-18	0.886	0.177	9/16-18	1.850	0.177
4725X06X06X06LN	0.669	1.000	11/16-16	1.024	0.256	11/16-16	1.024	0.256	11/16-16	2.047	0.256
4725X08X08X08LN	0.750	1.125	13/16-16	1.142	0.374	13/16-16	1.142	0.374	13/16-16	2.185	0.374
4725X10X10X10LN	1.063	1.313	1-14	1.358	0.492	1-14	1.358	0.492	1-14	2.480	0.492
4725X12X12X12LN	1.188	1.500	1-3/16-12	1.516	0.610	1-3/16-12	1.516	0.610	1-3/16-12	2.637	0.610
4725X16X16X16LN	1.438	1.750	1-7/16-12	1.673	0.807	1-7/16-12	1.673	0.807	1-7/16-12	2.795	0.807
4725X20X20X20LN	1.625	2.000	1-11/16-12	1.791	1.024	1-11/16-12	1.791	1.024	1-11/16-12	2.972	1.024
4725X24X24X24LN	1.875	2.375	2-12	1.949	1.260	2-12	1.949	1.260	2-12	3.130	1.260



Description: **Bulkhead Branch Tee Metric Hex**
WWF Part No.: **4725MH**
WWF Stainless Part No.: **/**
SAE: **52M0959**

Air-Way: FS2703-MH
Parker: WJMLO
Aeroquip: /
Gates: /

WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
4725X04X04X04MH	0.551	9/16-18	0.886	0.177	9/16-18	0.886	0.177	9/16-18	1.850	0.177



Description: **Bulkhead Run Tee**
WWF Part No.: **4726**
WWF Stainless Part No.: **/**
SAE: **520958**

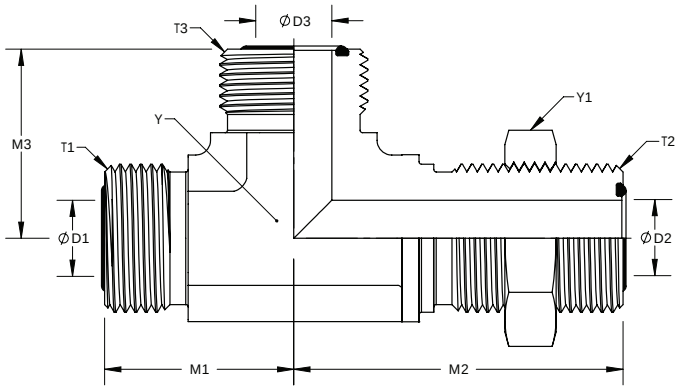
Air-Way: FS2704
Parker: WJJLO
Aeroquip: /
Gates: /

WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
4726X04X04X04	0.563	9/16-18	0.886	0.177	9/16-18	1.850	0.177	9/16-18	0.886	0.177
4726X06X06X06	0.669	11/16-16	1.024	0.256	11/16-16	2.047	0.256	11/16-16	1.024	0.256
4726X08X08X08	0.750	13/16-16	1.142	0.374	13/16-16	2.185	0.374	13/16-16	1.142	0.374
4726X10X10X10	1.063	1-14	1.358	0.492	1-14	2.480	0.492	1-14	1.358	0.492
4726X12X12X12	1.188	1-3/16-12	1.516	0.610	1-3/16-12	2.637	0.610	1-3/16-12	1.516	0.610
4726X16X16X16	1.438	1-7/16-12	1.673	0.807	1-7/16-12	2.795	0.807	1-7/16-12	1.673	0.807
4726X20X20X20	1.625	1-11/16-12	1.791	1.024	1-11/16-12	2.972	1.024	1-11/16-12	1.791	1.024
4726X24X24X24	1.875	2-12	1.949	1.260	2-12	3.130	1.260	2-12	1.949	1.260

B

Description: **Bulkhead Run Tee With Locknut**
WWF Part No.: **4726LN**
WWF Stainless Part No.: **/**
SAE: **520958**

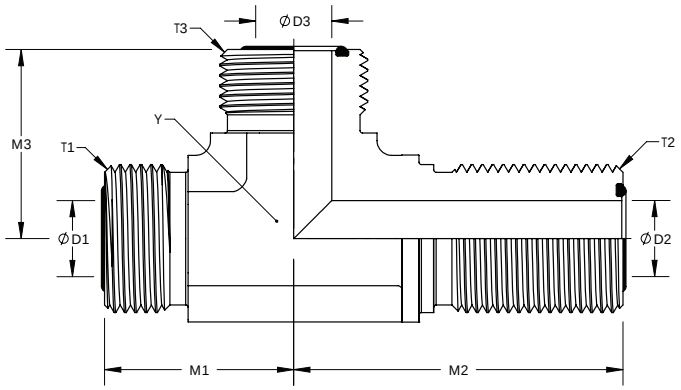
Air-Way: FS2704-LN
Parker: WJJLO-WLN
Aeroquip: FF2174T
Gates: /



WWF	Y HEX	Y1 HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
4726X04X04X04LN	0.563	0.813	9/16-18	0.886	0.177	9/16-18	1.850	0.177	9/16-18	0.886	0.177
4726X06X06X06LN	0.669	1.000	11/16-16	1.024	0.256	11/16-16	2.047	0.256	11/16-16	1.024	0.256
4726X08X08X08LN	0.750	1.125	13/16-16	1.142	0.374	13/16-16	2.185	0.374	13/16-16	1.142	0.374
4726X10X10X10LN	1.063	1.313	1-14	1.358	0.492	1-14	2.480	0.492	1-14	1.358	0.492
4726X12X12X12LN	1.188	1.500	1-3/16-12	1.516	0.610	1-3/16-12	2.637	0.610	1-3/16-12	1.516	0.610
4726X16X16X16LN	1.438	1.750	1-7/16-12	1.673	0.807	1-7/16-12	2.795	0.807	1-7/16-12	1.673	0.807
4726X20X20X20LN	1.625	2.000	1-11/16-12	1.791	1.024	1-11/16-12	2.972	1.024	1-11/16-12	1.791	1.024
4726X24X24X24LN	1.875	2.375	2-12	1.949	1.260	2-12	3.130	1.260	2-12	1.949	1.260

Description: **Bulkhead Run Tee Metric Hex**
WWF Part No.: **4726MH**
WWF Stainless Part No.: **/**
SAE: **52M0958**

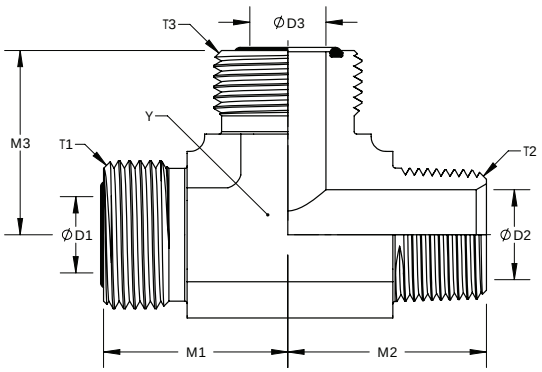
Air-Way: FS2704-MH
Parker: WJJMLO
Aeroquip: /
Gates: /



WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
4726X08X08X08MH	0.748	13/16-16	1.142	0.374	13/16-16	2.185	0.374	13/16-16	1.142	0.374
4726X10X10X10MH	0.945	1-14	1.358	0.492	1-14	2.480	0.492	1-14	1.358	0.492

Description: **Male Run Tee**
WWF Part No.: **4755**
WWF Stainless Part No.: **/**
SAE: **/**

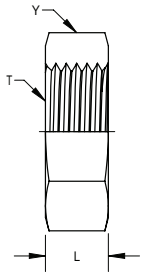
Air-Way: /
Parker: /
Aeroquip: /
Gates: /



WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
4755X04X04X04	0.563	9/16-18	0.846	0.177	1/4-18	1.090	0.281	9/16-18	0.846	0.177
4755X06X04X06	0.669	11/16-16	0.980	0.256	1/4-18	1.090	0.281	11/16-16	0.980	0.256
4755X06X06X06	0.750	11/16-16	0.980	0.256	3/8-18	1.220	0.406	11/16-16	0.980	0.256
4755X08X08X08	0.875	13/16-16	1.102	0.374	1/2-14	1.470	0.531	13/16-16	1.102	0.374

Description: **Straight Thread Locknut**
WWF Part No.: **4924**
WWF Stainless Part No.: **/**
SAE: **/**

Air-Way: /
Parker: /
Aeroquip: /
Gates: /

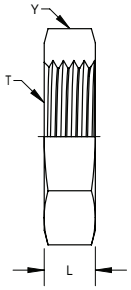


WWF	Y HEX	T	L
4924X04	0.625	7/16-20	0.315
4924X06	0.750	9/16-18	0.335
4924X08	0.938	3/4-16	0.405
4924X10	1.063	7/8-14	0.453
4924X12	1.375	1-1/16-12	0.504
4924X16	1.625	1-5/16-12	0.535
4924X20	1.875	1-5/8-12	0.535
4924X24	2.125	1-7/8-12	0.535

B

Description: **Bulkhead Locknut**
WWF Part No.: **4925**
WWF Stainless Part No.: **/**
SAE: **520118**

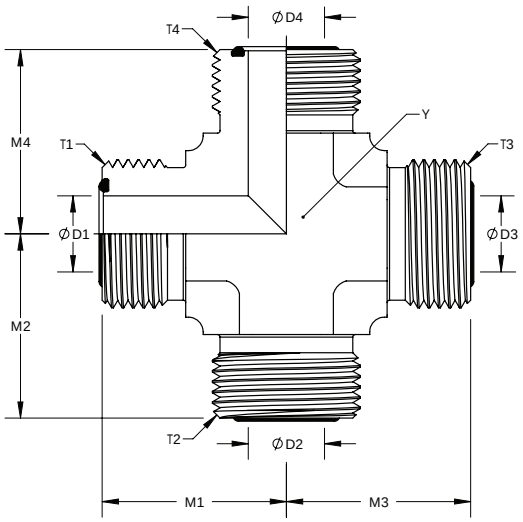
Air-Way: FS0306
Parker: WLNL
Aeroquip: FF9768
Gates: /



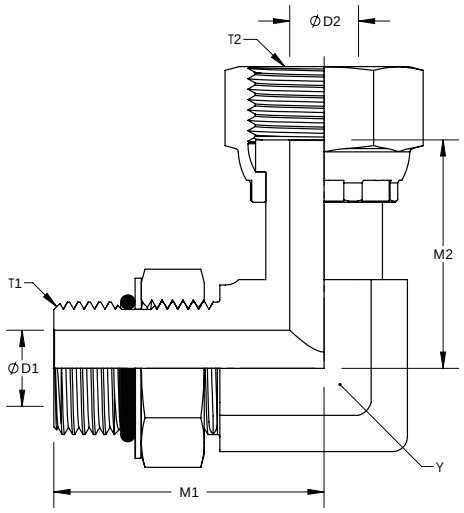
WWF	Y HEX	T	L
4925X04	0.813	9/16-18	0.275
4925X06	1.000	11/16-16	0.315
4925X08	1.125	13/16-16	0.354
4925X10	1.313	1-14	0.413
4925X12	1.500	1-3/16-12	0.413
4925X16	1.750	1-7/16-12	0.413
4925X20	2.000	1-11/16-12	0.413
4925X24	2.375	2-12	0.413

Description: **Union Cross**
WWF Part No.: **4955**
WWF Stainless Part No.: **/**
SAE: **520501**

Air-Way: FS2650
Parker: KLO
Aeroquip: /
Gates: /



WWF	Y HEX	T1 / T3	M1 / M3	D1 / D4	T2 / T4	M2 / M4	D2 / D4
4955X04X04X04X04	0.563	9/16-18	0.846	0.177	9/16-18	0.846	0.177
4955X06X06X06X06	0.669	11/16-16	0.984	0.256	11/16-16	0.984	0.256
4955X08X08X08X08	0.750	13/16-16	1.102	0.374	13/16-16	1.102	0.374
4955X10X10X10X10	1.063	1-14	1.319	0.492	1-14	1.319	0.492
4955X12X12X12X12	1.188	1-3/16-12	1.476	0.610	1-3/16-12	1.476	0.610
4955X16X16X16X16	1.438	1-7/16-12	1.634	0.807	1-7/16-12	1.634	0.807
4955X20X20X20X20	1.625	1-11/16-12	1.752	1.024	1-11/16-12	1.752	1.024
4955X24X24X24X24	1.875	2-12	1.929	1.260	2-12	1.929	1.260



Description: **Swivel 90° Adjustable Stud Elbow**
WWF Part No.: **FS6809**
WWF Stainless Part No.: **/**
SAE: **520281**

Air-Way: FS6809
Parker: /
Aeroquip: /
Gates: /

WWF	Y HEX	T1	M1	D1	T2	M2	D2
FS6809X04X04	0.563	7/16-20	1.299	0.177	9/16-18	1.043	0.157
FS6809X06X06	0.669	9/16-18	1.457	0.295	11/16-16	1.142	0.256
FS6809X08X08	0.750	3/4-16	1.594	0.394	13/16-16	1.496	0.354
FS6809X10X10	1.063	7/8-14	1.969	0.492	1-14	1.614	0.453
FS6809X12X12	1.188	1-1/16-12	2.165	0.610	1-3/16-12	1.831	0.551
FS6809X16X16	1.438	1-5/16-12	2.342	0.846	1-7/16-12	2.106	0.787
FS6809X20X20	1.625	1-5/8-12	2.441	1.083	1-11/16-12	2.283	1.024

NOTES

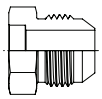
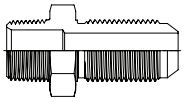
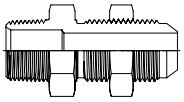
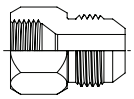
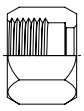
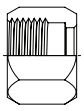
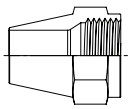
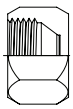
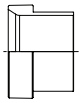
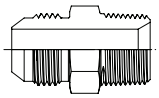
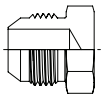
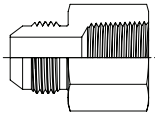
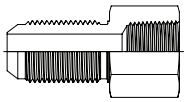
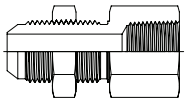
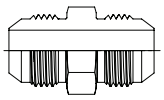
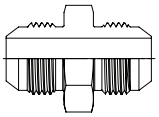
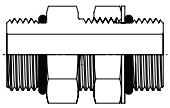
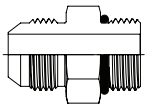
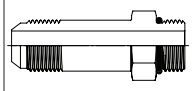
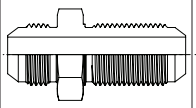
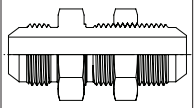
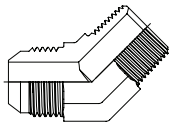
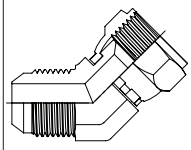
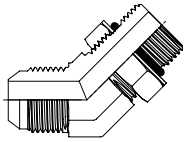
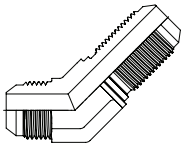
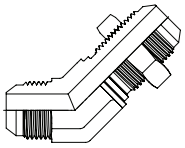
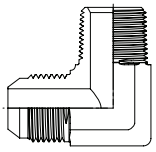
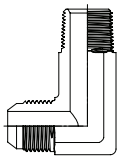
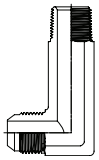
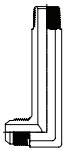
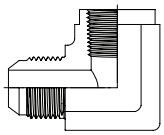
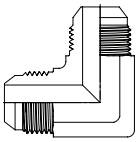
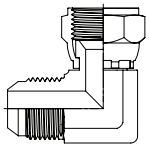
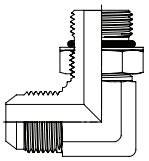
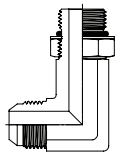
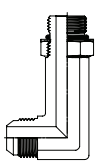
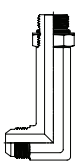
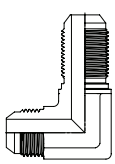
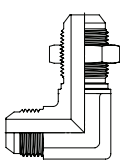
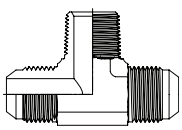
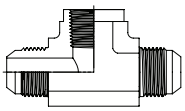
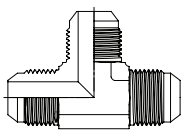


Steel 37° Flare (JIC) Fittings

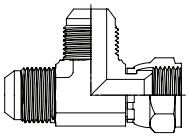
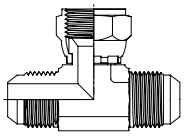
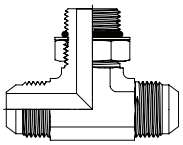
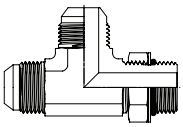
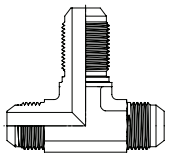
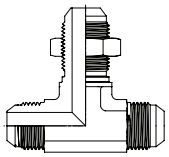
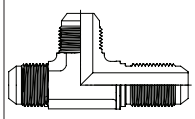
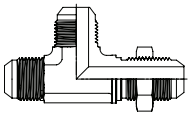
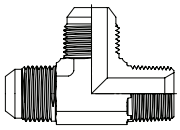
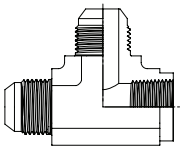
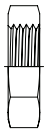
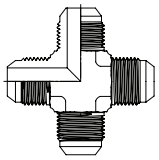
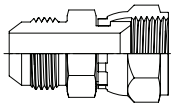
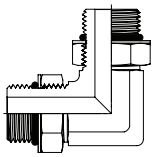
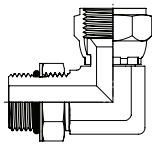
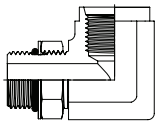
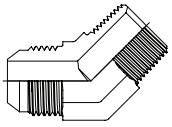
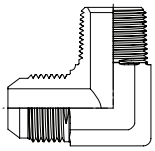
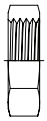
5000 SERIES

5000 SERIES - STEEL 37° FLARE (JIC) FITTINGS

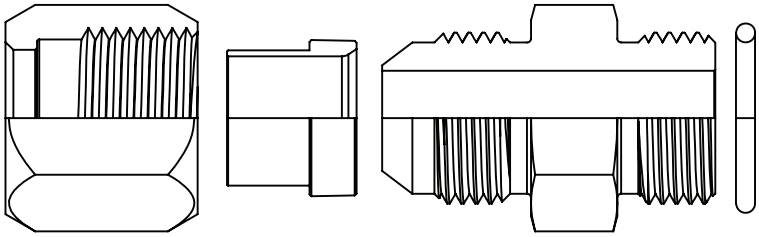
C

0403 Page 96	**2706** Page 96	**2706-LN** Page 97	**2406** Page 97	**0318** Page 99	**M0318** Page 99	**0304** Page 100
						
0403 Male JIC Braze Connector	2706 Male JIC to Male Pipe Bulkhead	2706LN Male JIC to Male Pipe Bulkhead With Locknut	5015 Tube End Reducer (1 Piece)	5105 Short Nut	5105MH Short Nut Metric Hex	5115 Long Nut
0304-C Page 100	**0319** Page 101	**2404** Page 101	**2408** Page 103	**2405** Page 104	**2705** Page 105	**2705-LN** Page 105
						
5129 Cap	5165 Sleeve	5205 Male Connector	5229 Plug	5255 Female Connector	5275 Female Bulkhead Connector	5275LN Female Bulkhead Connector With Locknut
2403 Page 106	**2403-LH** Page 107	**3474** Page 107	**6400** Page 108	**6400-L** Page 110	**2700** Page 110	**2700-LN** Page 111
						
5305 Union	5306 Large Hex Union	5314 Adjustable Union	5315 Straight Thread Connector Short	5316 Straight Thread Connector Long	5325 Bulkhead Union	5325LN Bulkhead Union With Locknut
2503 Page 111	**6502** Page 113	**6802** Page 113	**2702** Page 115	**2702-LN** Page 115	**2501** Page 116	**2501-L** Page 118
						
F5355 45º Male Elbow	F5356 45º Swivel Elbow	F5365 45º Straight Thread Elbow	F5375 45º Bulkhead Elbow	F5375LN 45º Bulkhead Elbow With Locknut	F5405 90º Male Elbow	F5425 90º Male Long Elbow
2501-LL Page 119	**2501-LLL** Page 120	**2502** Page 121	**2500** Page 122	**6500** Page 123	**6801** Page 124	**6801-L** Page 126
						
F5435 90º Male Extra Long Elbow	F5445 90º Male Extra Extra Long Elbow	F5455 90º Female Elbow	F5505 90º Union Elbow	F5506 90º Swivel Elbow	F5515 90º Straight Thread Elbow	F5515L 90º Straight Thread Elbow Long
6801-LL Page 127	**6801-LLL** Page 128	**2701** Page 128	**2701-LN** Page 129	**2601** Page 129	**2602** Page 131	**2603** Page 132
						
F5515LL 90º Straight Thread Elbow Extra Long	F5515LLL 90º Straight Thread Elbow Extra Extra Long	F5525 90º Bulkhead Elbow	F5525LN 90º Bulkhead Elbow With Locknut	F5605 Male Branch Tee	F5655 Female Branch Tee	F5705 Union Tee

5000 SERIES - STEEL 37° FLARE (JIC) FITTINGS

6602 Page 133	**6600** Page 134	**6803** Page 135	**6804** Page 136	**2703** Page 137	**2703-LN** Page 137	**2704** Page 138
						
F5706	F5707	F5715	F5716	F5725	F5725LN	F5726
Swivel Run Tee	Swivel Branch Tee	Straight Thread Branch Tee	Straight Thread Run Tee	Bulkhead Branch Tee	Bulkhead Branch Tee With Locknut	Bulkhead Run Tee
2704-LN Page 138	**2605** Page 139	**2606** Page 140	**0306** Page 140	**2650** Page 141	**6504** Page 141	**6807** Page 142
						
F5726LN	F5755	F5805	5924	F5955	6504	6807
Bulkhead Run Tee With Locknut	Male Run Tee	Female Run Tee	Bulkhead Locknut	Cross	Female Swivel to Male JIC	Adjustable ORB Union Elbow
6809 Page 142	**6815** Page 143	**7100** Page 143	**7200** Page 144	Page 165	Page 166	**0306-N** Page 144
						
6809	6815	7100	7200	7629	7269M	8924
90° Female Swivel to Male ORB	90° Male ORB to Female ORB	45° Male Elbow	90° Male Elbow	90 Durometer “O” Ring	90 Durometer Metric “O” Ring	Straight Thread Locknut

5000 SERIES - STEEL 37° FLARE (JIC) FITTINGS



5000 Series Assembly

C

CONSTRUCTION
5000 Series Fittings consist of three main components: Bodies, Nuts, and Sleeves.
Bodies – Straight bodies are machined from bar stock. Shape fittings (elbows, tees, & crosses) are made from forgings.
Tube Nuts – Tube Nuts in sizes 1/4", 3/8", 1/2", 5/8",3/4", 1", are Cold Formed in 1010 steel. Tube Nuts in sizes 1/8", 3/16", 5/16", 7/8", 1-1/4", 1-1/2", & 2" are hot forged from 1045.
Tube Sleeves – Tube Sleeves for 5000 series fittings are machined from 12L14 bar stock.

APPLICATIONS
For use with machine tools, agricultural and earth moving machinery, instrumentation, chemical processing systems, and most other high pressure hydraulic applications.

PRESSURE RATINGS
Working pressures up to 5000 PSI. Working pressures will vary depending on tube and fitting size.
(For applications using extreme pressures at 5000 PSI or above, contact World Wide Fittings.)

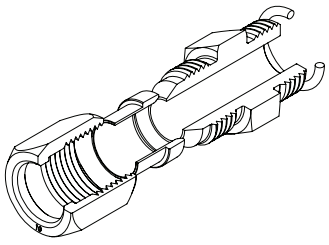
MATERIAL
Steel – Bar Stock 12L14, 1045
Cold Formed 1010
Stainless Steel – Type 316

PLATING
Clear Zinc Trivalent
Passivated

HOW TO ORDER
Tubing sizes are measured in sixteenths of an inch. Available sizes are 1/8" through 2". When ordering, the tube end of the fitting must be specified first followed by the pipe thread or straight thread end. All fittings in this section are ordered as bodies only unless specified by customers when ordering.
(Contact World Wide for details on ordering fittings preassembled with nuts and sleeves.)

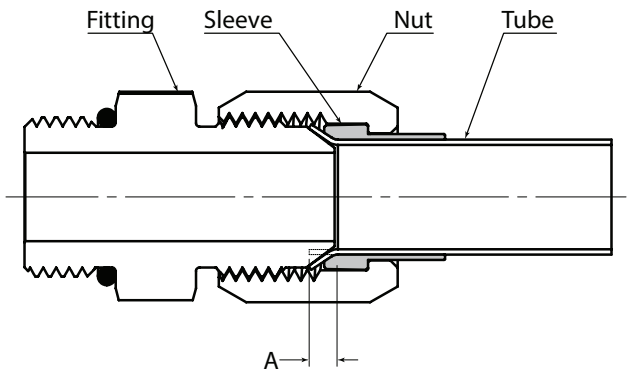
CONFORMANCE
5000 Series Fittings Meet SAE J514 and MS (Military Specifications).

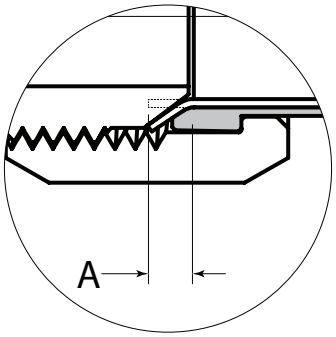
ASSEMBLY INSTRUCTIONS
1. Cut the tubing to the desired length making sure the ends are square. Remove all burrs from the tubing ends and clean thoroughly.
2. Slide the tube nut on the tubing making sure that the open end of the nut is facing the tube end. Then slide the tube sleeve on the tubing making sure the seat of the sleeve is facing the tube end.
3. Using a 37° flaring tool, flare the tubing end. Inspect the flared end for dimensions that are out of tolerance and may cause underflare, overflare, and excessive wall thinning which can interfere with the operation and quality of the assembled fitting.
   (For examples of underflaring and overflaring refer to the tube flaring drawings.)
4. Pull the sleeve up to the flared end and then pull the tube nut up and over the sleeve and flared end.
5. Lubricate the threads on both the nut and the fitting body, align the flared end against the nose of the fitting and assemble to the finger-tight position.
6. Using a wrench tighten the assembly until the nut is snug, then tighten the nut an additional one to two flats further. (Refer to the assembly torque charts during installation of 5000 series fittings from the port and thread assemblies section.)



5000 SERIES - STEEL 37° FLARE (JIC) FITTINGS

Correct assembly





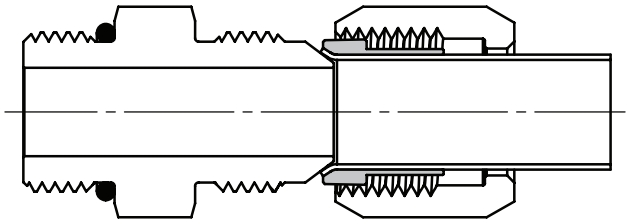
Tube length allowance

(See table below)

Nominal Tube O.D.		A
Inch	Metric	
1/8	-	0.07
3/16	-	0.08
1/4	6	0.09
5/16	8	0.08
3/8	10	0.08
1/2	12	0.12
5/8	14, 15, 16	0.13
3/4	18, 20	0.15
7/8	22	0.15
1	25	0.15
1-1/4	30, 32	0.20
1-1/2	38	0.18
2	42	0.28

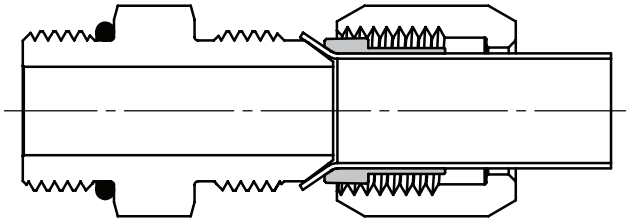
Tube length allowance table

Incorrect assembly



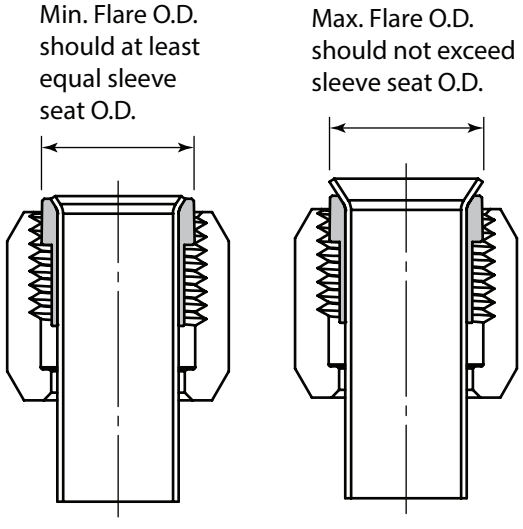
Under flared assembly

Underflaring reduces contact area causing excessive nose collapse and leakage; or in extreme cases, tube pull out under pressure.



Over flared assembly

Overflaring causes tube nut thread interference, either preventing assembly altogether, or giving a false sense of joint tightness resulting in leakage.

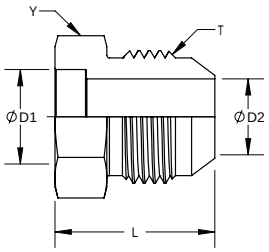


Minimum Flare Maximum Flare

Comparing flare O.D. with sleeve seat and O.D.

Description**:** **Male JIC Braze Connector**
WWF Part No.: **0403**
WWF Stainless Part No.: **0403-SS**
SAE: ***/***

Air-Way: 0403
Parker: /
Aeroquip: 73014
Gates: MJ-FBO

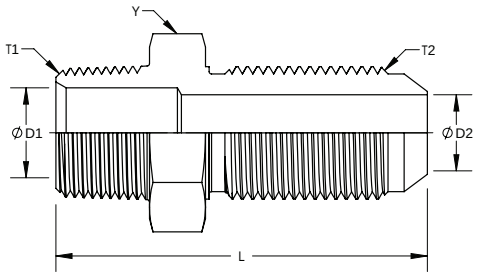


C

WWF	Y HEX	T	D1	D2	L
0403X04X04	0.500	7/16-20	0.256	0.172	0.800
0403X05X05	0.563	1/2-20	0.318	0.234	0.800
0403X06X04	0.500	9/16-18	0.381	0.172	0.800
0403X06X06	0.625	9/16-18	0.381	0.297	0.840
0403X06X08	0.813	3/4-16	0.381	0.297	0.940
0403X08X06	0.625	9/16-18	0.506	0.297	0.840
0403X08X08	0.813	3/4-16	0.506	0.391	0.940
0403X10X08	0.813	3/4-16	0.631	0.391	0.940
0403X10X10	0.938	7/8-14	0.631	0.484	1.100
0403X12X12	1.125	1-1/16-12	0.757	0.609	1.280
0403X14X14	1.250	1-3/16-12	0.882	0.609	1.310
0403X16X16	1.375	1-5/16-12	1.007	0.844	1.330
0403X16X20	1.688	1-5/8-12	1.007	0.844	1.330
0403X20X16	1.375	1-5/16-12	1.258	0.844	1.330
0403X20X20	1.688	1-5/8-12	1.258	1.078	1.450
0403X24X24	2.000	1-7/8-12	1.508	1.313	1.650
0403X32X32	2.625	2-1/2-12	2.008	1.781	2.050

Description**:** **Male JIC to Male Pipe Bulkhead**
WWF Part No.: **2706**
WWF Stainless Part No.: **2706-SS**
SAE: ***/***

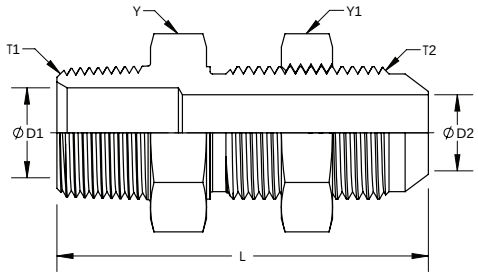
Air-Way: 2706
Parker: WFTX
Aeroquip: /
Gates: MJBKHD-MP



WWF	Y HEX	T1	D1	T2	D2	L
2706X02X04	0.688	1/8-27	0.188	7/16-20	0.172	1.900
2706X04X04	0.688	1/4-18	0.281	7/16-20	0.172	2.080
2706X06X06	0.813	3/8-18	0.406	9/16-18	0.297	2.184
2706X08X08	1.000	1/2-14	0.531	3/4-16	0.391	2.560
2706X12X12	1.375	3/4-14	0.719	1-1/16-12	0.609	2.976
2706X16X16	1.625	1-11-1/2	0.938	1-5/16-12	0.844	3.169
2706X24X24	2.125	1-1/2-11-1/2	1.500	1-7/8-12	1.313	3.437

Description**:** **Male JIC to Male Pipe Bulkhead With Locknut**
WWF Part No.: **2706LN**
WWF Stainless Part No.: **2706-LN-SS**
SAE: **/**

Air-Way: 2706-LN
Parker: WFTX-WLN
Aeroquip: 2240
Gates: /

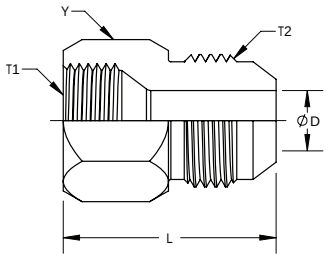


C

WWF	Y HEX	Y1 HEX	T1	D1	T2	D2	L
2706X04X04LN	0.688	0.688	1/4-18	0.281	7/16-20	0.172	2.080
2706X06X06LN	0.813	0.813	3/8-18	0.406	9/16-18	0.297	2.184
2706X08X08LN	1.000	1.000	1/2-14	0.531	3/4-16	0.391	2.560
2706X12X12LN	1.375	1.375	3/4-14	0.719	1-1/16-12	0.609	2.976
2706X16X16LN	1.625	1.625	1-11-1/2	0.938	1-5/16-12	0.844	3.169

Description**:** **Tube End Reducer (1 Piece)**
WWF Part No.: **5015**
WWF Stainless Part No.: **2406-SS**
SAE: **070123**

Air-Way: 2406
Parker: TRTX
Aeroquip: 2215
Gates: MJ-FJ



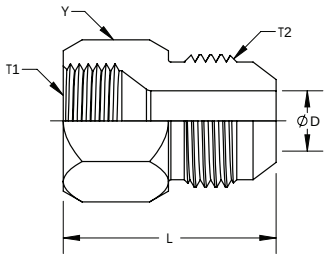
WWF	Y HEX	T1	D	T2	L
5015X04X02	0.563	7/16-20	0.063	5/16-24	1.042
5015X04X06	0.688	7/16-20	0.172	9/16-18	1.150
5015X04X08	0.813	7/16-20	0.391	3/4-16	1.251
5015X05X04	0.625	1/2-20	0.172	7/16-20	1.159
5015X06X04	0.688	9/16-18	0.172	7/16-20	1.175
5015X06X06	0.688	9/16-18	0.297	9/16-18	1.181
5015X06X08	0.813	9/16-18	0.297	3/4-16	1.282
5015X08X04	0.875	3/4-16	0.172	7/16-20	1.300
5015X08X06	0.875	3/4-16	0.297	9/16-18	1.306
5015X08X10	0.938	3/4-16	0.391	7/8-14	1.508
5015X08X12	1.125	3/4-16	0.609	1-1/16-12	1.614
5015X08X16	1.375	3/4-16	0.844	1-5/16-12	1.661
5015X10X04	1.000	7/8-14	0.172	7/16-20	1.394
5015X10X06	1.000	7/8-14	0.297	9/16-18	1.400
5015X10X08	1.000	7/8-14	0.391	3/4-16	1.501

Continued on page 98

Continued from page 97

Description**:** **Tube End Reducer (1 Piece)**
WWF Part No.: **5015**
WWF Stainless Part No.: **2406-SS**
SAE: **070123**

Air-Way: 2406
Parker: TRTX
Aeroquip: 2215
Gates: MJ-FJ

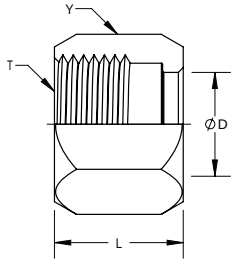


C

WWF	Y HEX	T1	D	T2	L
5015X10X12	1.125	7/8-14	0.484	1-1/16-12	1.708
5015X12X04	1.250	1-1/16-12	0.172	7/16-20	1.456
5015X12X06	1.250	1-1/16-12	0.297	9/16-18	1.462
5015X12X08	1.250	1-1/16-12	0.391	3/4-16	1.563
5015X12X10	1.250	1-1/16-12	0.484	7/8-14	1.664
5015X12X16	1.500	1-1/16-12	0.844	1-5/16-12	1.817
5015X12X20	1.688	1-1/16-12	1.078	1-5/8-12	1.864
5015X14X06	1.375	1-3/16-12	0.297	9/16-18	1.525
5015X14X08	1.375	1-3/16-12	0.391	3/4-16	1.626
5015X14X10	1.375	1-3/16-12	0.484	7/8-14	1.727
5015X14X12	1.375	1-3/16-12	0.609	1-1/16-12	1.833
5015X16X04	1.500	1-5/16-12	0.172	7/16-20	1.566
5015X16X06	1.500	1-5/16-12	0.297	9/16-18	1.572
5015X16X08	1.500	1-5/16-12	0.391	3/4-16	1.673
5015X16X10	1.500	1-5/16-12	0.484	7/8-14	1.774
5015X16X12	1.500	1-5/16-12	0.609	1-1/16-12	1.880
5015X16X14	1.500	1-5/16-12	0.719	1-3/16-12	1.906
5015X16X20	1.688	1-5/16-12	1.078	1-5/8-12	1.974
5015X16X24	2.000	1-5/16-12	1.313	1-7/8-12	2.099
5015X20X12	2.000	1-5/8-12	0.609	1-1/16-12	1.926
5015X20X16	2.000	1-5/8-12	0.844	1-5/16-12	1.973
5015X20X24	2.000	1-5/8-12	1.313	1-7/8-12	2.145
5015X24X12	2.250	1-7/8-12	0.609	1-1/16-12	2.052
5015X24X16	2.250	1-7/8-12	0.844	1-5/16-12	2.099
5015X24X20	2.250	1-7/8-12	1.078	1-5/8-12	2.146
5015X24X32	2.625	1-7/8-12	1.313	2-1/2-12	2.521
5015X32X24	2.875	2-1/2-12	1.313	1-7/8-12	2.521

Description**:** **Short Nut**
WWF Part No.: **5105**
WWF Stainless Part No.: **0318-SS**
SAE: **070110**

Air-Way: 0318
Parker: BTX
Aeroquip: 1290
Gates: TSN

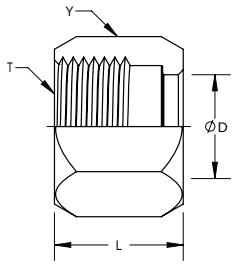


C

WWF	Y HEX	T	D	L
5105X02	0.375	5/16-24	0.179	0.550
5105X03	0.438	3/8-24	0.241	0.610
5105X04CF	0.563	7/16-20	0.304	0.620
5105X05CF	0.625	1/2-20	0.373	0.680
5105X06CF	0.688	9/16-18	0.439	0.730
5105X08CF	0.875	3/4-16	0.568	0.850
5105X10CF	1.000	7/8-14	0.696	0.980
5105X12CF	1.250	1-1/16-12	0.832	1.030
5105X14CF	1.375	1-3/16-12	0.959	1.090
5105X16CF	1.500	1-5/16-12	1.087	1.130
5105X20CF	2.000	1-5/8-12	1.344	1.230
5105X24CF	2.250	1-7/8-12	1.614	1.420
5105X32CF	2.875	2-1/2-12	2.164	1.750

Description**:** **Short Nut Metric Hex**
WWF Part No.: **5105MH**
WWF Stainless Part No.: **M0318-SS**
SAE: ***/***

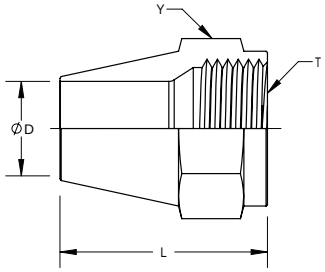
Air-Way: M0318
Parker: /
Aeroquip: /
Gates: /



WWF	Y HEX	T	D	L
5105X04MH	0.551	7/16-20	0.304	0.620
5105X05MH	0.669	1/2-20	0.373	0.680
5105X06MH	0.748	9/16-18	0.439	0.730
5105X08MH	0.866	3/4-16	0.568	0.850
5105X10MH	1.063	7/8-14	0.696	0.980
5105X12MH	1.260	1-1/16-12	0.832	1.030
5105X14MH	1.417	1-3/16-12	0.959	1.090
5105X16MH	1.614	1-5/16-12	1.087	1.130
5105X20MH	1.969	1-5/8-12	1.344	1.230
5105X24MH	2.362	1-7/8-12	1.614	1.420
5105X32MH	2.952	2-1/2-12	2.164	1.750

Description**:** **Long Nut**
WWF Part No.: **5115**
WWF Stainless Part No.: **0304-SS**
SAE: **070111**

Air-Way: 0304
Parker: /
Aeroquip: /
Gates: /

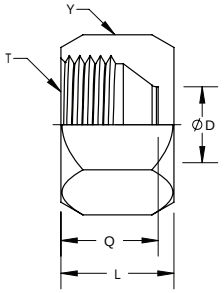


C

WWF	Y HEX	T	D	L
5115X02	0.375	5/16-24	0.130	0.840
5115X03	0.438	3/8-24	0.193	0.940
5115X04	0.563	7/16-20	0.255	1.000
5115X05	0.625	1/2-20	0.318	1.060
5115X06	0.688	9/16-18	0.380	1.090
5115X08	0.875	3/4-16	0.505	1.280
5115X10	1.000	7/8-14	0.631	1.480
5115X12	1.250	1-1/16-12	0.756	1.660
5115X14	1.375	1-3/16-12	0.881	1.810
5115X16	1.500	1-5/16-12	1.006	1.940
5115X20	2.000	1-5/8-12	1.260	2.190
5115X24	2.250	1-7/8-12	1.510	2.310
5115X32	2.875	2-1/2-12	2.014	2.750

Description**:** **Cap**
WWF Part No.: **5129**
WWF Stainless Part No.: **0304-C-SS**
SAE: **070112**

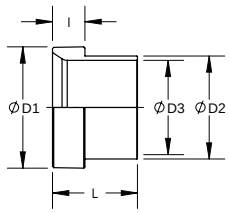
Air-Way: 0304-C
Parker: FNTX
Aeroquip: 210292
Gates: FJ-CAP



WWF	Y HEX	T	D	Q	L
5129X02	0.375	5/16-24	0.063	0.438	0.500
5129X03	0.438	3/8-24	0.125	0.500	0.563
5129X04CF	0.563	7/16-20	0.172	0.531	0.594
5129X05	0.625	1/2-20	0.234	0.547	0.609
5129X06CF	0.688	9/16-18	0.297	0.563	0.625
5129X08CF	0.875	3/4-16	0.391	0.625	0.750
5129X10CF	1.000	7/8-14	0.484	0.719	0.844
5129X12CF	1.250	1-1/16-12	0.609	0.781	0.906
5129X14	1.375	1-3/16-12	0.719	0.844	0.969
5129X16CF	1.500	1-5/16-12	0.844	0.859	1.016
5129X20CF	2.000	1-5/8-12	1.078	0.906	1.063
5129X24CF	2.250	1-7/8-12	1.313	1.031	1.188
5129X32CF	2.875	2-1/2-12	1.781	1.281	1.438

Description**:** **Sleeve**
WWF Part No.: **5165**
WWF Stainless Part No.: **0319-SS**
SAE: **070115**

Air-Way: 0319
Parker: TX
Aeroquip: 900605
Gates: TS

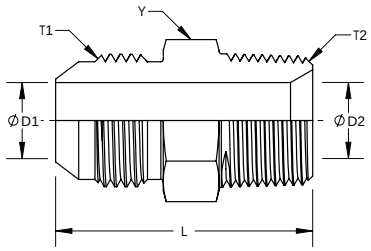


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WWF	D1	D2	D3	I	L
5165X02	0.267	0.172	0.130	0.120	0.340
5165X03	0.329	0.234	0.193	0.140	0.340
5165X04CF	0.383	0.297	0.255	0.140	0.410
5165X05CF	0.445	0.366	0.318	0.160	0.440
5165X06CF	0.502	0.432	0.380	0.170	0.500
5165X08CF	0.682	0.563	0.505	0.220	0.560
5165X10CF	0.797	0.690	0.631	0.240	0.660
5165X12CF	0.972	0.826	0.756	0.260	0.680
5165X14CF	1.097	0.953	0.881	0.260	0.760
5165X16CF	1.222	1.081	1.006	0.280	0.780
5165X20CF	1.534	1.339	1.260	0.310	0.910
5165X24CF	1.784	1.609	1.510	0.340	1.120
5165X32CF	2.409	2.159	2.014	0.410	1.190

Description**:** **Male Connector**
WWF Part No.: **5205**
WWF Stainless Part No.: **2404-SS**
SAE: **070102**

Air-Way: 2404
Parker: FTX
Aeroquip: 2021-[R]
Gates: MJ-MP



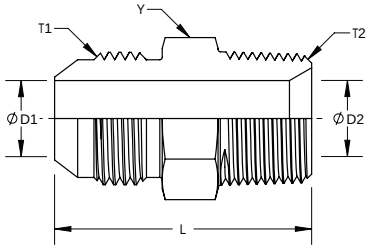
WWF	Y HEX	T1	D1	T2	D2	L
5205X02X02	0.438	5/16-24	0.063	1/8-27	0.188	1.110
5205X02X04	0.625	5/16-24	0.063	1/4-18	0.281	1.320
5205X03X02	0.438	3/8-24	0.125	1/8-27	0.188	1.140
5205X03X04	0.625	3/8-24	0.125	1/4-18	0.281	1.350
5205X04X02	0.500	7/16-20	0.172	1/8-27	0.188	1.220
5205X04X04	0.563	7/16-20	0.172	1/4-18	0.281	1.420
5205X04X06	0.750	7/16-20	0.172	3/8-18	0.406	1.420

Continued on page 102

Continued from page 101

Description**:** **Male Connector**
WWF Part No.: **5205**
WWF Stainless Part No.: **2404-SS**
SAE: **070102**

Air-Way: 2404
Parker: FTX
Aeroquip: 2021-[R]
Gates: MJ-MP



C

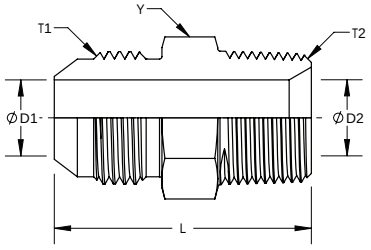
WWF	Y HEX	T1	D1	T2	D2	L
5205X04X08	0.875	7/16-20	0.172	1/2-14	0.531	1.680
5205X05X02	0.563	1/2-20	0.234	1/8-27	0.188	1.220
5205X05X04	0.563	1/2-20	0.234	1/4-18	0.281	1.420
5205X05X06	0.813	1/2-20	0.234	3/8-18	0.406	1.420
5205X06X02	0.625	9/16-18	0.297	1/8-27	0.188	1.240
5205X06X04	0.625	9/16-18	0.297	1/4-18	0.281	1.430
5205X06X06	0.750	9/16-18	0.297	3/8-18	0.406	1.430
5205X06X08	0.875	9/16-18	0.297	1/2-14	0.531	1.690
5205X06X12	1.125	9/16-18	0.297	3/4-14	0.719	1.750
5205X08X02	0.813	3/4-16	0.391	1/8-27	0.188	1.340
5205X08X04	0.813	3/4-16	0.391	1/4-18	0.281	1.530
5205X08X06	0.813	3/4-16	0.391	3/8-18	0.406	1.530
5205X08X08	0.875	3/4-16	0.391	1/2-14	0.531	1.790
5205X08X12	1.125	3/4-16	0.391	3/4-14	0.719	1.850
5205X08X16	1.375	3/4-16	0.391	1-11-1/2	0.938	2.050
5205X10X04	0.938	7/8-14	0.484	1/4-18	0.281	1.700
5205X10X06	0.938	7/8-14	0.484	3/8-18	0.406	1.700
5205X10X08	0.938	7/8-14	0.484	1/2-14	0.531	1.890
5205X10X12	1.125	7/8-14	0.484	3/4-14	0.719	1.950
5205X10X16	1.375	7/8-14	0.484	1-11-1/2	0.938	2.150
5205X12X06	1.125	1-1/16-12	0.609	3/8-18	0.406	1.870
5205X12X08	1.125	1-1/16-12	0.609	1/2-14	0.531	2.060
5205X12X12	1.125	1-1/16-12	0.609	3/4-14	0.719	2.060
5205X12X16	1.375	1-1/16-12	0.609	1-11-1/2	0.938	2.250
5205X12X20	1.688	1-1/16-12	0.609	1-1/4-11-1/2	1.250	2.360
5205X12X24	2.000	1-1/16-12	0.609	1-1/2-11-1/2	1.500	2.460
5205X14X08	1.250	1-3/16-12	0.719	1/2-14	0.531	2.090
5205X14X12	1.250	1-3/16-12	0.719	3/4-14	0.719	2.090
5205X16X08	1.375	1-5/16-12	0.844	1/2-14	0.531	2.110
5205X16X12	1.375	1-5/16-12	0.844	3/4-14	0.719	2.110
5205X16X16	1.375	1-5/16-12	0.844	1-11-1/2	0.938	2.300
5205X16X20	1.688	1-5/16-12	0.844	1-1/4-11-1/2	1.250	2.400
5205X16X24	2.000	1-5/16-12	0.844	1-1/2-11-1/2	1.500	2.510
5205X20X16	1.688	1-5/8-12	1.078	1-11-1/2	0.938	2.420

Continued on page 103

Continued from page 102

Description**:** **Male Connector**
WWF Part No.: **5205**
WWF Stainless Part No.: **2404-SS**
SAE: **070102**

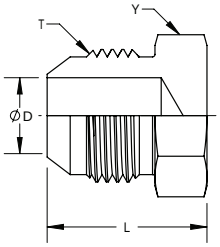
Air-Way: 2404
Parker: FTX
Aeroquip: 2021-[R]
Gates: MJ-MP



WWF	Y HEX	T1	D1	T2	D2	L
5205X20X20	1.688	1-5/8-12	1.078	1-1/4-11-1/2	1.250	2.450
5205X20X24	2.000	1-5/8-12	1.078	1-1/2-11-1/2	1.500	2.550
5205X20X32	2.625	1-5/8-12	1.078	2-11-1/2	1.938	2.730
5205X24X16	2.000	1-7/8-12	1.313	1-11-1/2	0.938	2.620
5205X24X20	2.000	1-7/8-12	1.313	1-1/4-11-1/2	1.250	2.650
5205X24X24	2.000	1-7/8-12	1.313	1-1/2-11-1/2	1.500	2.680
5205X24X32	2.500	1-7/8-12	1.313	2-11-1/2	1.938	2.860
5205X32X20	2.625	2-1/2-12	1.781	1-1/4-11-1/2	1.250	3.050
5205X32X24	2.625	2-1/2-12	1.781	1-1/2-11-1/2	1.500	3.080
5205X32X32	2.625	2-1/2-12	1.781	2-11-1/2	1.938	3.110

Description: **Plug**
WWF Part No.: **5229**
WWF Stainless Part No.: **2408-SS**
SAE: **070109**

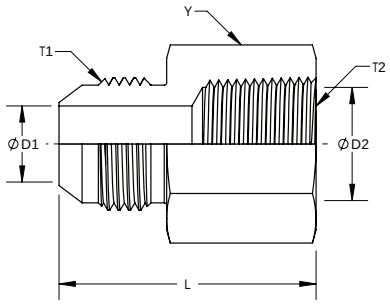
Air-Way: 2408
Parker: PNTX
Aeroquip: 900599
Gates: MJ-PLUG



WWF	Y HEX	T	D	L
5229X02	0.438	5/16-24	0.063	0.700
5229X03	0.438	3/8-24	0.125	0.730
5229X04	0.500	7/16-20	0.172	0.800
5229X05	0.563	1/2-20	0.234	0.800
5229X06	0.625	9/16-18	0.297	0.840
5229X08	0.813	3/4-16	0.391	0.940
5229X10	0.938	7/8-14	0.484	1.100
5229X12	1.125	1-1/16-12	0.609	1.280
5229X14	1.250	1-3/16-12	0.719	1.310
5229X16	1.375	1-5/16-12	0.844	1.330
5229X20	1.688	1-5/8-12	1.078	1.450
5229X24	2.000	1-7/8-12	1.313	1.650
5229X32	2.625	2-1/2-12	1.781	2.050

Description: **Female Connector**
WWF Part No.: **5255**
WWF Stainless Part No.: **2405-SS**
SAE: **070103**

Air-Way: 2405
Parker: GTX-S
Aeroquip: 2022-[R]
Gates: MJ-FP

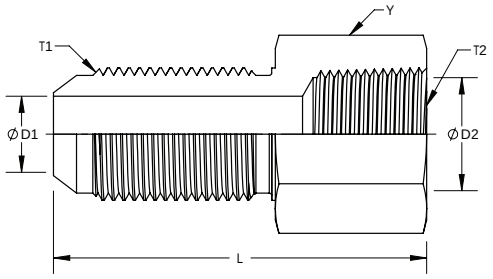


C

WWF	Y HEX	T1	D1	T2	D2	L
5255X02X02	0.563	5/16-24	0.063	1/8-27	0.332	1.120
5255X03X02	0.563	3/8-24	0.125	1/8-27	0.332	1.130
5255X04X02	0.563	7/16-20	0.172	1/8-27	0.332	1.190
5255X04X04	0.750	7/16-20	0.172	1/4-18	0.438	1.390
5255X04X06	0.875	7/16-20	0.172	3/8-18	0.563	1.450
5255X04X08	1.125	7/16-20	0.172	1/2-14	0.703	1.680
5255X05X02	0.563	1/2-20	0.234	1/8-27	0.332	1.170
5255X05X04	0.750	1/2-20	0.234	1/4-18	0.438	1.390
5255X06X02	0.750	9/16-18	0.297	1/8-27	0.332	1.190
5255X06X04	0.750	9/16-18	0.297	1/4-18	0.438	1.400
5255X06X06	0.875	9/16-18	0.297	3/8-18	0.563	1.460
5255X06X08	1.125	9/16-18	0.297	1/2-14	0.703	1.690
5255X08X04	0.875	3/4-16	0.391	1/4-18	0.438	1.550
5255X08X06	0.875	3/4-16	0.391	3/8-18	0.563	1.560
5255X08X08	1.125	3/4-16	0.391	1/2-14	0.703	1.790
5255X08X12	1.375	3/4-16	0.391	3/4-14	0.906	1.850
5255X10X06	1.125	7/8-14	0.484	3/8-18	0.563	1.670
5255X10X08	1.125	7/8-14	0.484	1/2-14	0.703	1.890
5255X10X12	1.375	7/8-14	0.484	3/4-14	0.906	1.950
5255X10X16	1.625	7/8-14	0.484	1-11-1/2	1.141	2.200
5255X12X08	1.375	1-1/16-12	0.609	1/2-14	0.703	2.050
5255X12X12	1.375	1-1/16-12	0.609	3/4-14	0.906	2.060
5255X12X16	1.625	1-1/16-12	0.609	1-11-1/2	1.141	2.300
5255X14X12	1.375	1-3/16-12	0.719	3/4-14	0.906	2.060
5255X16X12	1.625	1-5/16-12	0.844	3/4-14	0.906	2.120
5255X16X16	1.625	1-5/16-12	0.844	1-11-1/2	1.141	2.350
5255X16X20	2.000	1-5/16-12	0.844	1-1/4-11-1/2	1.484	2.440
5255X20X16	2.000	1-5/8-12	1.078	1-11-1/2	1.141	2.470
5255X20X20	2.000	1-5/8-12	1.078	1-1/4-11-1/2	1.484	2.490
5255X20X24	2.375	1-5/8-12	1.078	1-1/2-11-1/2	1.744	2.490
5255X24X20	2.375	1-7/8-12	1.313	1-1/4-11-1/2	1.484	2.620
5255X24X24	2.375	1-7/8-12	1.313	1-1/2-11-1/2	1.744	2.620
5255X32X32	2.875	2-1/2-12	1.781	2-11-1/2	2.213	2.970

Description: **Female Bulkhead Connector**
WWF Part No.: **5275**
WWF Stainless Part No.: **2705-SS**
SAE: **/**

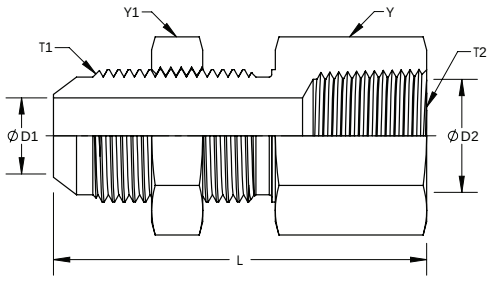
Air-Way: 2705 **Reversed**
Parker: WGTX
Aeroquip: /
Gates: /



WWF	Y HEX	T1	D1	T2	D2	L
5275X02X04	0.750	5/16-24	0.063	1/4-18	0.438	2.010
5275X04X02	0.688	7/16-20	0.172	1/8-27	0.332	1.840
5275X04X04	0.750	7/16-20	0.172	1/4-18	0.438	2.090
5275X04X06	0.875	7/16-20	0.172	3/8-18	0.563	2.140
5275X06X04	0.813	9/16-18	0.297	1/4-18	0.438	2.170
5275X06X06	0.875	9/16-18	0.297	3/8-18	0.563	2.230
5275X08X06	1.000	3/4-16	0.391	3/8-18	0.563	2.390
5275X08X08	1.125	3/4-16	0.391	1/2-14	0.703	2.620
5275X10X08	1.125	7/8-14	0.484	1/2-14	0.703	2.760
5275X12X08	1.375	1-1/16-12	0.609	1/2-14	0.703	2.910
5275X12X12	1.375	1-1/16-12	0.609	3/4-14	0.906	2.990
5275X16X16	1.625	1-5/16-12	0.844	1-11-1/2	1.141	3.240
5275X20X20	2.000	1-5/8-12	1.078	1-1/4-11-1/2	1.484	3.340
5275X24X24	2.375	1-7/8-12	1.313	1-1/2-11-1/2	1.744	3.400

Description: **Female Bulkhead Connector With Locknut**
WWF Part No.: **5275LN**
WWF Stainless Part No.: **2705-LN-SS**
SAE: **/**

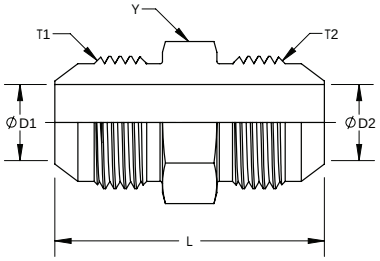
Air-Way: 2705-LN **Reversed**
Parker: WGTX-WLN
Aeroquip: 2239
Gates: /



WWF	Y HEX	Y1 HEX	T1	D1	T2	D2	L
5275X02X04LN	0.750	0.563	5/16-24	0.063	1/4-18	0.438	2.010
5275X04X02LN	0.688	0.688	7/16-20	0.172	1/8-27	0.332	1.840
5275X04X04LN	0.750	0.688	7/16-20	0.172	1/4-18	0.438	2.090
5275X04X06LN	0.875	0.688	7/16-20	0.172	3/8-18	0.563	2.140
5275X06X04LN	0.813	0.813	9/16-18	0.297	1/4-18	0.438	2.170
5275X06X06LN	0.875	0.813	9/16-18	0.297	3/8-18	0.563	2.230
5275X08X06LN	1.000	1.000	3/4-16	0.391	3/8-18	0.563	2.390
5275X08X08LN	1.125	1.000	3/4-16	0.391	1/2-14	0.703	2.620
5275X10X08LN	1.125	1.125	7/8-14	0.484	1/2-14	0.703	2.760
5275X12X12LN	1.375	1.375	1-1/16-12	0.609	3/4-14	0.906	2.990
5275X16X16LN	1.625	1.625	1-5/16-12	0.844	1-11-1/2	1.141	3.240
5275X20X20LN	2.000	1.875	1-5/8-12	1.078	1-1/4-11-1/2	1.484	3.340

Description: **Union**
WWF Part No.: **5305**
WWF Stainless Part No.: **2403-SS**
SAE: **070101**

Air-Way: 2403
Parker: HTX
Aeroquip: 2027
Gates: MJ-MJ

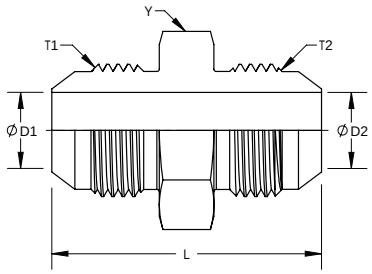


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WWF	Y HEX	T1	D1	T2	D2	L
5305X02X02	0.438	5/16-24	0.063	5/16-24	0.063	1.170
5305X03X03	0.438	3/8-24	0.125	3/8-24	0.125	1.230
5305X04X02	0.500	7/16-20	0.172	5/16-24	0.063	1.270
5305X04X04	0.500	7/16-20	0.172	7/16-20	0.172	1.370
5305X05X05	0.563	1/2-20	0.234	1/2-20	0.234	1.370
5305X06X04	0.625	9/16-18	0.297	7/16-20	0.172	1.400
5305X06X06	0.625	9/16-18	0.297	9/16-18	0.297	1.410
5305X08X04	0.813	3/4-16	0.391	7/16-20	0.172	1.510
5305X08X06	0.813	3/4-16	0.391	9/16-18	0.297	1.520
5305X08X08	0.813	3/4-16	0.391	3/4-16	0.391	1.620
5305X10X04	0.938	7/8-14	0.484	7/16-20	0.172	1.670
5305X10X06	0.938	7/8-14	0.484	9/16-18	0.297	1.680
5305X10X08	0.938	7/8-14	0.484	3/4-16	0.391	1.780
5305X10X10	0.938	7/8-14	0.484	7/8-14	0.484	1.880
5305X12X08	1.125	1-1/16-12	0.609	3/4-16	0.391	1.950
5305X12X10	1.125	1-1/16-12	0.609	7/8-14	0.484	2.050
5305X12X12	1.125	1-1/16-12	0.609	1-1/16-12	0.609	2.160
5305X14X14	1.250	1-3/16-12	0.719	1-3/16-12	0.719	2.210
5305X16X08	1.375	1-5/16-12	0.844	3/4-16	0.391	2.000
5305X16X10	1.375	1-5/16-12	0.844	7/8-14	0.484	2.100
5305X16X12	1.375	1-5/16-12	0.844	1-1/16-12	0.609	2.200
5305X16X16	1.375	1-5/16-12	0.844	1-5/16-12	0.844	2.250
5305X20X12	1.688	1-5/8-12	1.078	1-1/16-12	0.609	2.340
5305X20X16	1.688	1-5/8-12	1.078	1-5/16-12	0.844	2.380
5305X20X20	1.688	1-5/8-12	1.078	1-5/8-12	1.078	2.430
5305X24X12	2.000	1-7/8-12	1.313	1-1/16-12	0.609	2.530
5305X24X16	2.000	1-7/8-12	1.313	1-5/16-12	0.844	2.580
5305X24X20	2.000	1-7/8-12	1.313	1-5/8-12	1.078	2.620
5305X24X24	2.000	1-7/8-12	1.313	1-7/8-12	1.313	2.750
5305X32X32	2.625	2-1/2-12	1.781	2-1/2-12	1.781	3.400

Description: **Large Hex Union**
WWF Part No.: **5306**
WWF Stainless Part No.: **2403-LH-SS**
SAE: **070119**

Air-Way: 2403-LH
Parker: LHTX
Aeroquip: 202712
Gates: /

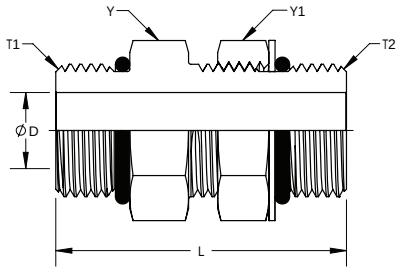


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WWF	Y HEX	T1	D1	T2	D2	L
5306X04X04	0.688	7/16-20	0.172	7/16-20	0.172	1.370
5306X05X05	0.750	1/2-20	0.234	1/2-20	0.234	1.370
5306X06X06	0.813	9/16-18	0.297	9/16-18	0.297	1.410
5306X08X04	1.000	3/4-16	0.391	7/16-20	0.172	1.510
5306X08X08	1.000	3/4-16	0.391	3/4-16	0.391	1.620
5306X10X10	1.125	7/8-14	0.484	7/8-14	0.484	1.880
5306X12X12	1.375	1-1/16-12	0.609	1-1/16-12	0.609	2.160
5306X14X14	1.500	1-3/16-12	0.719	1-3/16-12	0.719	2.210
5306X16X16	1.625	1-5/16-12	0.844	1-5/16-12	0.844	2.250
5306X20X20	1.875	1-5/8-12	1.078	1-5/8-12	1.078	2.430
5306X24X24	2.125	1-7/8-12	1.313	1-7/8-12	1.313	2.750

Description: **Adjustable Union**
WWF Part No.: **5314**
WWF Stainless Part No.: **3474-SS**
SAE: ***/***

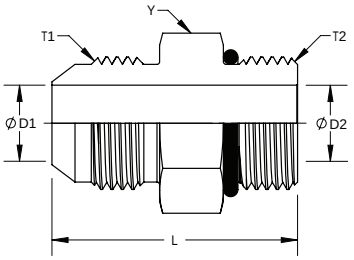
Air-Way: 3474
Parker: /
Aeroquip: /
Gates: /



WWF	Y HEX	Y1 HEX	T1	D	T2	L
5314X04X04	0.563	0.563	7/16-20	0.172	7/16-20	1.470
5314X06X06	0.688	0.688	9/16-18	0.297	9/16-18	1.560
5314X08X08	0.875	0.875	3/4-16	0.391	3/4-16	1.760
5314X10X10	1.000	1.000	7/8-14	0.484	7/8-14	2.040
5314X12X12	1.250	1.250	1-1/16-12	0.609	1 1/16-12	2.330
5314X16X16	1.500	1.500	1-5/16-12	0.844	1 5/16-12	2.360
5314X20X20	1.875	1.875	1-5/8-12	1.078	1 5/8-12	2.310
5314X24X24	2.125	2.125	1-7/8-12	1.313	1-7/8-12	2.420
5314X32X32	2.750	2.750	2-1/2-12	1.781	2-1/2-12	2.590

Description: **Straight Thread Connector Short**
WWF Part No.: **5315**
WWF Stainless Part No.: **6400-SS**
SAE: **070120**

Air-Way: 6400
Parker: F5OX
Aeroquip: 202702-[R]
Gates: MB-MJ



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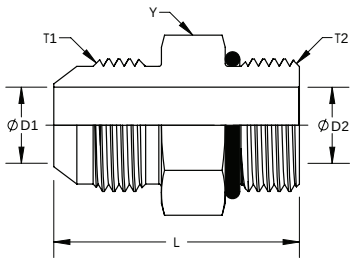
WWF	Y HEX	T1	D1	T2	D2	L
5315X02X02	0.438	5/16-24	0.063	5/16-24	0.063	1.060
5315X03X03	0.500	3/8-24	0.125	3/8-24	0.125	1.100
5315X04X02	0.563	7/16-20	0.172	5/16-24	0.063	1.170
5315X04X03	0.563	7/16-20	0.172	3/8-24	0.125	1.170
5315X04X04	0.563	7/16-20	0.172	7/16-20	0.172	1.230
5315X04X05	0.625	7/16-20	0.172	1/2-20	0.234	1.230
5315X04X06	0.688	7/16-20	0.172	9/16-18	0.297	1.290
5315X04X08	0.875	7/16-20	0.172	3/4-16	0.391	1.370
5315X04X10	1.000	7/16-20	0.172	7/8-14	0.484	1.490
5315X04X12	1.250	7/16-20	0.172	1-1/16-12	0.609	1.660
5315X05X04	0.563	1/2-20	0.234	7/16-20	0.172	1.230
5315X05X05	0.625	1/2-20	0.234	1/2-20	0.234	1.230
5315X05X06	0.688	1/2-20	0.234	9/16-18	0.297	1.290
5315X06X04	0.625	9/16-18	0.297	7/16-20	0.172	1.270
5315X06X05	0.625	9/16-18	0.297	1/2-20	0.234	1.270
5315X06X06	0.688	9/16-18	0.297	9/16-18	0.297	1.300
5315X06X08	0.875	9/16-18	0.297	3/4-16	0.391	1.380
5315X06X10	1.000	9/16-18	0.297	7/8-14	0.484	1.500
5315X06X12	1.250	9/16-18	0.297	1-1/16-12	0.609	1.660
5315X08X04	0.813	3/4-16	0.391	7/16-20	0.172	1.490
5315X08X06	0.813	3/4-16	0.391	9/16-18	0.297	1.440
5315X08X08	0.875	3/4-16	0.391	3/4-16	0.391	1.480
5315X08X10	1.000	3/4-16	0.391	7/8-14	0.484	1.600
5315X08X12	1.250	3/4-16	0.391	1-1/16-12	0.609	1.760
5315X08X16	1.500	3/4-16	0.391	1-5/16-12	0.844	1.790
5315X08X20	1.875	3/4-16	0.391	1-5/8-12	1.078	1.870
5315X10X04	1.000	7/8-14	0.484	7/16-20	0.172	1.650
5315X10X06	0.938	7/8-14	0.484	9/16-18	0.297	1.710
5315X10X08	0.938	7/8-14	0.484	3/4-16	0.391	1.640
5315X10X10	1.000	7/8-14	0.484	7/8-14	0.484	1.700
5315X10X12	1.250	7/8-14	0.484	1-1/16-12	0.609	1.860
5315X10X16	1.500	7/8-14	0.484	1-5/16-12	0.844	1.890
5315X12X06	1.125	1-1/16-12	0.609	9/16-18	0.297	1.860

Continued on page 109

Continued from page 108

Description: **Straight Thread Connector Short**
WWF Part No.: **5315**
WWF Stainless Part No.: **6400-SS**
SAE: **070120**

Air-Way: 6400
Parker: F5OX
Aeroquip: 202702-[R]
Gates: MB-MJ

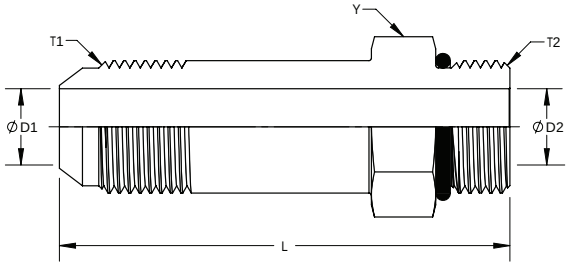


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WWF	Y HEX	T1	D1	T2	D2	L
5315X12X08	1.125	1-1/16-12	0.609	3/4-16	0.391	1.940
5315X12X10	1.125	1-1/16-12	0.609	7/8-14	0.484	1.880
5315X12X12	1.250	1-1/16-12	0.609	1-1/16-12	0.609	1.970
5315X12X14	1.375	1-1/16-12	0.609	1-3/16-12	0.719	1.960
5315X12X16	1.500	1-1/16-12	0.609	1-5/16-12	0.844	1.990
5315X12X20	1.875	1-1/16-12	0.609	1/5/8-12	1.078	2.080
5315X14X12	1.250	1-3/16-12	0.719	1-1/16-12	0.609	1.990
5315X14X14	1.375	1-3/16-12	0.719	1-3/16-12	0.719	1.990
5315X14X16	1.500	1-3/16-12	0.719	1-5/16-12	0.844	2.020
5315X16X08	1.375	1-5/16-12	0.844	3/4-16	0.391	2.010
5315X16X10	1.375	1-5/16-12	0.844	7/8-14	0.484	2.070
5315X16X12	1.375	1-5/16-12	0.844	1-1/16-12	0.609	2.040
5315X16X14	1.375	1-5/16-12	0.844	1-3/16-12	0.719	2.040
5315X16X16	1.500	1-5/16-12	0.844	1-5/16-12	0.844	2.040
5315X16X20	1.875	1-5/16-12	0.844	1-5/8-12	1.078	2.120
5315X16X24	2.125	1-5/16-12	0.844	1-7/8-12	1.313	2.200
5315X20X16	1.688	1-5/8-12	1.078	1-5/16-12	0.844	2.330
5315X20X20	1.875	1-5/8-12	1.078	1-5/8-12	1.078	2.170
5315X20X24	2.125	1-5/8-12	1.078	1-7/8-12	1.313	2.240
5315X24X16	2.750	1-7/8-12	1.313	1-5/16-12	0.844	2.530
5315X24X20	2.125	1-7/8-12	1.313	1-5/8-12	1.078	2.530
5315X24X24	2.125	1-7/8-12	1.313	1-7/8-12	1.313	2.370
5315X24X32	2.750	1-7/8-12	1.313	2-1/2-12	1.781	2.530
5315X32X20	2.625	2-1/2-12	1.781	1-5/8-12	1.078	2.940
5315X32X24	2.750	2-1/2-12	1.781	1-7/8-12	1.313	2.940
5315X32X32	2.750	2-1/2-12	1.781	2-1/2-12	1.781	2.780

Description: **Straight Thread Connector Long**
WWF Part No.: **5316**
WWF Stainless Part No.: **6400-L-SS**
SAE: **071702**

Air-Way: 6400-L
Parker: FF5O-X
Aeroquip: 202713-[R]
Gates: /

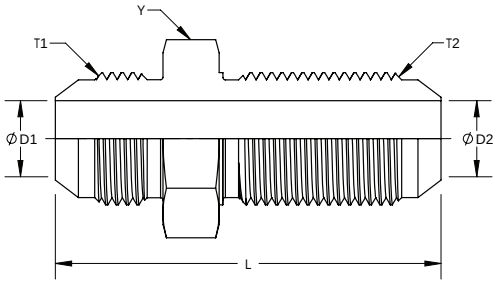


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WWF	Y HEX	T1	D1	T2	D2	L
5316X04X04	0.563	7/16-20	0.172	7/16-20	0.172	2.080
5316X05X05	0.625	1/2-20	0.234	1/2-20	0.234	2.140
5316X06X06	0.688	9/16-18	0.297	9/16-18	0.297	2.310
5316X06X08	0.875	9/16-18	0.297	3/4-16	0.391	2.600
5316X08X08	0.875	3/4-16	0.391	3/4-16	0.391	2.700
5316X08X10	1.000	3/4-16	0.391	7/8-14	0.484	2.940
5316X10X10	1.000	7/8-14	0.484	7/8-14	0.484	3.040
5316X12X12	1.250	1-1/16-12	0.609	1-1/16-12	0.609	3.610
5316X14X14	1.375	1-3/16-12	0.719	1-3/16-12	0.719	3.800
5316X16X16	1.500	1-5/16-12	0.844	1-5/16-12	0.844	3.980
5316X20X16	1.875	1-5/8-12	1.078	1-5/16-12	0.844	4.690
5316X20X20	1.875	1-5/8-12	1.078	1-5/8-12	1.078	4.690

Description: **Bulkhead Union**
WWF Part No.: **5325**
WWF Stainless Part No.: **2700-SS**
SAE: **070601**

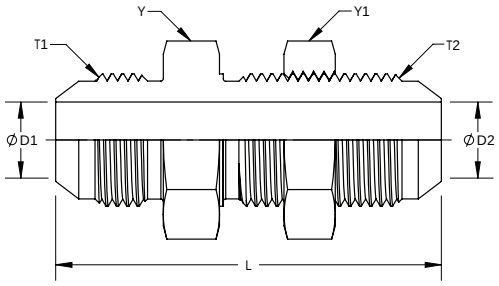
Air-Way: 2700
Parker: WTX
Aeroquip: 2041-1-[R]
Gates: MJ-BKHD



WWF	Y HEX	T1	D1	T2	D2	L
5325X04X04	0.688	7/16-20	0.172	7/16-20	0.172	2.070
5325X04X06	0.813	7/16-20	0.172	9/16-18	0.297	2.170
5325X05X05	0.750	1/2-20	0.234	1/2-20	0.234	2.070
5325X06X04	0.813	9/16-18	0.297	7/16-20	0.172	2.170
5325X06X06	0.813	9/16-18	0.297	9/16-18	0.297	2.180
5325X08X08	1.000	3/4-16	0.391	3/4-16	0.391	2.440
5325X10X10	1.125	7/8-14	0.484	7/8-14	0.484	2.740
5325X12X12	1.375	1-1/16-12	0.609	1-1/16-12	0.609	3.090
5325X14X14	1.500	1-3/16-12	0.719	1-3/16-12	0.719	3.120
5325X16X16	1.625	1-5/16-12	0.844	1-5/16-12	0.844	3.140
5325X20X20	1.875	1-5/8-12	1.078	1-5/8-12	1.078	3.310
5325X24X24	2.125	1-7/8-12	1.313	1-7/8-12	1.313	3.520

Description: **Bulkhead Union With Locknut**
WWF Part No.: **5325LN**
WWF Stainless Part No.: **2700-LN-SS**
SAE: **070601**

Air-Way: 2700-LN
Parker: WTX-WLN
Aeroquip: 2041-[R]
Gates: /

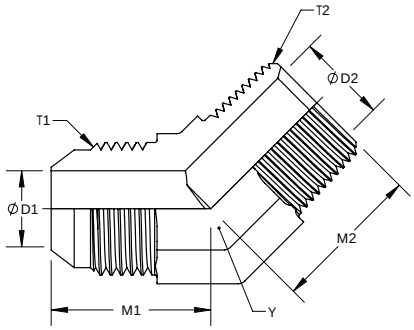


WWF	Y HEX	Y1 HEX	T1	D1	T2	D2	L
5325X04X04LN	0.688	0.688	7/16-20	0.172	7/16-20	0.172	2.070
5325X05X05LN	0.750	0.750	1/2-20	0.234	1/2-20	0.234	2.070
5325X06X06LN	0.813	0.813	9/16-18	0.297	9/16-18	0.297	2.180
5325X08X08LN	1.000	1.000	3/4-16	0.391	3/4-16	0.391	2.440
5325X10X10LN	1.125	1.125	7/8-14	0.484	7/8-14	0.484	2.740
5325X12X12LN	1.375	1.375	1-1/16-12	0.609	1-1/16-12	0.609	3.090
5325X14X14LN	1.500	1.500	1-3/16-12	0.719	1-3/16-12	0.719	3.120
5325X16X16LN	1.625	1.625	1-5/16-12	0.844	1-5/16-12	0.844	3.140
5325X20X20LN	1.875	1.875	1-5/8-12	1.078	1-5/8-12	1.078	3.310
5325X24X24LN	2.125	2.125	1-7/8-12	1.313	1-7/8-12	1.313	3.520

C

Description: **45° Male Elbow**
WWF Part No.: **F5355**
WWF Stainless Part No.: **2503-SS**
SAE: **070302**

Air-Way: 2503
Parker: VTX
Aeroquip: 2023-[R]
Gates: MJ-MP45



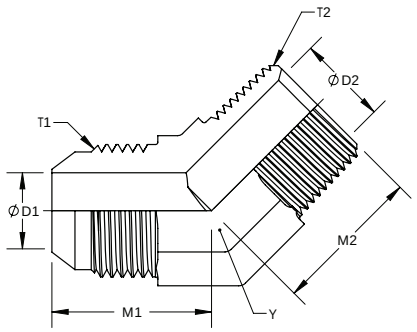
WWF	Y HEX	T1	M1	D1	T2	M2	D2
F5355X02X02	0.438	5/16-24	0.690	0.063	1/8-27	0.520	0.188
F5355X03X02	0.438	3/8-24	0.690	0.125	1/8-27	0.520	0.188
F5355X04X02	0.438	7/16-20	0.720	0.172	1/8-27	0.640	0.188
F5355X04X04	0.563	7/16-20	0.820	0.172	1/4-18	0.860	0.281
F5355X04X06	0.750	7/16-20	0.850	0.172	3/8-18	0.950	0.406
F5355X04X08	0.875	7/16-20	0.870	0.172	1/2-14	1.170	0.531
F5355X05X02	0.563	1/2-20	0.770	0.234	1/8-27	0.640	0.188
F5355X05X04	0.563	1/2-20	0.820	0.234	1/4-18	0.860	0.281
F5355X06X02	0.563	9/16-18	0.830	0.297	1/8-27	0.670	0.188
F5355X06X04	0.563	9/16-18	0.830	0.297	1/4-18	0.860	0.281
F5355X06X06	0.750	9/16-18	0.870	0.297	3/8-18	0.950	0.406

Continued on page 112

Continued from page 111

Description: **45° Male Elbow**
WWF Part No.: **F5355**
WWF Stainless Part No.: **2503-SS**
SAE: **070302**

Air-Way: 2503
Parker: VTX
Aeroquip: 2023-[R]
Gates: MJ-MP45

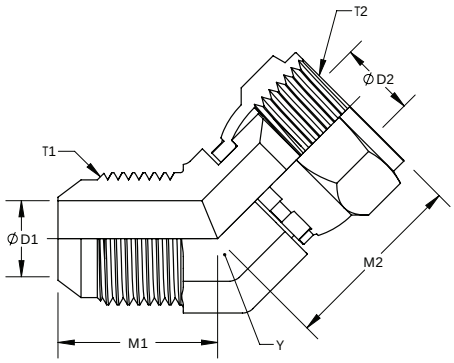


C

WWF	Y HEX	T1	M1	D1	T2	M2	D2
F5355X06X08	0.875	9/16-18	0.880	0.297	1/2-14	1.170	0.531
F5355X06X12	1.063	9/16-18	0.930	0.297	3/4-14	1.200	0.719
F5355X08X04	0.750	3/4-16	0.980	0.391	1/4-18	0.950	0.281
F5355X08X06	0.750	3/4-16	0.980	0.391	3/8-18	0.950	0.406
F5355X08X08	0.875	3/4-16	0.990	0.391	1/2-14	1.170	0.531
F5355X08X12	1.063	3/4-16	1.040	0.391	3/4-14	1.200	0.719
F5355X10X06	0.875	7/8-14	1.110	0.484	3/8-18	0.980	0.406
F5355X10X08	0.875	7/8-14	1.110	0.484	1/2-14	1.170	0.531
F5355X10X12	1.063	7/8-14	1.160	0.484	3/4-14	1.200	0.719
F5355X12X08	1.063	1-1/16-12	1.280	0.609	1/2-14	1.200	0.531
F5355X12X12	1.063	1-1/16-12	1.280	0.609	3/4-14	1.200	0.719
F5355X12X16	1.313	1-1/16-12	1.420	0.609	1-11-1/2	1.480	0.938
F5355X14X12	1.313	1-3/16-12	1.450	0.719	3/4-14	1.300	0.719
F5355X16X08	1.313	1-5/16-12	1.470	0.844	1/2-14	1.290	0.531
F5355X16X12	1.313	1-5/16-12	1.470	0.844	3/4-14	1.290	0.719
F5355X16X16	1.313	1-5/16-12	1.470	0.844	1-11-1/2	1.480	0.938
F5355X16X20	1.625	1-5/16-12	1.540	0.844	1-1/4-11-1/2	1.670	1.250
F5355X20X16	1.625	1-5/8-12	1.590	1.078	1-11-1/2	1.640	0.938
F5355X20X20	1.625	1-5/8-12	1.590	1.078	1-1/4-11-1/2	1.670	1.250
F5355X20X24	1.875	1-5/8-12	1.650	1.078	1-1/2-11-1/2	1.770	1.500
F5355X24X20	1.875	1-7/8-12	1.780	1.313	1-1/4-11-1/2	1.740	1.250
F5355X24X24	1.875	1-7/8-12	1.780	1.313	1-1/2-11-1/2	1.770	1.500
F5355X32X32	2.500	2-1/2-12	2.220	1.781	2-11-1/2	2.110	1.938

Description: **45° Swivel Elbow**
WWF Part No.: **F5356**
WWF Stainless Part No.: **6502-SS**
SAE: **070321**

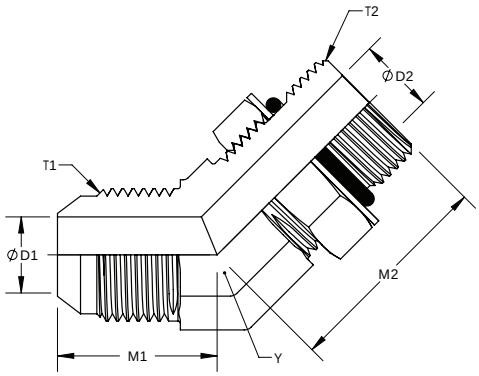
Air-Way: 6502
Parker: V6X
Aeroquip: 2070-[R]
Gates: MJ-FJX45



WWF	Y HEX	T1	M1	D1	T2	M2	D2
F5356X02X02	0.438	5/16-24	0.690	0.063	5/16-24	0.940	0.063
F5356X04X04	0.438	7/16-20	0.720	0.172	7/16-20	0.940	0.172
F5356X05X05	0.563	1/2-20	0.770	0.234	1/2-20	1.000	0.234
F5356X06X06	0.563	9/16-18	0.830	0.297	9/16-18	1.120	0.297
F5356X08X08	0.750	3/4-16	0.980	0.391	3/4-16	1.280	0.391
F5356X10X10	0.875	7/8-14	1.110	0.484	7/8-14	1.440	0.484
F5356X12X12	1.063	1-1/16-12	1.280	0.609	1-1/16-12	1.500	0.609
F5356X14X14	1.313	1-3/16-12	1.450	0.719	1-3/16-12	1.620	0.719
F5356X16X16	1.313	1-5/16-12	1.470	0.844	1-5/16-12	1.750	0.844
F5356X20X20	1.625	1-5/8-12	1.590	1.078	1-5/8-12	2.030	1.078
F5356X24X24	1.875	1-7/8-12	1.780	1.313	1-7/8-12	2.250	1.313
F5356X32X32	2.500	2-1/2-12	2.220	1.781	2-1/2-12	2.910	1.781

Description: **45° Straight Thread Elbow**
WWF Part No.: **F5365**
WWF Stainless Part No.: **6802-SS**
SAE: **070320**

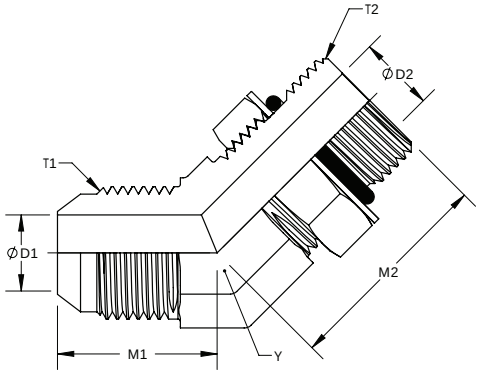
Air-Way: 6802
Parker: V5OX
Aeroquip: 2061-[R]
Gates: MB-MJ45



WWF	Y HEX	T1	M1	D1	T2	M2	D2
F5365X02X02	0.438	5/16-24	0.690	0.063	5/16-24	0.880	0.063
F5365X04X04	0.438	7/16-20	0.720	0.172	7/16-20	1.050	0.172
F5365X04X05	0.563	7/16-20	0.770	0.172	1/2-20	1.050	0.234
F5365X04X06	0.563	7/16-20	0.820	0.172	9/16-18	1.140	0.297
F5365X04X08	0.750	7/16-20	0.850	0.172	3/4-16	1.300	0.391
F5365X05X04	0.563	1/2-20	0.770	0.234	7/16-20	1.050	0.172
F5365X05X05	0.563	1/2-20	0.770	0.234	1/2-20	1.050	0.234
F5365X05X06	0.563	1/2-20	0.820	0.234	9/16-18	1.140	0.297
F5365X06X04	0.563	9/16-18	0.830	0.297	7/16-20	1.080	0.172
F5365X06X05	0.563	9/16-18	0.830	0.297	1/2-20	1.080	0.234

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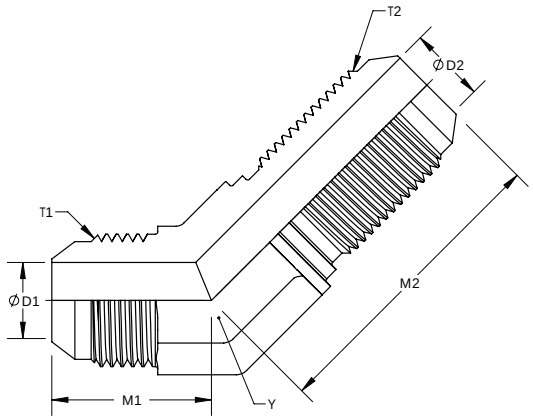


Description: **45° Straight Thread Elbow**
WWF Part No.: **F5365**
WWF Stainless Part No.: **6802-SS**
SAE: **070320**

Air-Way: 6802
Parker: V5OX
Aeroquip: 2061-[R]
Gates: MB-MJ45

C

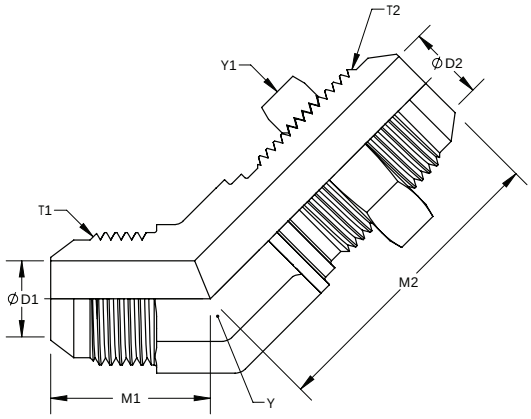
WWF	Y HEX	T1	M1	D1	T2	M2	D2
F5365X06X06	0.563	9/16-18	0.830	0.297	9/16-18	1.140	0.297
F5365X06X08	0.750	9/16-18	0.870	0.297	3/4-16	1.300	0.391
F5365X06X10	0.875	9/16-18	0.880	0.297	7/8-14	1.520	0.484
F5365X08X06	0.750	3/4-16	0.980	0.391	9/16-18	1.170	0.297
F5365X08X08	0.750	3/4-16	0.980	0.391	3/4-16	1.300	0.391
F5365X08X10	0.875	3/4-16	0.990	0.391	7/8-14	1.520	0.484
F5365X08X12	1.063	3/4-16	1.040	0.391	1-1/16-12	1.730	0.609
F5365X10X08	0.875	7/8-14	1.110	0.484	3/4-16	1.360	0.391
F5365X10X10	0.875	7/8-14	1.110	0.484	7/8-14	1.520	0.484
F5365X10X12	1.063	7/8-14	1.160	0.484	1-1/16-12	1.730	0.609
F5365X12X08	1.063	1-1/16-12	1.280	0.609	3/4-16	1.410	0.391
F5365X12X10	1.063	1-1/16-12	1.280	0.609	7/8-14	1.570	0.484
F5365X12X12	1.063	1-1/16-12	1.280	0.609	1-1/16-12	1.730	0.609
F5365X12X16	1.313	1-1/16-12	1.420	0.609	1-5/16-12	1.860	0.844
F5365X14X14	1.313	1-3/16-12	1.450	0.719	1-3/16-12	1.860	0.719
F5365X16X12	1.313	1-5/16-12	1.470	0.844	1-1/16-12	1.860	0.609
F5365X16X16	1.313	1-5/16-12	1.470	0.844	1-5/16-12	1.860	0.844
F5365X16X20	1.625	1-5/16-12	1.540	0.844	1-5/8-12	1.910	1.078
F5365X20X16	1.625	1-5/8-12	1.590	1.078	1-5/16-12	1.910	0.844
F5365X20X20	1.625	1-5/8-12	1.590	1.078	1-5/8-12	1.910	1.078
F5365X24X24	1.875	1-7/8-12	1.780	1.313	1-7/8-12	1.910	1.313
F5365X32X32	2.500	2-1/2-12	2.220	1.781	2-1/2-12	1.860	1.781



Description: **45° Bulkhead Elbow**
WWF Part No.: **F5375**
WWF Stainless Part No.: **2702-SS**
SAE: **070801**

Air-Way: 2702
Parker: WNTX
Aeroquip: 2042-1
Gates: MJ-BKHD45

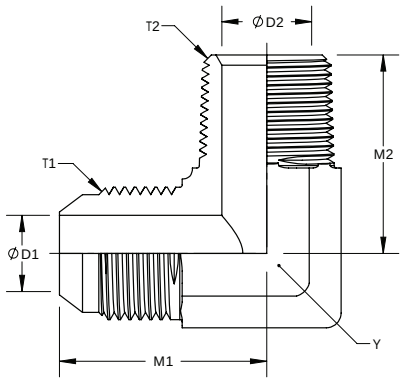
WWF	Y HEX	T1	M1	D1	T2	M2	D2
F5375X03X03	0.438	3/8-24	0.690	0.125	3/8-24	1.420	0.125
F5375X04X04	0.438	7/16-20	0.720	0.172	7/16-20	1.530	0.172
F5375X05X05	0.563	1/2-20	0.770	0.234	1/2-20	1.660	0.234
F5375X06X06	0.563	9/16-18	0.830	0.297	9/16-18	1.670	0.297
F5375X08X06	0.750	3/4-16	0.980	0.391	9/16-18	1.830	0.297
F5375X08X08	0.750	3/4-16	0.980	0.391	3/4-16	1.940	0.391
F5375X10X10	0.875	7/8-14	1.110	0.484	7/8-14	2.170	0.484
F5375X12X12	1.063	1-1/16-12	1.280	0.609	1-1/16-12	2.440	0.609
F5375X16X16	1.313	1-5/16-12	1.470	0.844	1-5/16-12	2.560	0.844
F5375X20X20	1.625	1-5/8-12	1.590	1.078	1-5/8-12	2.650	1.078
F5375X24X24	1.875	1-7/8-12	1.780	1.313	1-7/8-12	2.670	1.313



Description: **45° Bulkhead Elbow With Locknut**
WWF Part No.: **F5375LN**
WWF Stainless Part No.: **2702-LN-SS**
SAE: **070801**

Air-Way: 2702-LN
Parker: WNTX-WLN
Aeroquip: 2042
Gates: /

WWF	Y HEX	Y1 HEX	T1	M1	D1	T2	M2	D2
F5375X03X03LN	0.438	0.375	3/8-24	0.690	0.125	3/8-24	1.420	0.125
F5375X04X04LN	0.438	0.688	7/16-20	0.720	0.172	7/16-20	1.530	0.172
F5375X05X05LN	0.563	0.750	1/2-20	0.770	0.234	1/2-20	1.660	0.234
F5375X06X06LN	0.563	0.813	9/16-18	0.830	0.297	9/16-18	1.670	0.297
F5375X08X06LN	0.750	0.813	3/4-16	0.980	0.391	9/16-18	1.830	0.297
F5375X08X08LN	0.750	1.000	3/4-16	0.980	0.391	3/4-16	1.940	0.391
F5375X10X10LN	0.875	1.125	7/8-14	1.110	0.484	7/8-14	2.170	0.484
F5375X12X12LN	1.063	1.375	1-1/16-12	1.280	0.609	1-1/16-12	2.440	0.609
F5375X16X16LN	1.313	1.625	1-5/16-12	1.470	0.844	1-5/16-12	2.560	0.844
F5375X20X20LN	1.625	1.875	1-5/8-12	1.590	1.078	1-5/8-12	2.650	1.078
F5375X24X24LN	1.875	2.125	1-7/8-12	1.780	1.313	1-7/8-12	2.670	1.313



Description: **90° Male Elbow**
WWF Part No.: **F5405**
WWF Stainless Part No.: **2501-SS**
SAE: **070202**

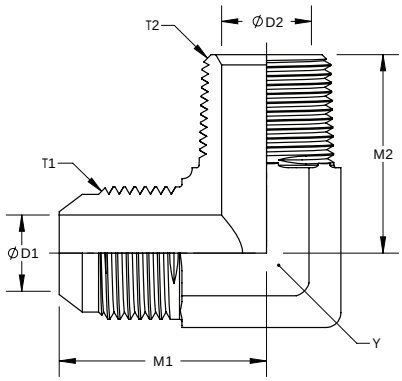
Air-Way: 2501
Parker: CTX
Aeroquip: 2024-[R]
Gates: MJ-MP90

C

WWF	Y HEX	T1	M1	D1	T2	M2	D2
F5405X02X02	0.438	5/16-24	0.770	0.063	1/8-27	0.720	0.188
F5405X02X04	0.563	5/16-24	0.940	0.063	1/4-18	1.090	0.281
F5405X03X02	0.438	3/8-24	0.830	0.125	1/8-27	0.720	0.188
F5405X04X02	0.438	7/16-20	0.890	0.172	1/8-27	0.780	0.188
F5405X04X04	0.563	7/16-20	1.050	0.172	1/4-18	1.090	0.281
F5405X04X06	0.750	7/16-20	1.120	0.172	3/8-18	1.220	0.406
F5405X04X08	0.875	7/16-20	1.210	0.172	1/2-14	1.470	0.531
F5405X04X12	1.063	7/16-20	1.300	0.172	3/4-14	1.590	0.719
F5405X05X02	0.563	1/2-20	0.950	0.234	1/8-27	0.780	0.188
F5405X05X04	0.563	1/2-20	1.050	0.234	1/4-18	1.090	0.281
F5405X05X06	0.750	1/2-20	1.120	0.234	3/8-18	1.220	0.406
F5405X05X08	0.875	1/2-20	1.210	0.234	1/2-14	1.470	0.531
F5405X06X02	0.563	9/16-18	1.060	0.297	1/8-27	0.900	0.188
F5405X06X04	0.563	9/16-18	1.060	0.297	1/4-18	1.090	0.281
F5405X06X06	0.750	9/16-18	1.140	0.297	3/8-18	1.220	0.406
F5405X06X08	0.875	9/16-18	1.220	0.297	1/2-14	1.470	0.531
F5405X06X12	1.063	9/16-18	1.310	0.297	3/4-14	1.590	0.719
F5405X08X02	0.750	3/4-16	1.250	0.391	1/8-27	1.030	0.188
F5405X08X04	0.750	3/4-16	1.250	0.391	1/4-18	1.220	0.281
F5405X08X06	0.750	3/4-16	1.250	0.391	3/8-18	1.220	0.406
F5405X08X08	0.875	3/4-16	1.330	0.391	1/2-14	1.470	0.531
F5405X08X12	1.063	3/4-16	1.420	0.391	3/4-14	1.590	0.719
F5405X08X16	1.313	3/4-16	1.520	0.391	1-11-1/2	1.970	0.938
F5405X10X06	0.875	7/8-14	1.450	0.484	3/8-18	1.280	0.406
F5405X10X08	0.875	7/8-14	1.450	0.484	1/2-14	1.470	0.531
F5405X10X12	1.063	7/8-14	1.540	0.484	3/4-14	1.590	0.719
F5405X10X16	1.313	7/8-14	1.640	0.484	1-11-1/2	1.970	0.938
F5405X12X06	1.063	1-1/16-12	1.660	0.609	3/8-18	1.400	0.406
F5405X12X08	1.063	1-1/16-12	1.660	0.609	1/2-14	1.590	0.531
F5405X12X12	1.063	1-1/16-12	1.660	0.609	3/4-14	1.590	0.719
F5405X12X16	1.313	1-1/16-12	1.760	0.609	1-11-1/2	1.970	0.938
F5405X12X20	1.625	1-1/16-12	1.970	0.609	1-1/4-11-1/2	2.380	1.250
F5405X12X24	1.875	1-1/16-12	2.110	0.609	1-1/2-11-12	2.640	1.500

Continued on page 117

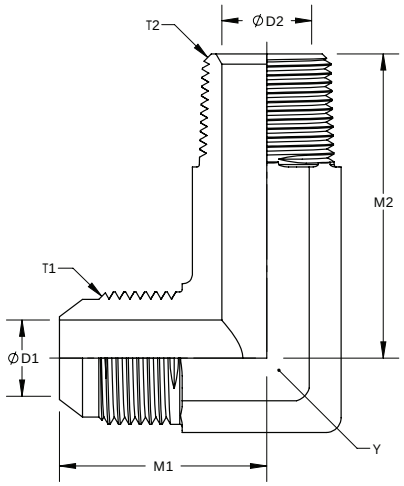
Continued from page 116



Description: **90° Male Elbow**
WWF Part No.: **F5405**
WWF Stainless Part No.: **2501-SS**
SAE: **070202**

Air-Way: 2501
Parker: CTX
Aeroquip: 2024-[R]
Gates: MJ-MP90

WWF	Y HEX	T1	M1	D1	T2	M2	D2
F5405X14X12	1.313	1-3/16-12	1.800	0.719	3/4-14	1.690	0.719
F5405X16X08	1.313	1-5/16-12	1.810	0.844	1/2-14	1.780	0.531
F5405X16X12	1.313	1-5/16-12	1.810	0.844	3/4-14	1.780	0.719
F5405X16X16	1.313	1-5/16-12	1.810	0.844	1-11-1/2	1.970	0.938
F5405X16X20	1.625	1-5/16-12	2.010	0.844	1-1/4-11-1/2	2.380	1.250
F5405X16X24	1.875	1-5/16-12	2.160	0.844	1-1/2-11-12	2.640	1.500
F5405X20X12	1.625	1-5/8-12	2.060	1.078	3/4-14	2.160	0.719
F5405X20X16	1.625	1-5/8-12	2.060	1.078	1-11-1/2	2.350	0.938
F5405X20X20	1.625	1-5/8-12	2.060	1.078	1-1/4-11-1/2	2.380	1.250
F5405X20X24	1.875	1-5/8-12	2.200	1.078	1-1/2-11-12	2.640	1.500
F5405X24X16	1.875	1-7/8-12	2.330	1.313	1-11-1/2	2.580	0.938
F5405X24X20	1.875	1-7/8-12	2.330	1.313	1-1/4-11-1/2	2.610	1.250
F5405X24X24	1.875	1-7/8-12	2.330	1.313	1-1/2-11-12	2.640	1.500
F5405X24X32	2.500	1-7/8-12	2.810	1.313	2-11-1/2	3.000	1.938
F5405X32X24	2.500	2-1/2-12	3.060	1.781	1-1/2-11-12	2.970	1.500
F5405X32X32	2.500	2-1/2-12	3.060	1.781	2-11-1/2	3.000	1.938

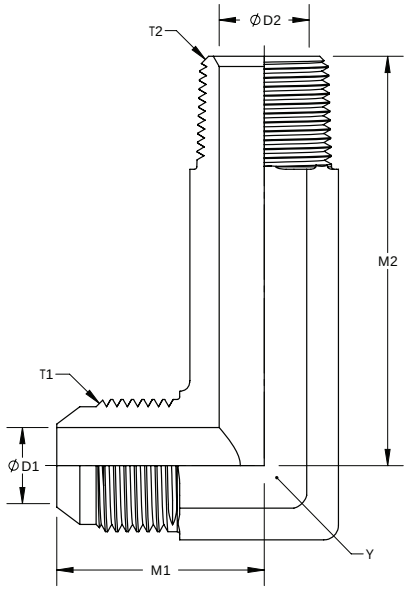


Description: **90° Male Long Elbow**
WWF Part No.: **F5425**
WWF Stainless Part No.: **2501-L-SS**
SAE: **071502**

Air-Way: 2501-L
Parker: CCTX
Aeroquip: 202411-[R]
Gates: /

C

WWF	Y HEX	T1	M1	D1	T2	M2	D2
F5425X04X02	0.438	7/16-20	0.890	0.172	1/8-27	1.170	0.188
F5425X04X04	0.563	7/16-20	1.050	0.172	1/4-18	1.580	0.281
F5425X05X02	0.563	1/2-20	0.950	0.234	1/8-27	1.170	0.188
F5425X05X04	0.563	1/2-20	1.050	0.234	1/4-18	1.580	0.281
F5425X06X02	0.563	9/16-18	1.060	0.297	1/8-27	1.390	0.188
F5425X06X04	0.563	9/16-18	1.060	0.297	1/4-18	1.580	0.281
F5425X06X06	0.750	9/16-18	1.140	0.297	3/8-18	1.820	0.406
F5425X06X08	0.875	9/16-18	1.220	0.297	1/2-14	2.170	0.531
F5425X08X04	0.750	3/4-16	1.250	0.391	1/4-18	1.820	0.281
F5425X08X06	0.750	3/4-16	1.250	0.391	3/8-18	1.820	0.406
F5425X08X08	0.875	3/4-16	1.330	0.391	1/2-14	2.170	0.531
F5425X08X12	1.063	3/4-16	1.420	0.391	3/4-14	2.440	0.719
F5425X10X08	0.875	7/8-14	1.450	0.484	1/2-14	2.170	0.531
F5425X10X12	1.063	7/8-14	1.540	0.484	3/4-14	2.440	0.719
F5425X12X12	1.063	1-1/16-12	1.660	0.609	3/4-14	2.440	0.719
F5425X12X16	1.313	1-1/16-12	1.760	0.609	1-11-1/2	3.010	0.938
F5425X14X12	1.313	1-3/16-12	1.800	0.719	3/4-14	2.590	0.719
F5425X16X16	1.313	1-5/16-12	1.810	0.844	1-11-1/2	3.010	0.938
F5425X20X20	1.625	1-5/8-12	2.060	1.078	1-1/4-11-1/2	3.690	1.250
F5425X24X24	1.875	1-7/8-12	2.330	1.313	1-1/2-11-1/2	4.100	1.500

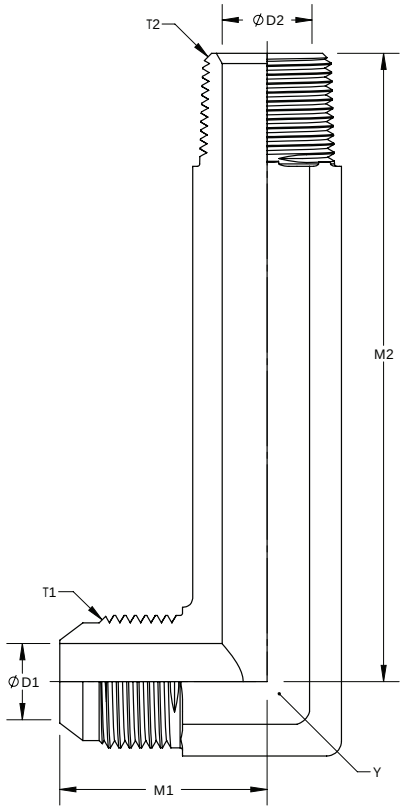


Description: **90° Male Extra Long Elbow**
WWF Part No.: **F5435**
WWF Stainless Part No.: **2501-LL-SS**
SAE: **071602**

Air-Way: 2501-LL
Parker: CCCTX
Aeroquip: 202413-[R]
Gates: /

WWF	Y HEX	T1	M1	D1	T2	M2	D2
F5435X04X02	0.438	7/16-20	0.890	0.172	1/8-27	1.560	0.188
F5435X04X04	0.563	7/16-20	1.050	0.172	1/4-18	2.070	0.281
F5435X05X02	0.563	1/2-20	0.950	0.234	1/8-27	1.630	0.188
F5435X05X04	0.563	1/2-20	1.050	0.234	1/4-18	2.070	0.281
F5435X06X04	0.563	9/16-18	1.060	0.297	1/4-18	2.070	0.281
F5435X06X06	0.750	9/16-18	1.140	0.297	3/8-18	2.420	0.406
F5435X06X08	0.875	9/16-18	1.220	0.297	1/2-14	2.870	0.531
F5435X08X06	0.750	3/4-16	1.250	0.391	3/8-18	2.420	0.406
F5435X08X08	0.875	3/4-16	1.330	0.391	1/2-14	2.870	0.531
F5435X10X08	0.875	7/8-14	1.450	0.484	1/2-14	2.870	0.531
F5435X12X08	1.063	1-1/16-12	1.660	0.609	1/2-14	3.280	0.531
F5435X12X12	1.063	1-1/16-12	1.660	0.609	3/4-14	3.280	0.719
F5435X14X12	1.313	1-3/16-12	1.800	0.719	3/4-14	3.500	0.719
F5435X16X16	1.313	1-5/16-12	1.810	0.844	1-11-1/2	4.050	0.938
F5435X20X20	1.625	1-5/8-12	2.060	1.078	1-1/4-11-1/2	5.000	1.250

C



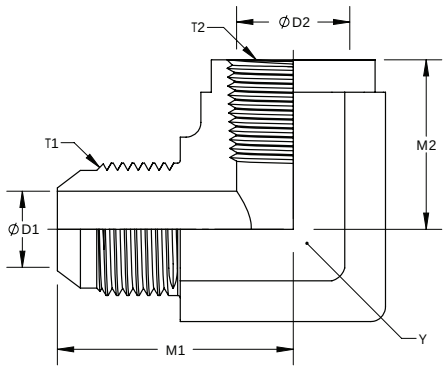
Description: **90° Male Extra Extra Long Elbow**
WWF Part No.: **F5445**
WWF Stainless Part No.: **2501-LLL-SS**
SAE: ***/***

Air-Way: 2501-LLL
Parker: /
Aeroquip: 202414-[R]
Gates: /

WWF	Y HEX	T1	M1	D1	T2	M2	D2
F5445X04X02	0.438	7/16-20	0.890	0.172	1/8-27	2.310	0.188
F5445X04X04	0.563	7/16-20	1.050	0.172	1/4-18	3.060	0.281
F5445X05X02	0.563	1/2-20	0.950	0.234	1/8-27	2.310	0.188
F5445X06X04	0.563	9/16-18	1.060	0.297	1/4-18	3.060	0.281
F5445X06X06	0.750	9/16-18	1.140	0.297	3/8-18	3.750	0.406
F5445X08X06	0.750	3/4-16	1.250	0.391	3/8-18	3.750	0.406
F5445X08X08	0.875	3/4-16	1.330	0.391	1/2-14	4.500	0.531
F5445X10X08	0.875	7/8-14	1.450	0.484	1/2-14	4.500	0.531
F5445X12X12	1.063	1-1/16-12	1.660	0.609	3/4-14	5.030	0.719
F5445X16X16	1.313	1-5/16-12	1.810	0.844	1-11-1/2	6.340	0.938

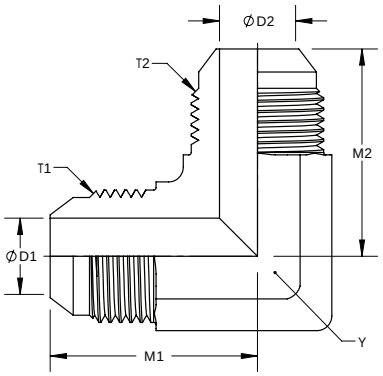
Description: **90° Female Elbow**
WWF Part No.: **F5455**
WWF Stainless Part No.: **2502-SS**
SAE: **070203**

Air-Way: 2502
Parker: DTX
Aeroquip: 2025-[R]
Gates: MJ-FP90



C

WWF	Y HEX	T1	M1	D1	T2	M2	D2
F5455X02X02	0.563	5/16-24	1.000	0.063	1/8-27	0.660	0.332
F5455X03X02	0.563	3/8-24	1.030	0.125	1/8-27	0.660	0.332
F5455X04X02	0.563	7/16-20	1.080	0.172	1/8-27	0.660	0.332
F5455X04X04	0.750	7/16-20	1.220	0.172	1/4-18	0.880	0.438
F5455X04X06	0.875	7/16-20	1.290	0.172	3/8-18	1.020	0.563
F5455X04X08	1.063	7/16-20	1.400	0.172	1/2-14	1.230	0.703
F5455X05X02	0.563	1/2-20	1.080	0.234	1/8-27	0.660	0.332
F5455X05X04	0.750	1/2-20	1.220	0.234	1/4-18	0.880	0.438
F5455X05X06	0.875	1/2-20	1.290	0.234	3/8-18	1.020	0.563
F5455X06X02	0.563	9/16-18	1.230	0.297	1/8-27	0.670	0.332
F5455X06X04	0.750	9/16-18	1.230	0.297	1/4-18	0.880	0.438
F5455X06X06	0.875	9/16-18	1.310	0.297	3/8-18	1.020	0.563
F5455X06X08	1.063	9/16-18	1.410	0.297	1/2-14	1.230	0.703
F5455X08X04	0.875	3/4-16	1.420	0.391	1/4-18	1.010	0.438
F5455X08X06	0.875	3/4-16	1.420	0.391	3/8-18	1.020	0.563
F5455X08X08	1.063	3/4-16	1.520	0.391	1/2-14	1.230	0.703
F5455X08X12	1.313	3/4-16	1.650	0.391	3/4-14	1.360	0.906
F5455X10X06	1.063	7/8-14	1.640	0.484	3/8-18	1.010	0.563
F5455X10X08	1.063	7/8-14	1.640	0.484	1/2-14	1.230	0.703
F5455X10X12	1.313	7/8-14	1.770	0.484	3/4-14	1.360	0.906
F5455X12X08	1.313	1-1/16-12	1.890	0.609	1/2-14	1.350	0.703
F5455X12X12	1.313	1-1/16-12	1.890	0.609	3/4-14	1.360	0.906
F5455X12X16	1.625	1-1/16-12	2.120	0.609	1-11-1/2	1.620	1.141
F5455X14X12	1.313	1-3/16-12	1.860	0.719	3/4-14	1.420	0.906
F5455X16X12	1.313	1-5/16-12	2.170	0.844	3/4-14	1.390	0.906
F5455X16X16	1.625	1-5/16-12	2.170	0.844	1-11-1/2	1.620	1.141
F5455X16X20	1.875	1-5/16-12	2.280	0.844	1-1/4-11-1/2	1.700	1.484
F5455X20X20	1.875	1-5/8-12	2.330	1.078	1-1/4-11-1/2	1.700	1.484
F5455X24X24	2.562	1-7/8-12	2.890	1.313	1-1/2-11-1/2	2.080	1.744
F5455X32X32	2.812	2-1/2-12	3.300	1.781	2-11-1/2	2.390	2.213

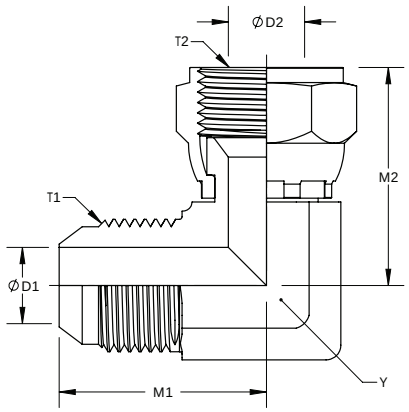


Description: **90° Union Elbow**
WWF Part No.: **F5505**
WWF Stainless Part No.: **2500-SS**
SAE: **070201**

Air-Way: 2500
Parker: ETX
Aeroquip: 2039
Gates: /

C

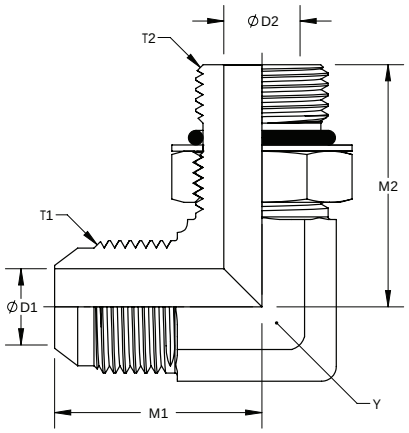
WWF	Y HEX	T1	M1	D1	T2	M2	D2
F5505X02X02	0.438	5/16-24	0.770	0.063	5/16-24	0.770	0.063
F5505X03X03	0.438	3/8-24	0.830	0.125	3/8-24	0.830	0.125
F5505X04X04	0.438	7/16-20	0.890	0.172	7/16-20	0.890	0.172
F5505X05X04	0.563	1/2-20	0.950	0.234	7/16-20	0.950	0.172
F5505X05X05	0.563	1/2-20	0.950	0.234	1/2-20	0.950	0.234
F5505X06X04	0.563	9/16-18	1.060	0.297	7/16-20	1.050	0.172
F5505X06X05	0.563	9/16-18	1.060	0.297	1/2 -20	1.050	0.234
F5505X06X06	0.563	9/16-18	1.060	0.297	9/16-18	1.060	0.297
F5505X08X04	0.750	3/4-16	1.250	0.391	7/16-20	1.120	0.172
F5505X08X06	0.750	3/4-16	1.250	0.391	9/16-18	1.140	0.297
F5505X08X08	0.750	3/4-16	1.250	0.391	3/4-16	1.250	0.391
F5505X10X08	0.875	7/8-14	1.450	0.484	3/4-16	1.330	0.391
F5505X10X10	0.875	7/8-14	1.450	0.484	7/8-14	1.450	0.484
F5505X12X08	1.063	1-1/16-12	1.660	0.609	3/4-16	1.420	0.391
F5505X12X10	1.063	1-1/16-12	1.660	0.609	7/8-14	1.540	0.484
F5505X12X12	1.063	1-1/16-12	1.660	0.609	1-1/16-12	1.660	0.609
F5505X14X14	1.313	1-3/16-12	1.800	0.719	1-3/16-12	1.800	0.719
F5505X16X12	1.313	1-5-16-12	1.810	0.844	1-1/16-12	1.760	0.609
F5505X16X16	1.313	1-5/16-12	1.810	0.844	1-5/16-12	1.810	0.844
F5505X20X20	1.625	1-5/8-12	2.060	1.078	1-5/8-12	2.060	1.078
F5505X24X24	1.875	1-7/8-12	2.330	1.313	1-7/8-12	2.330	1.313
F5505X32X32	2.500	2-1/2-12	3.060	1.781	2-1/2-12	3.060	1.781



Description: **90° Swivel Elbow**
WWF Part No.: **F5506**
WWF Stainless Part No.: **6500-SS**
SAE: **070221**

Air-Way: 6500
Parker: C6X
Aeroquip: 2071-[R]
Gates: MJ-FJX90

WWF	Y HEX	T1	M1	D1	T2	M2	D2
F5506X02X02	0.438	5/16-24	0.770	0.063	5/16-24	0.970	0.063
F5506X03X03	0.438	3/8-24	0.830	0.125	3/8-24	1.000	0.125
F5506X04X04	0.438	7/16-20	0.890	0.172	7/16-20	1.000	0.172
F5506X04X06	0.563	7/16-20	1.050	0.172	9/16-18	1.250	0.297
F5506X05X05	0.563	1/2-20	0.950	0.234	1/2-20	1.060	0.234
F5506X06X04	0.563	9/16-18	1.060	0.297	7/16-20	1.240	0.172
F5506X06X06	0.563	9/16-18	1.060	0.297	9/16-18	1.250	0.297
F5506X06X08	0.750	9/16-18	1.140	0.297	3/4-16	1.380	0.391
F5506X08X06	0.750	3/4-16	1.250	0.391	9/16-18	1.290	0.297
F5506X08X08	0.750	3/4-16	1.250	0.391	3/4-16	1.380	0.391
F5506X08X10	0.875	3/4-16	1.330	0.391	7/8-14	1.620	0.484
F5506X08X12	1.063	3/4-16	1.420	0.391	1-1/16-12	1.750	0.609
F5506X10X08	0.875	7/8-14	1.450	0.484	3/4-16	1.520	0.391
F5506X10X10	0.875	7/8-14	1.450	0.484	7/8-14	1.620	0.484
F5506X10X12	1.063	7/8-14	1.540	0.484	1-1/16-12	1.750	0.609
F5506X12X08	1.063	1-1/16-12	1.660	0.609	3/4-16	1.550	0.391
F5506X12X10	1.063	1-1/16-12	1.660	0.609	7/8-14	1.630	0.484
F5506X12X12	1.063	1-1/16-12	1.660	0.609	1-1/16-12	1.750	0.609
F5506X12X16	1.313	1-1/16-12	1.760	0.609	1-5/16-12	2.000	0.844
F5506X14X14	1.313	1-3/16-12	1.800	0.719	1-3/16-12	1.780	0.719
F5506X16X12	1.313	1-5/16-12	1.810	0.844	1-1/16-12	1.910	0.609
F5506X16X16	1.313	1-5/16-12	1.810	0.844	1-5/16-12	2.000	0.844
F5506X20X20	1.625	1-5/8-12	2.060	1.078	1-5/8-12	2.310	1.078
F5506X24X24	1.875	1-7/8-12	2.330	1.313	1-7/8-12	2.590	1.313
F5506X32X32	2.500	2-1/2-12	3.060	1.781	2-1/2-12	3.380	1.781



Description: **90° Straight Thread Elbow**
WWF Part No.: **F5515**
WWF Stainless Part No.: **6801-SS**
SAE: **070220**

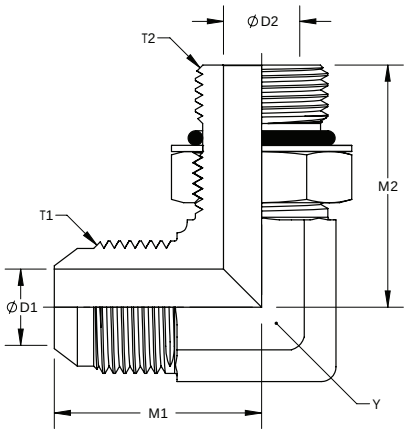
Air-Way: 6801
Parker: C5OX
Aeroquip: 2062-[R]
Gates: MB-MJ90

C

WWF	Y HEX	T1	M1	D1	T2	M2	D2
F5515X02X02	0.438	5/16-24	0.770	0.063	5/16-24	0.940	0.063
F5515X03X03	0.438	3/8-24	0.830	0.125	3/8-24	0.940	0.125
F5515X04X02	0.438	7/16-20	0.890	0.172	5/16-24	0.920	0.063
F5515X04X03	0.438	7/16-20	0.890	0.172	3/8-24	1.030	0.125
F5515X04X04	0.438	7/16-20	0.890	0.172	7/16-20	1.030	0.172
F5515X04X05	0.563	7/16-20	0.950	0.172	1/2-20	1.130	0.234
F5515X04X06	0.563	7/16-20	1.050	0.172	9/16-18	1.250	0.297
F5515X04X08	0.750	7/16-20	1.120	0.172	3/4-16	1.450	0.391
F5515X05X04	0.563	1/2-20	0.950	0.234	7/16-20	1.130	0.172
F5515X05X05	0.563	1/2-20	0.950	0.234	1/2-20	1.130	0.234
F5515X05X06	0.563	1/2-20	1.050	0.234	9/16-18	1.250	0.297
F5515X05X08	0.750	1/2-20	1.120	0.234	3/4-16	1.450	0.391
F5515X06X04	0.563	9/16-18	1.060	0.297	7/16-20	1.190	0.172
F5515X06X05	0.563	9/16-18	1.060	0.297	1/2-20	1.190	0.234
F5515X06X06	0.563	9/16-18	1.060	0.297	9/16-18	1.250	0.297
F5515X06X08	0.750	9/16-18	1.140	0.297	3/4-16	1.450	0.391
F5515X06X10	0.875	9/16-18	1.220	0.297	7/8-14	1.700	0.484
F5515X06X12	1.063	9/16-18	1.310	0.297	1-1/16-12	1.940	0.609
F5515X08X04	0.750	3/4-16	1.250	0.391	7/16-20	1.260	0.172
F5515X08X06	0.750	3/4-16	1.250	0.391	9/16-18	1.320	0.297
F5515X08X08	0.750	3/4-16	1.250	0.391	3/4-16	1.450	0.391
F5515X08X10	0.875	3/4-16	1.330	0.391	7/8-14	1.700	0.484
F5515X08X12	1.063	3/4-16	1.420	0.391	1-1/16-12	1.940	0.609
F5515X08X16	1.313	3/4-16	1.520	0.391	1-5/16-12	2.050	0.844
F5515X10X06	0.875	7/8-14	1.450	0.484	9/16-18	1.410	0.297
F5515X10X08	0.875	7/8-14	1.450	0.484	3/4-16	1.540	0.391
F5515X10X10	0.875	7/8-14	1.450	0.484	7/8-14	1.700	0.484
F5515X10X12	1.063	7/8-14	1.540	0.484	1-1/16-12	1.940	0.609
F5515X10X16	1.313	7/8-14	1.640	0.484	1-5/16-12	2.050	0.844
F5515X12X06	1.063	1-1/16-12	1.660	0.609	9/16-18	1.490	0.297
F5515X12X08	1.063	1-1/16-12	1.660	0.609	3/4-16	1.620	0.391

Continued on page 125

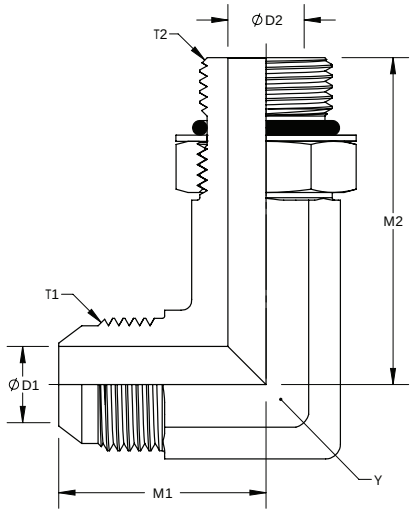
Continued from page 124



Description: **90° Straight Thread Elbow**
WWF Part No.: **F5515**
WWF Stainless Part No.: **6801-SS**
SAE: **070220**

Air-Way: 6801
Parker: C5OX
Aeroquip: 2062-[R]
Gates: MB-MJ90

WWF	Y HEX	T1	M1	D1	T2	M2	D2
F5515X12X10	1.063	1-1/16-12	1.660	0.609	7/8-14	1.780	0.484
F5515X12X12	1.063	1-1/16-12	1.660	0.609	1-1/16-12	1.940	0.609
F5515X12X14	1.313	1-1/16-12	1.770	0.609	1-3/16-12	2.000	0.719
F5515X12X16	1.313	1-1/16-12	1.760	0.609	1-5/16-12	2.050	0.844
F5515X12X20	1.625	1-1/16-12	1.970	0.609	1-5/8-12	2.250	1.078
F5515X14X12	1.313	1-3/16-12	1.800	0.719	1-1/16-12	2.000	0.609
F5515X14X14	1.313	1-3/16-12	1.800	0.719	1-3/16-12	2.000	0.719
F5515X16X08	1.313	1-5/16-12	1.810	0.844	3/4-16	1.730	0.391
F5515X16X10	1.313	1-5/16-12	1.810	0.844	7/8-14	1.890	0.484
F5515X16X12	1.313	1-5/16-12	1.810	0.844	1-1/16-12	2.050	0.609
F5515X16X14	1.313	1-5/16-12	1.810	0.844	1-3/16-12	2.050	0.719
F5515X16X16	1.313	1-5/16-12	1.810	0.844	1-5/16-12	2.050	0.844
F5515X16X20	1.625	1-5/16-12	2.010	0.844	1-5/8-12	2.250	1.078
F5515X16X24	1.875	1-5/16-12	2.160	0.844	1-7/8-12	2.390	1.313
F5515X20X12	1.625	1-5/8-12	2.060	1.078	1-1/16-12	2.250	0.609
F5515X20X16	1.625	1-5/8-12	2.060	1.078	1-5/16-12	2.250	0.844
F5515X20X20	1.625	1-5/8-12	2.060	1.078	1-5/8-12	2.250	1.078
F5515X20X24	1.875	1-5/8-12	2.200	1.078	1-7/8-12	2.390	1.313
F5515X24X16	1.875	1-7/8-12	2.330	1.313	1-5/16-12	2.390	0.844
F5515X24X20	1.875	1-7/8-12	2.330	1.313	1-5/8-12	2.390	1.078
F5515X24X24	1.875	1-7/8-12	2.330	1.313	1-7/8-12	2.390	1.313
F5515X32X24	2.500	2-1/2-12	3.060	1.781	1-7/8-12	2.890	1.313
F5515X32X32	2.500	2-1/2-12	3.060	1.781	2-1/2-12	2.890	1.781

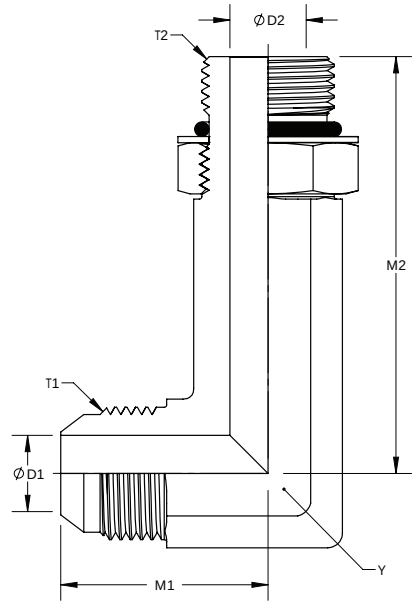


Description: **90° Straight Thread Elbow Long**
WWF Part No.: **F5515L**
WWF Stainless Part No.: **6801-L-SS**
SAE: **071520**

Air-Way: 6801-L
Parker: CC5OX
Aeroquip: /
Gates: /

C

WWF	Y HEX	T1	M1	D1	T2	M2	D2
F5515X04X04L	0.438	7/16-20	0.890	0.172	7/16-20	1.540	0.172
F5515X04X06L	0.563	7/16-20	1.050	0.172	9/16-18	1.660	0.297
F5515X06X06L	0.563	9/16-18	1.060	0.297	9/16-18	1.660	0.297
F5515X06X08L	0.750	9/16-18	1.140	0.297	3/4-16	1.970	0.391
F5515X08X08L	0.750	3/4-16	1.250	0.391	3/4-16	1.970	0.391
F5515X08X10L	0.875	3/4-16	1.330	0.391	7/8-14	2.260	0.484
F5515X10X08L	0.875	7/8-14	1.450	0.484	3/4-16	2.100	0.391
F5515X10X10L	0.875	7/8-14	1.450	0.484	7/8-14	2.260	0.484
F5515X12X12L	1.063	1-1/16-12	1.660	0.609	1-1/16-12	2.620	0.609
F5515X16X16L	1.313	1- 5/16-12	1.810	0.844	1-5/16-12	3.060	0.844

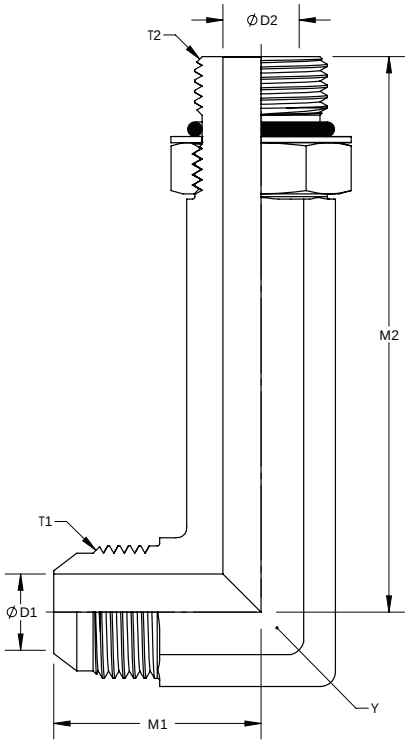


Description: **90° Straight Thread Elbow Extra Long**
WWF Part No.: **F5515LL**
WWF Stainless Part No.: **6801-LL-SS**
SAE: **071620**

Air-Way: 6801-LL
Parker: /
Aeroquip: /
Gates: /

WWF	Y HEX	T1	M1	D1	T2	M2	D2
F5515X04X04LL	0.438	7/16-20	0.890	0.172	7/16-20	1.730	0.172
F5515X04X06LL	0.563	7/16-20	1.050	0.172	9/16-18	2.080	0.297
F5515X06X06LL	0.563	9/16-18	1.060	0.297	9/16-18	2.080	0.297
F5515X06X08LL	0.750	9/16-18	1.140	0.297	3/4-16	2.480	0.391
F5515X08X06LL	0.750	3/4-16	1.250	0.391	9/16-18	2.350	0.297
F5515X08X08LL	0.750	3/4-16	1.250	0.391	3/4-16	2.480	0.391
F5515X08X10LL	0.875	3/4-16	1.330	0.391	7/8-14	2.890	0.484
F5515X10X08LL	0.875	7/8-14	1.450	0.484	3/4-16	2.730	0.391
F5515X10X10LL	0.875	7/8-14	1.450	0.484	7/8-14	2.890	0.484
F5515X12X12LL	1.063	1-1/16-12	1.660	0.609	1-1/16-12	3.340	0.609
F5515X12X16LL	1.313	1-1/16-12	1.760	0.609	1-5/16-12	3.720	0.844
F5515X16X12LL	1.313	1-5/16-12	1.810	0.844	1-1/16-12	3.720	0.609
F5515X16X16LL	1.313	1-5/16-12	1.810	0.844	1-5/16-12	3.720	0.844
F5515X20X20LL	1.625	1-5/8-12	2.060	1.078	1-5/8-12	4.410	1.078

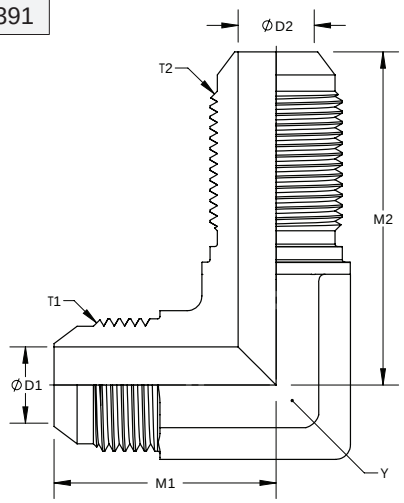
C



Description: **90° Straight Thread Elbow Extra Extra Long**
WWF Part No.: **F5515LLL**
WWF Stainless Part No.: **6801-LLL-SS**
SAE: **072120**

Air-Way: 6801-LLL
Parker: /
Aeroquip: /
Gates: /

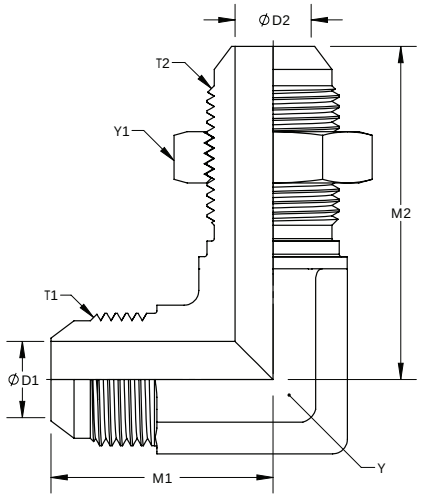
WWF	Y HEX	T1	M1	D1	T2	M2	D2
F5515X04X04LLL	0.438	7/16-20	0.890	0.172	7/16-20	2.440	0.172
F5515X06X06LLL	0.563	9/16-18	1.060	0.297	9/16-18	2.910	0.297
F5515X06X08LLL	0.750	9/16-18	1.140	0.297	3/4-16	3.530	0.391
F5515X08X08LLL	0.750	3/4-16	1.250	0.391	3/4-16	3.530	0.391



Description: **90° Bulkhead Elbow**
WWF Part No.: **F5525**
WWF Stainless Part No.: **2701-SS**
SAE: **070701**

Air-Way: 2701
Parker: WETX
Aeroquip: 2043-1-[R]
Gates: MJ-BKHD90

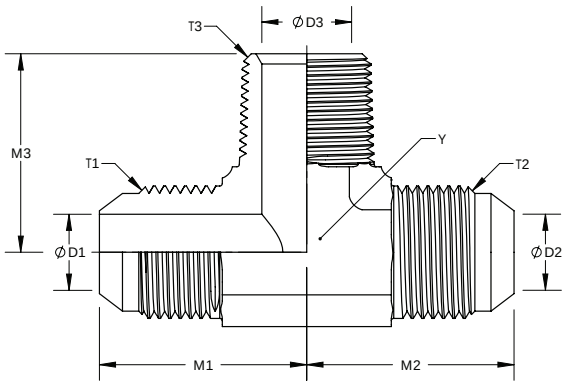
WWF	Y HEX	T1	M1	D1	T2	M2	D2
F5525X03X03	0.438	3/8-24	0.940	0.125	3/8-24	1.500	0.125
F5525X04X04	0.438	7/16-20	0.970	0.172	7/16-20	1.590	0.172
F5525X05X05	0.563	1/2-20	1.060	0.234	1/2-20	1.720	0.234
F5525X06X06	0.563	9/16-18	1.090	0.297	9/16-18	1.810	0.297
F5525X08X08	0.750	3/4-16	1.360	0.391	3/4-16	2.110	0.391
F5525X10X10	0.875	7/8-14	1.560	0.484	7/8-14	2.390	0.484
F5525X12X12	1.063	1-1/16-12	1.780	0.609	1-1/16-12	2.670	0.609
F5525X16X16	1.313	1-5/16-12	1.940	0.844	1-5/16-12	2.800	0.844
F5525X20X20	1.625	1-5/8-12	2.170	1.078	1-5/8-12	3.120	1.078



Description: **90° Bulkhead Elbow With Locknut**
WWF Part No.: **F5525LN**
WWF Stainless Part No.: **2701-LN-SS**
SAE: **070701**

Air-Way: 2701-LN
Parker: WETX-WLN
Aeroquip: 2043-[R]
Gates: /

WWF	Y HEX	Y1 HEX	T1	M1	D1	T2	M2	D2
F5525X03X03LN	0.438	0.625	3/8-24	0.940	0.125	3/8-24	1.500	0.125
F5525X04X04LN	0.438	0.688	7/16-20	0.970	0.172	7/16-20	1.590	0.172
F5525X05X05LN	0.563	0.750	1/2-20	1.060	0.234	1/2-20	1.720	0.234
F5525X06X06LN	0.563	0.813	9/16-18	1.090	0.297	9/16-18	1.810	0.297
F5525X08X08LN	0.750	1.000	3/4-16	1.360	0.391	3/4-16	2.110	0.391
F5525X10X10LN	0.875	1.125	7/8-14	1.560	0.484	7/8-14	2.390	0.484
F5525X12X12LN	1.063	1.375	1-1/16-12	1.780	0.609	1-1/16-12	2.670	0.609
F5525X16X16LN	1.313	1.625	1-5/16-12	1.940	0.844	1-5/16-12	2.800	0.844
F5525X20X20LN	1.625	1.875	1-5/8-12	2.170	1.078	1-5/8-12	3.120	1.078



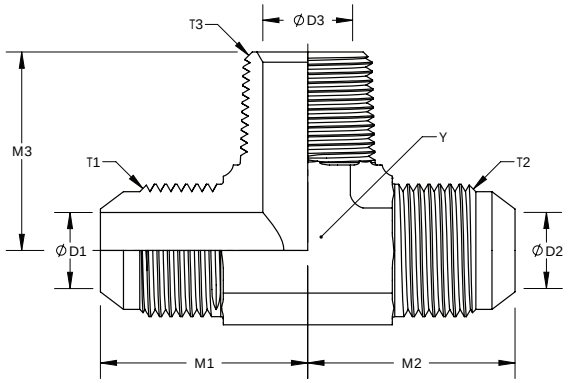
Description: **Male Branch Tee**
WWF Part No.: **F5605**
WWF Stainless Part No.: **2601-SS**
SAE: **070425**

Air-Way: 2601
Parker: STX
Aeroquip: 2030-[R]
Gates: MJ-MJ-MP

WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
F5605X03X03X02	0.438	3/8-24	0.830	0.125	3/8-24	0.830	0.125	1/8-27	0.720	0.188
F5605X04X04X02	0.438	7/16-20	0.890	0.172	7/16-20	0.890	0.172	1/8-27	0.780	0.188
F5605X04X04X04	0.563	7/16-20	1.050	0.172	7/16-20	1.050	0.172	1/4-18	1.090	0.281
F5605X04X04X06	0.750	7/16-20	1.120	0.172	7/16-20	1.120	0.172	3/8-18	1.220	0.406
F5605X05X05X02	0.563	1/2-20	0.950	0.234	1/2-20	0.950	0.234	1/8-27	0.780	0.188
F5605X05X05X04	0.563	1/2-20	1.050	0.234	1/2-20	1.050	0.234	1/4-18	1.090	0.281
F5605X06X06X04	0.563	9/16-18	1.060	0.297	9/16-18	1.060	0.297	1/4-18	1.090	0.281
F5605X06X06X06	0.750	9/16-18	1.140	0.297	9/16-18	1.140	0.297	3/8-18	1.220	0.406

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Continued from page 129



Description: **Male Branch Tee**
WWF Part No.: **F5605**
WWF Stainless Part No.: **2601-SS**
SAE: **070425**

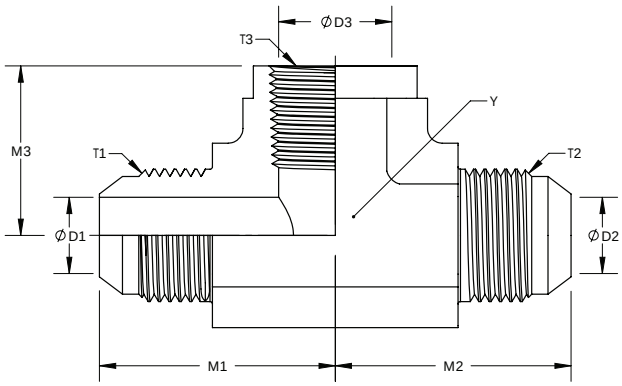
Air-Way: 2601
Parker: STX
Aeroquip: 2030-[R]
Gates: MJ-MJ-MP

C

WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
F5605X06X06X08	0.875	9/16-18	1.220	0.297	9/16-18	1.220	0.297	1/2-14	1.470	0.531
F5605X08X08X04	0.750	3/4-16	1.250	0.391	3/4-16	1.250	0.391	1/4-18	1.220	0.281
F5605X08X08X06	0.750	3/4-16	1.250	0.391	3/4-16	1.250	0.391	3/8-18	1.220	0.406
F5605X08X08X08	0.875	3/4-16	1.330	0.391	3/4-16	1.330	0.391	1/2-14	1.470	0.531
F5605X08X08X12	1.063	3/4-16	1.420	0.391	3/4-16	1.420	0.391	3/4-14	1.590	0.719
F5605X10X10X06	0.875	7/8-14	1.450	0.484	7/8-14	1.450	0.484	3/8-18	1.280	0.406
F5605X10X10X08	0.875	7/8-14	1.450	0.484	7/8-14	1.450	0.484	1/2-14	1.470	0.531
F5605X10X10X12	1.063	7/8-14	1.540	0.484	7/8-14	1.540	0.484	3/4-14	1.590	0.719
F5605X12X12X08	1.063	1-1/16-12	1.660	0.609	1-1/16-12	1.660	0.609	1/2-14	1.590	0.531
F5605X12X12X12	1.063	1-1/16-12	1.660	0.609	1-1/16-12	1.660	0.609	3/4-14	1.590	0.719
F5605X12X12X16	1.313	1-1/16-12	1.760	0.609	1-1/16-12	1.760	0.609	1-11-1/2	1.970	0.938
F5605X14X14X12	1.313	1-3/16-12	1.800	0.719	1-3/16-12	1.800	0.719	3/4-14	1.690	0.719
F5605X16X16X12	1.313	1-5/16-12	1.810	0.844	1-5/16-12	1.810	0.844	3/4-14	1.780	0.719
F5605X16X16X16	1.313	1-5/16-12	1.810	0.844	1-5/16-12	1.810	0.844	1-11-1/2	1.970	0.938
F5605X20X20X20	1.625	1-5/8-12	2.060	1.078	1-5/8-12	2.060	1.078	1-1/4-11-1/2	2.380	1.250
F5605X24X24X24	1.875	1-7/8-12	2.330	1.313	1-7/8-12	2.330	1.313	1-1/2-11-1/2	2.640	1.500
F5605X32X32X32	2.500	2-1/2-12	3.060	1.781	2-1/2-12	3.060	1.781	2-11-1/2	3.000	1.938

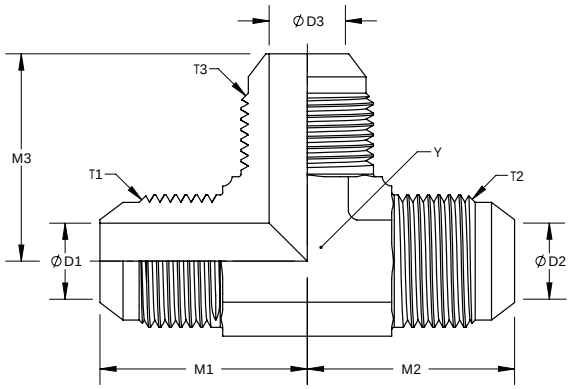
Description: **Female Branch Tee**
WWF Part No.: **F5655**
WWF Stainless Part No.: **2602-SS**
SAE: **070427**

Air-Way: 2602
Parker: OTX
Aeroquip: 2031-[R]
Gates: /



C

WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
F5655X04X04X02	0.563	7/16-20	1.080	0.172	7/16-20	1.080	0.172	1/8-27	0.660	0.332
F5655X04X04X04	0.750	7/16-20	1.220	0.172	7/16-20	1.220	0.172	1/4-18	0.880	0.438
F5655X05X05X02	0.563	1/2-20	1.080	0.234	1/2-20	1.080	0.234	1/8-27	0.660	0.332
F5655X06X06X04	0.750	9/16-18	1.230	0.297	9/16-18	1.230	0.297	1/4-18	0.880	0.438
F5655X06X06X06	0.875	9/16-18	1.310	0.297	9/16-18	1.310	0.297	3/8-18	1.020	0.563
F5655X08X08X04	0.875	3/4-16	1.420	0.391	3/4-16	1.420	0.391	1/4-18	1.010	0.438
F5655X08X08X06	0.875	3/4-16	1.420	0.391	3/4-16	1.420	0.391	3/8-18	1.020	0.563
F5655X08X08X08	1.063	3/4-16	1.520	0.391	3/4-16	1.520	0.391	1/2-14	1.230	0.703
F5655X10X10X08	1.063	7/8-14	1.640	0.484	7/8-14	1.640	0.484	1/2-14	1.230	0.703
F5655X10X10X12	1.313	7/8-14	1.770	0.484	7/8-14	1.770	0.484	3/4-14	1.360	0.906
F5655X12X12X08	1.313	1-1/16-12	1.890	0.609	1-1/16-12	1.890	0.609	1/2-14	1.350	0.703
F5655X12X12X12	1.313	1-1/16-12	1.890	0.609	1-1/16-12	1.890	0.609	3/4-14	1.360	0.906
F5655X12X12X16	1.625	1-1/16-12	2.120	0.609	1-1/16-12	2.120	0.609	1-11-1/2	1.620	1.141
F5655X14X14X12	1.313	1-3/16-12	1.860	0.719	1-3/16-12	1.860	0.719	3/4-14	1.420	0.906
F5655X16X16X12	1.625	1-5/16-12	2.170	0.844	1-5/16-12	2.170	0.844	3/4-14	1.390	0.906
F5655X16X16X16	1.625	1-5/16-12	2.170	0.844	1-5/16-12	2.170	0.844	1-11-1/2	1.620	1.141
F5655X20X20X20	1.875	1-5/8-12	2.330	1.078	1-5/8-12	2.330	1.078	1-1/4-11-1/2	1.700	1.484
F5655X24X24X24	2.562	1-7/8-12	2.890	1.313	1-7/8-12	2.890	1.313	1-1/2-11-1/2	2.080	1.744
F5655X32X32X32	2.812	2-1/2-12	3.300	1.781	2-1/2-12	3.300	1.781	2-11-1/2	2.390	2.213

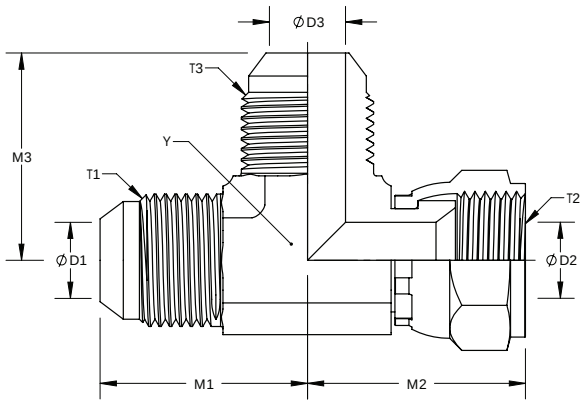


Description: **Union Tee**
WWF Part No.: **F5705**
WWF Stainless Part No.: **2603-SS**
SAE: **070401**

Air-Way: 2603
Parker: JTX
Aeroquip: 2033
Gates: MJ-MJ-MJ

C

WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
F5705X02X02X02	0.438	5/16-24	0.770	0.063	5/16-24	0.770	0.063	5/16-24	0.770	0.063
F5705X03X03X03	0.438	3/8-24	0.830	0.125	3/8-24	0.830	0.125	3/8-24	0.830	0.125
F5705X04X04X04	0.438	7/16-20	0.890	0.172	7/16-20	0.890	0.172	7/16-20	0.890	0.172
F5705X04X04X06	0.563	7/16-20	1.050	0.172	7/16-20	1.050	0.172	9/16-18	1.060	0.297
F5705X05X05X05	0.563	1/2-20	0.950	0.234	1/2-20	0.950	0.234	1/2-20	0.950	0.234
F5705X06X06X04	0.563	9/16-18	1.060	0.297	9/16-18	1.060	0.297	7/16-20	1.050	0.172
F5705X06X06X06	0.563	9/16-18	1.060	0.297	9/16-18	1.060	0.297	9/16-18	1.060	0.297
F5705X06X06X08	0.750	9/16-18	1.140	0.297	9/16-18	1.140	0.297	3/4-16	1.250	0.391
F5705X08X08X08	0.750	3/4-16	1.250	0.391	3/4-16	1.250	0.391	3/4-16	1.250	0.391
F5705X08X08X10	0.875	3/4-16	1.330	0.391	3/4-16	1.330	0.391	7/8-14	1.450	0.484
F5705X08X08X12	1.063	3/4-16	1.420	0.391	3/4-16	1.420	0.391	1-1/16-12	1.660	0.609
F5705X08X10X10	0.875	3/4-16	1.330	0.391	7/8-14	1.450	0.484	7/8-14	1.450	0.484
F5705X10X08X08	0.875	7/8-14	1.450	0.484	3/4-16	1.330	0.391	3/4-16	1.330	0.391
F5705X10X10X08	0.875	7/8-14	1.450	0.484	7/8-14	1.450	0.484	3/4-16	1.330	0.391
F5705X10X10X10	0.875	7/8-14	1.450	0.484	7/8-14	1.450	0.484	7/8-14	1.450	0.484
F5705X12X10X12	1.063	1-1/16-12	1.660	0.609	7/8-14	1.540	0.484	1-1/16-12	1.660	0.609
F5705X12X12X08	1.063	1-1/16-12	1.660	0.609	1-1/16-12	1.660	0.609	3/4-16	1.420	0.391
F5705X12X12X12	1.063	1-1/16-12	1.660	0.609	1-1/16-12	1.660	0.609	1-1/16-12	1.660	0.609
F5705X12X12X16	1.313	1-1/16-12	1.760	0.609	1-1/16-12	1.760	0.609	1-5/16-12	1.810	0.844
F5705X14X14X14	1.313	1-3/16-12	1.800	0.719	1-3/16-12	1.800	0.719	1-3/16-12	1.800	0.719
F5705X16X12X20	1.625	1-5/16-12	2.010	0.844	1-1/16-12	1.970	0.609	1-5/8-12	2.060	1.078
F5705X16X16X12	1.313	1-5/16-12	1.810	0.844	1-5/16-12	1.810	0.844	1-1/16-12	1.760	0.609
F5705X16X16X16	1.313	1-5/16-12	1.810	0.844	1-5/16-12	1.810	0.844	1-5/16-12	1.810	0.844
F5705X16X16X20	1.625	1-5/16-12	2.010	0.844	1-5/16-12	2.010	0.844	1-5/8-12	2.060	1.078
F5705X20X16X16	1.625	1-5/8-12	2.060	1.078	1-5/16-12	2.010	0.844	1-5/16-12	2.010	0.844
F5705X20X20X20	1.625	1-5/8-12	2.060	1.078	1-5/8-12	2.060	1.078	1-5/8-12	2.060	1.078
F5705X24X24X24	1.875	1-7/8-12	2.330	1.313	1-7/8-12	2.330	1.313	1-7/8-12	2.330	1.313
F5705X32X32X32	2.500	2-1/2-12	3.060	1.781	2-1/2-12	3.060	1.781	2-1/2-12	3.060	1.781

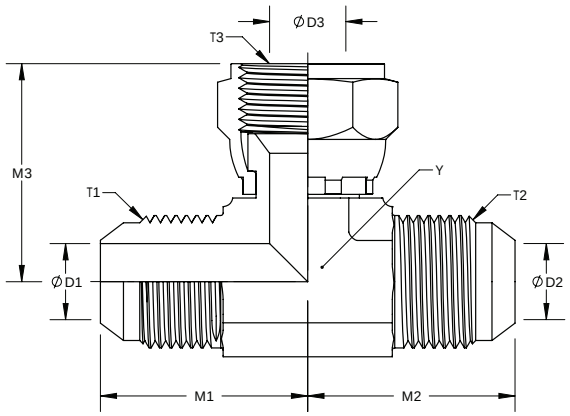


Description: **Swivel Run Tee**
WWF Part No.: **F5706**
WWF Stainless Part No.: **6602-SS**
SAE: **070432**

Air-Way: 6602
Parker: R6X
Aeroquip: 203102-[R]
Gates: MJ-FJX-MJ

C

WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
F5706X03X03X03	0.438	3/8-24	0.830	0.125	3/8-24	1.000	0.125	3/8-24	0.830	0.125
F5706X04X04X04	0.438	7/16-20	0.890	0.172	7/16-20	1.000	0.172	7/16-20	0.890	0.172
F5706X04X08X08	0.750	7/16-20	1.120	0.172	3/4-16	1.380	0.391	3/4-16	1.250	0.391
F5706X05X05X05	0.563	1/2-20	0.950	0.234	1/2-20	1.060	0.234	1/2-20	0.950	0.234
F5706X06X06X04	0.563	9/16-18	1.060	0.297	9/16-18	1.250	0.297	7/16-20	1.050	0.172
F5706X06X06X06	0.563	9/16-18	1.060	0.297	9/16-18	1.250	0.297	9/16-18	1.060	0.297
F5706X08X06X08	0.750	3/4-16	1.250	0.297	9/16-18	1.290	0.297	3/4-16	1.250	0.391
F5706X08X08X06	0.750	3/4-16	1.250	0.391	3/4-16	1.380	0.391	9/16-18	1.140	0.297
F5706X08X08X08	0.750	3/4-16	1.250	0.391	3/4-16	1.380	0.391	3/4-16	1.250	0.391
F5706X08X08X12	1.063	3/4-16	1.420	0.391	3/4-16	1.550	0.391	1-1/16-12	1.660	0.609
F5706X10X08X10	0.875	7/8-14	1.450	0.391	3/4-16	1.520	0.391	7/8-14	1.450	0.484
F5706X10X10X06	0.875	7/8-14	1.450	0.484	7/8-14	1.620	0.484	9/16-18	1.220	0.297
F5706X10X10X08	0.875	7/8-14	1.450	0.484	7/8-14	1.620	0.484	3/4-16	1.330	0.391
F5706X10X10X10	0.875	7/8-14	1.450	0.484	7/8-14	1.620	0.484	7/8-14	1.450	0.484
F5706X10X10X12	1.063	7/8-14	1.540	0.484	7/8-14	1.650	0.484	1-1/16-12	1.660	0.609
F5706X12X12X12	1.063	1-1/16-12	1.660	0.609	1-1/16-12	1.750	0.609	1-1/16-12	1.660	0.609
F5706X14X14X14	1.313	1-3/16-12	1.800	0.719	1-3/16-12	1.780	0.719	1-3/16-12	1.800	0.719
F5706X16X16X10	1.313	1-5/16-12	1.810	0.844	1-5/16-12	2.000	0.844	7/8-14	1.640	0.484
F5706X16X16X16	1.313	1-5/16-12	1.810	0.844	1-5/16-12	2.000	0.844	1-5/16-12	1.810	0.844
F5706X20X20X20	1.625	1-5/8-12	2.060	1.078	1-5/8-12	2.310	1.078	1-5/8-12	2.060	1.078
F5706X24X24X24	1.875	1-7/8-12	2.330	1.313	1-7/8-12	2.590	1.313	1-7/8-12	2.330	1.313
F5706X32X32X32	2.500	2-1/2-12	3.060	1.781	2-1/2-12	3.380	1.781	2-1/2-12	3.060	1.781



Description: **Swivel Branch Tee**
WWF Part No.: **F5707**
WWF Stainless Part No.: **6600-SS**
SAE: **070433**

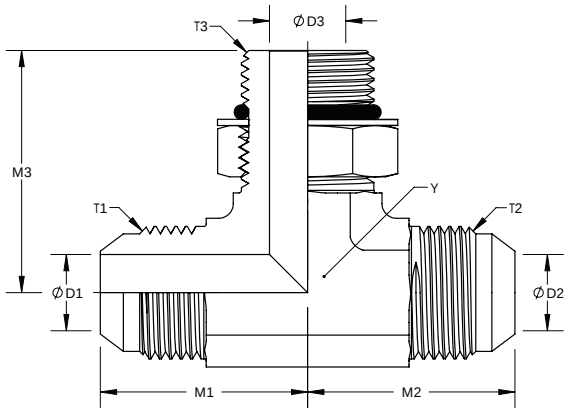
Air-Way: 6600
Parker: S6X
Aeroquip: 203101-[R]
Gates: MJ-MJ-FJX

C

WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
F5707X03X03X03	0.438	3/8-24	0.830	0.125	3/8-24	0.830	0.125	3/8-24	1.000	0.125
F5707X04X04X04	0.438	7/16-20	0.890	0.172	7/16-20	0.890	0.172	7/16-20	1.000	0.172
F5707X05X05X05	0.563	1/2-20	0.950	0.234	1/2-20	0.950	0.234	1/2-20	1.060	0.234
F5707X06X06X06	0.563	9/16-18	1.060	0.297	9/16-18	1.060	0.297	9/16-18	1.250	0.297
F5707X06X06X08	0.750	9/16-18	1.140	0.297	9/16-18	1.140	0.297	3/4-16	1.380	0.391
F5707X08X08X08	0.750	3/4-16	1.250	0.391	3/4-16	1.250	0.391	3/4-16	1.380	0.391
F5707X10X10X10	0.875	7/8-14	1.450	0.484	7/8-14	1.450	0.484	7/8-14	1.620	0.484
F5707X12X10X12	1.063	1-1/16-12	1.660	0.609	7/8-14	1.540	0.484	1-1/16-12	1.750	0.609
F5707X12X12X12	1.063	1-1/16-12	1.660	0.609	1-1/16-12	1.660	0.609	1-1/16-12	1.750	0.609
F5707X14X14X14	1.313	1-3/16-12	1.800	0.719	1-3/16-12	1.800	0.719	1-3/16-12	1.780	0.719
F5707X16X16X16	1.313	1-5/16-12	1.810	0.844	1-5/16-12	1.810	0.844	1-5/16-12	2.000	0.844
F5707X20X20X20	1.625	1-5/8-12	2.060	1.078	1-5/8-12	2.060	1.078	1-5/8-12	2.310	1.078
F5707X24X24X24	1.875	1-7/8-12	2.330	1.313	1-7/8-12	2.330	1.313	1-7/8-12	2.590	1.313
F5707X32X32X32	2.500	2-1/2-12	3.060	1.781	2-1/2-12	3.060	1.781	2-1/2-12	3.380	1.781

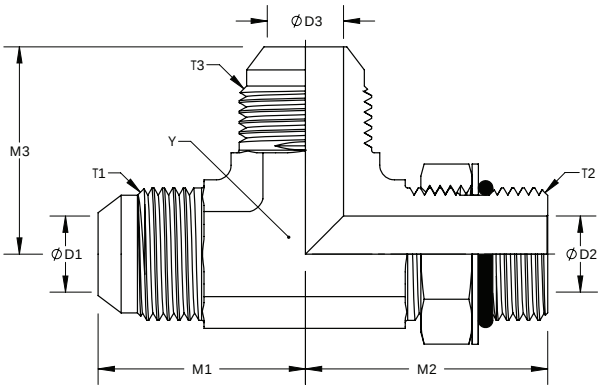
Description: **Straight Thread Branch Tee**
WWF Part No.: **F5715**
WWF Stainless Part No.: **6803-SS**
SAE: **070429**

Air-Way: 6803
Parker: S5OX
Aeroquip: 203003-[R]
Gates: MJ-MJ-MB



C

WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
F5715X02X02X02	0.438	5/16-24	0.770	0.063	5/16-24	0.770	0.063	5/16-24	0.940	0.063
F5715X04X04X03	0.438	7/16-20	0.890	0.172	7/16-20	0.890	0.172	3/8-24	0.920	0.125
F5715X04X04X04	0.438	7/16-20	0.890	0.172	7/16-20	0.890	0.172	7/16-20	1.030	0.172
F5715X04X04X06	0.563	7/16-20	1.050	0.172	7/16-20	1.050	0.172	9/16-18	1.250	0.297
F5715X05X05X05	0.563	1/2-20	0.950	0.234	1/2-20	0.950	0.234	1/2-20	1.130	0.234
F5715X06X06X04	0.563	9/16-18	1.060	0.297	9/16-18	1.060	0.297	7/16-20	1.190	0.172
F5715X06X06X06	0.563	9/16-18	1.060	0.297	9/16-18	1.060	0.297	9/16-18	1.250	0.297
F5715X06X06X08	0.750	9/16-18	1.140	0.297	9/16-18	1.140	0.297	3/4-16	1.450	0.391
F5715X08X08X06	0.750	3/4-16	1.250	0.391	3/4-16	1.250	0.391	9/16-18	1.320	0.297
F5715X08X08X08	0.750	3/4-16	1.250	0.391	3/4-16	1.250	0.391	3/4-16	1.450	0.391
F5715X08X08X10	0.875	3/4-16	1.330	0.391	3/4-16	1.330	0.391	7/8-14	1.700	0.484
F5715X10X10X08	0.875	7/8-14	1.450	0.484	7/8-14	1.450	0.484	3/4-16	1.540	0.391
F5715X10X10X10	0.875	7/8-14	1.450	0.484	7/8-14	1.450	0.484	7/8-14	1.700	0.484
F5715X10X10X12	1.063	7/8-14	1.540	0.484	7/8-14	1.540	0.484	1-1/16-12	1.940	0.609
F5715X12X10X12	1.063	1-1/16-12	1.660	0.484	7/8-14	1.540	0.484	1-1/16-12	1.940	0.609
F5715X12X12X08	1.063	1-1/16-12	1.660	0.609	1-1/16-12	1.660	0.609	3/4-16	1.620	0.391
F5715X12X12X10	1.063	1-1/16-12	1.660	0.609	1-1/16-12	1.660	0.609	7/8-14	1.780	0.484
F5715X12X12X12	1.063	1-1/16-12	1.660	0.609	1-1/16-12	1.660	0.609	1-1/16-12	1.940	0.609
F5715X12X12X16	1.313	1-1/16-12	1.760	0.609	1-1/16-12	1.760	0.609	1-5/16-12	2.050	0.844
F5715X16X12X16	1.313	1-5/16-12	1.810	0.844	1-1/16-12	1.760	0.609	1-5/16-12	2.050	0.844
F5715X16X16X12	1.313	1-5/16-12	1.810	0.844	1-5/16-12	1.810	0.844	1-1/16-12	2.050	0.609
F5715X16X16X16	1.313	1-5/16-12	1.810	0.844	1-5/16-12	1.810	0.844	1-5/16-12	2.050	0.844
F5715X20X20X20	1.625	1-5/8-12	2.060	1.078	1-5/8-12	2.060	1.078	1-5/8-12	2.250	1.078
F5715X24X24X24	1.875	1-7/8-12	2.330	1.313	1-7/8-12	2.330	1.313	1-7/8-12	2.390	1.313

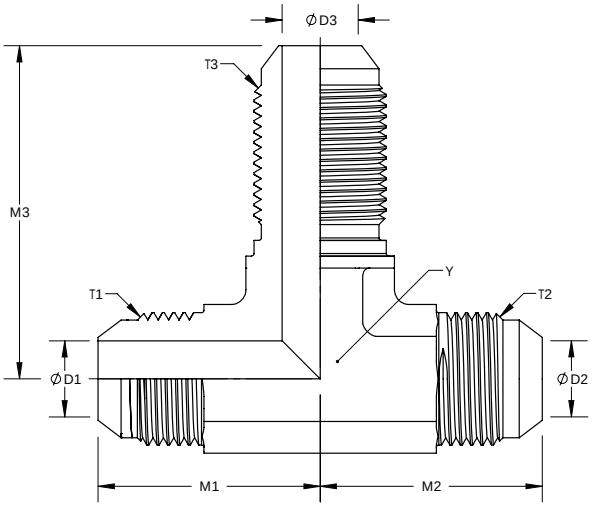


Description: **Straight Thread Run Tee**
WWF Part No.: **F5716**
WWF Stainless Part No.: **6804-SS**
SAE: **070428**

Air-Way: 6804
Parker: R5OX
Aeroquip: 203005-[R]
Gates: MB-MJ-MJ

C

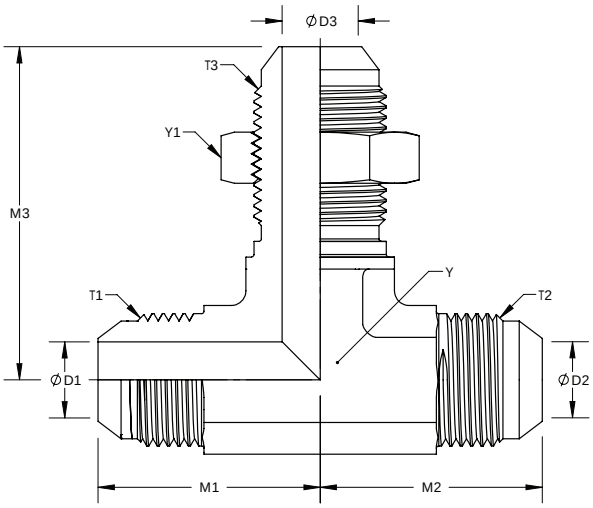
WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
F5716X04X02X04	0.438	7/16-20	0.890	0.172	5/16-24	0.920	0.063	7/16-20	0.890	0.172
F5716X04X04X04	0.438	7/16-20	0.890	0.172	7/16-20	1.030	0.172	7/16-20	0.890	0.172
F5716X04X04X06	0.563	7/16-20	1.050	0.172	7/16-20	1.190	0.172	9/16-18	1.060	0.297
F5716X04X06X04	0.563	7/16-20	1.050	0.172	9/16-18	1.250	0.297	7/16-20	1.050	0.172
F5716X04X06X06	0.563	7/16-20	1.050	0.172	9/16-18	1.250	0.297	9/16-18	1.060	0.297
F5716X05X05X05	0.563	1/2-20	0.950	0.234	1/2-20	1.130	0.234	1/2-20	0.950	0.234
F5716X06X04X06	0.563	9/16-18	1.060	0.297	7/16-20	1.190	0.172	9/16-18	1.060	0.297
F5716X06X06X06	0.563	9/16-18	1.060	0.297	9/16-18	1.250	0.297	9/16-18	1.060	0.297
F5716X06X06X08	0.750	9/16-18	1.140	0.297	9/16-18	1.320	0.297	3/4-16	1.250	0.391
F5716X06X08X06	0.750	9/16-18	1.140	0.297	3/4-16	1.450	0.391	9/16-18	1.140	0.297
F5716X08X06X08	0.750	3/4-16	1.250	0.391	9/16-18	1.320	0.297	3/4-16	1.250	0.391
F5716X08X08X04	0.750	3/4-16	1.250	0.391	3/4-16	1.450	0.391	7/16-20	1.120	0.172
F5716X08X08X08	0.750	3/4-16	1.250	0.391	3/4-16	1.450	0.391	3/4-16	1.250	0.391
F5716X08X10X08	0.875	3/4-16	1.330	0.391	7/8-14	1.700	0.484	3/4-16	1.330	0.391
F5716X08X12X08	1.063	3/4-16	1.420	0.391	1-1/16-12	1.940	0.609	3/4-16	1.420	0.391
F5716X08X16X16	1.313	3/4-16	1.520	0.391	1-5/16-12	2.050	0.844	1-5/16-12	1.810	0.844
F5716X10X10X10	0.875	7/8-14	1.450	0.484	7/8-14	1.700	0.484	7/8-14	1.450	0.484
F5716X10X10X12	1.063	7/8-14	1.540	0.484	7/8-14	1.780	0.484	1-1/16-12	1.660	0.609
F5716X10X12X10	1.063	7/8-14	1.540	0.484	1-1/16-12	1.940	0.609	7/8-14	1.540	0.484
F5716X12X10X12	1.063	1-1/16-12	1.660	0.609	7/8-14	1.780	0.484	1-1/16-12	1.660	0.609
F5716X12X12X08	1.063	1-1/16-12	1.660	0.609	1-1/16-12	1.940	0.609	3/4-16	1.420	0.391
F5716X12X12X12	1.063	1-1/16-12	1.660	0.609	1-1/16-12	1.940	0.609	1-1/16-12	1.660	0.609
F5716X12X12X16	1.313	1-1/16-12	1.760	0.609	1-1/16-12	2.050	0.609	1-5/16-12	1.810	0.844
F5716X12X16X12	1.313	1-1/16-12	1.760	0.609	1-5/16-12	2.050	0.844	1-1/16-12	1.760	0.609
F5716X16X12X16	1.313	1-5/16-12	1.810	0.844	1-1/16-12	2.050	0.609	1-5/16-12	1.810	0.844
F5716X16X16X12	1.313	1-5/16-12	1.810	0.844	1-5/16-12	2.050	0.844	1-1/16-12	1.760	0.609
F5716X16X16X16	1.313	1-5/16-12	1.810	0.844	1-5/16-12	2.050	0.844	1-5/16-12	1.810	0.844
F5716X20X20X20	1.625	1-5/8-12	2.060	1.078	1-5/8-12	2.250	1.078	1-5/8-12	2.060	1.078
F5716X24X24X24	1.875	1-7/8-12	2.330	1.313	1-7/8-12	2.390	1.313	1-7/8-12	2.330	1.313
F5716X32X32X32	2.500	2-1/2-12	3.060	1.781	2-1/2-12	2.890	1.781	2-1/2-12	3.060	1.781



Description: **Bulkhead Branch Tee**
WWF Part No.: **F5725**
WWF Stainless Part No.: **2703-SS**
SAE: **070959**

Air-Way: 2703
Parker: WJTX
Aeroquip: 203002-1
Gates: MJ-MJ-MJBKHD

WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
F5725X03X03X03	0.438	3/8-24	0.940	0.125	3/8-24	0.940	0.125	3/8-24	1.500	0.125
F5725X04X04X04	0.438	7/16-20	0.970	0.172	7/16-20	0.970	0.172	7/16-20	1.590	0.172
F5725X04X04X06	0.563	7/16-20	1.080	0.172	7/16-20	1.080	0.172	9/16-18	1.810	0.297
F5725X05X05X05	0.563	1/2-20	1.060	0.234	1/2-20	1.060	0.234	1/2-20	1.720	0.234
F5725X06X06X06	0.563	9/16-18	1.090	0.297	9/16-18	1.090	0.297	9/16-18	1.810	0.297
F5725X08X08X08	0.750	3/4-16	1.360	0.391	3/4-16	1.360	0.391	3/4-16	2.110	0.391
F5725X10X10X10	0.875	7/8-14	1.560	0.484	7/8-14	1.560	0.484	7/8-14	2.390	0.484
F5725X12X12X12	1.063	1-1/16-12	1.780	0.609	1-1/16-12	1.780	0.609	1-1/16-12	2.670	0.609
F5725X16X16X16	1.313	1-5/16-12	1.940	0.844	1-5/16-12	1.940	0.844	1-5/16-12	2.800	0.844
F5725X20X20X20	1.625	1-5/8-12	2.170	1.078	1-5/8-12	2.170	1.078	1-5/8-12	3.120	1.078



Description: **Bulkhead Branch Tee With Locknut**
WWF Part No.: **F5725LN**
WWF Stainless Part No.: **2703-LN-SS**
SAE: **070959**

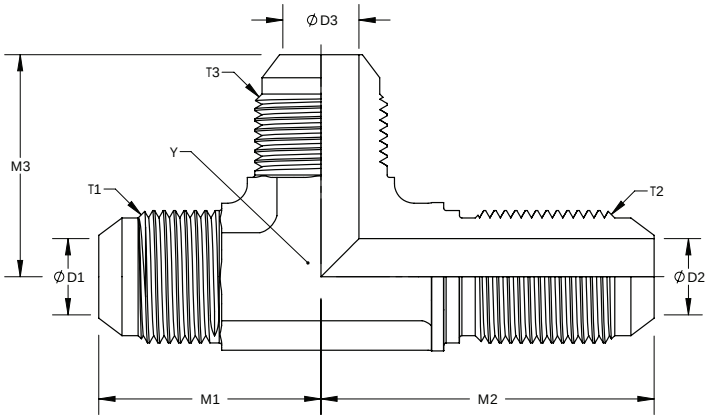
Air-Way: 2703-LN
Parker: WJTX-WLN
Aeroquip: 203002
Gates: /

WWF	Y HEX	Y1 HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
F5725X04X04X04LN	0.438	0.688	7/16-20	0.970	0.172	7/16-20	0.970	0.172	7/16-20	1.590	0.172
F5725X04X04X06LN	0.563	0.813	7/16-20	1.080	0.172	7/16-20	1.080	0.172	9/16-18	1.810	0.297
F5725X05X05X05LN	0.563	0.750	1/2-20	1.060	0.234	1/2-20	1.060	0.234	1/2-20	1.720	0.234
F5725X06X06X06LN	0.563	0.813	9/16-18	1.090	0.297	9/16-18	1.090	0.297	9/16-18	1.810	0.297
F5725X08X08X08LN	0.750	1.000	3/4-16	1.360	0.391	3/4-16	1.360	0.391	3/4-16	2.110	0.391
F5725X10X10X10LN	0.875	1.125	7/8-14	1.560	0.484	7/8-14	1.560	0.484	7/8-14	2.390	0.484
F5725X12X12X12LN	1.063	1.375	1-1/16-12	1.780	0.609	1-1/16-12	1.780	0.609	1-1/16-12	2.670	0.609
F5725X16X16X16LN	1.313	1.625	1-5/16-12	1.940	0.844	1-5/16-12	1.940	0.844	1-5/16-12	2.800	0.844
F5725X20X20X20LN	1.625	1.875	1-5/8-12	2.170	1.078	1-5/8-12	2.170	1.078	1-5/8-12	3.120	1.078

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Description: **Bulkhead Run Tee**
WWF Part No.: **F5726**
WWF Stainless Part No.: **2704-SS**
SAE: **070958**

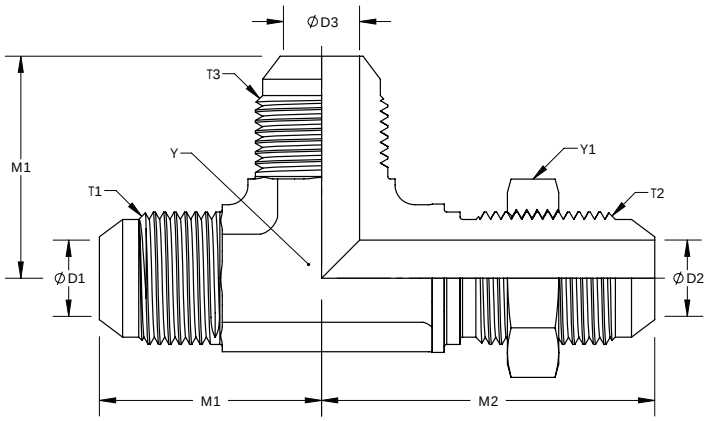
Air-Way: 2704
Parker: WJJTX
Aeroquip: FF1065
Gates: MJ-MJBKHD-MJ



WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
F5726X03X03X03	0.438	3/8-24	0.940	0.125	3/8-24	1.500	0.125	3/8-24	0.940	0.125
F5726X04X04X04	0.438	7/16-20	0.970	0.172	7/16-20	1.590	0.172	7/16-20	0.970	0.172
F5726X04X06X04	0.563	7/16-20	1.080	0.172	9/16-18	1.810	0.297	7/16-20	1.080	0.172
F5726X06X06X06	0.563	9/16-18	1.090	0.297	9/16-18	1.810	0.297	9/16-18	1.090	0.297
F5726X08X08X08	0.750	3/4-16	1.360	0.391	3/4-16	2.110	0.391	3/4-16	1.360	0.391
F5726X08X10X08	0.875	3/4-16	1.440	0.391	7/8-14	2.390	0.484	3/4-16	1.440	0.391
F5726X10X08X08	0.875	7/8-14	1.560	0.484	3/4-16	2.270	0.391	3/4-16	1.440	0.391
F5726X10X10X10	0.875	7/8-14	1.560	0.484	7/8-14	2.390	0.484	7/8-14	1.560	0.484
F5726X12X12X12	1.063	1-1/16-12	1.780	0.609	1-1/16-12	2.670	0.609	1-1/16-12	1.780	0.609
F5726X16X16X16	1.313	1-5/16-12	1.940	0.844	1-5/16-12	2.800	0.844	1-5/16-12	1.940	0.844
F5726X20X20X20	1.625	1-5/8-12	2.170	1.078	1-5/8-12	3.120	1.078	1-5/8-12	2.170	1.078

Description: **Bulkhead Run Tee With Locknut**
WWF Part No.: **F5726LN**
WWF Stainless Part No.: **2704-LN-SS**
SAE: **070958**

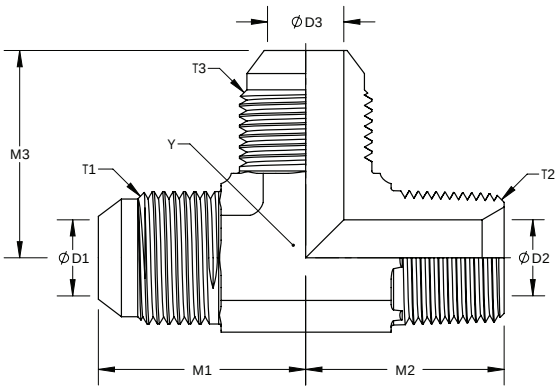
Air-Way: 2704-LN
Parker: WJJTX-WLN
Aeroquip: 203008
Gates: /



WWF	Y HEX	Y1 HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
F5726X04X04X04LN	0.438	0.688	7/16-20	0.970	0.172	7/16-20	1.590	0.172	7/16-20	0.970	0.172
F5726X04X06X04LN	0.563	0.813	7/16-20	1.080	0.172	9/16-18	1.810	0.297	7/16-20	1.080	0.172
F5726X06X06X06LN	0.563	0.813	9/16-18	1.090	0.297	9/16-18	1.810	0.297	9/16-18	1.090	0.297
F5726X08X08X08LN	0.750	1.000	3/4-16	1.360	0.391	3/4-16	2.110	0.391	3/4-16	1.360	0.391
F5726X08X10X08LN	0.875	1.125	3/4-16	1.440	0.391	7/8-14	2.390	0.484	3/4-16	1.440	0.391
F5726X10X08X08LN	0.875	1.000	7/8-14	1.560	0.484	3/4-16	2.270	0.391	3/4-16	1.440	0.391
F5726X10X10X10LN	0.875	1.125	7/8-14	1.560	0.484	7/8-14	2.390	0.484	7/8-14	1.560	0.484
F5726X12X12X12LN	1.063	1.375	1-1/16-12	1.780	0.609	1-1/16-12	2.670	0.609	1-1/16-12	1.780	0.609
F5726X16X16X16LN	1.313	1.625	1-5/16-12	1.940	0.844	1-5/16-12	2.800	0.844	1-5/16-12	1.940	0.844
F5726X20X20X20LN	1.625	1.875	1-5/8-12	2.170	1.078	1-5/8-12	3.120	1.078	1-5/8-12	2.170	1.078

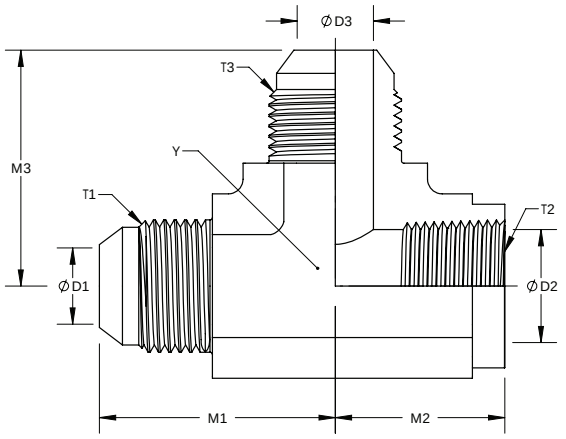
Description: **Male Run Tee**
WWF Part No.: **F5755**
WWF Stainless Part No.: **2605-SS**
SAE: **070424**

Air-Way: 2605
Parker: RTX
Aeroquip: 2028-[R]
Gates: /



C

WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
F5755X03X02X03	0.438	3/8-24	0.830	0.125	1/8-27	0.720	0.188	3/8-24	0.830	0.125
F5755X04X02X04	0.438	7/16-20	0.890	0.172	1/8-27	0.780	0.188	7/16-20	0.890	0.172
F5755X04X04X04	0.563	7/16-20	1.050	0.172	1/4-18	1.090	0.281	7/16-20	1.050	0.172
F5755X05X02X05	0.563	1/2-20	0.950	0.234	1/8-27	0.780	0.188	1/2-20	0.950	0.234
F5755X06X02X06	0.563	9/16-18	1.060	0.297	1/8-27	0.900	0.188	9/16-18	1.060	0.297
F5755X06X04X04	0.563	9/16-18	1.060	0.297	1/4-18	1.090	0.281	7/16-20	1.050	0.172
F5755X06X04X06	0.563	9/16-18	1.060	0.297	1/4-18	1.090	0.281	9/16-18	1.060	0.297
F5755X06X06X06	0.750	9/16-18	1.140	0.297	3/8-18	1.220	0.406	9/16-18	1.140	0.297
F5755X06X08X06	0.875	9/16-18	1.220	0.297	1/2-14	1.470	0.531	9/16-18	1.220	0.297
F5755X08X04X08	0.750	3/4-16	1.250	0.391	1/4-18	1.220	0.281	3/4-16	1.250	0.391
F5755X08X06X08	0.750	3/4-16	1.250	0.391	3/8-18	1.220	0.406	3/4-16	1.250	0.391
F5755X08X08X08	0.875	3/4-16	1.330	0.391	1/2-14	1.470	0.531	3/4-16	1.330	0.391
F5755X10X08X10	0.875	7/8-14	1.450	0.484	1/2-14	1.470	0.531	7/8-14	1.450	0.484
F5755X12X08X12	1.063	1-1/16-12	1.660	0.609	1/2-14	1.590	0.531	1-1/16-12	1.660	0.609
F5755X12X12X08	1.063	1-1/16-12	1.660	0.609	3/4-14	1.590	0.719	3/4-16	1.420	0.391
F5755X12X12X12	1.063	1-1/16-12	1.660	0.609	3/4-14	1.590	0.719	1-1/16-12	1.660	0.609
F5755X14X12X14	1.313	1-3/16-12	1.800	0.719	3/4-14	1.690	0.719	1-3/16-12	1.800	0.719
F5755X16X16X16	1.313	1-5/16-12	1.810	0.844	1-11-1/2	1.970	0.938	1-5/16-12	1.810	0.844
F5755X20X20X20	1.625	1-5/8-12	2.060	1.078	1-1/4-11-1/2	2.380	1.250	1-5/8-12	2.060	1.078
F5755X24X24X24	1.875	1-7/8-12	2.330	1.313	1-1/2-11-1/2	2.640	1.500	1-7/8-12	2.330	1.313
F5755X32X32X32	2.500	2-1/2-12	3.060	1.781	2-11-12	3.000	1.938	2-1/2-12	3.060	1.781



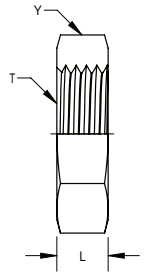
Description: **Female Run Tee**
WWF Part No.: **F5805**
WWF Stainless Part No.: **2606-SS**
SAE: **070426**

Air-Way: 2606
Parker: MTX
Aeroquip: 2029-[R]
Gates: /

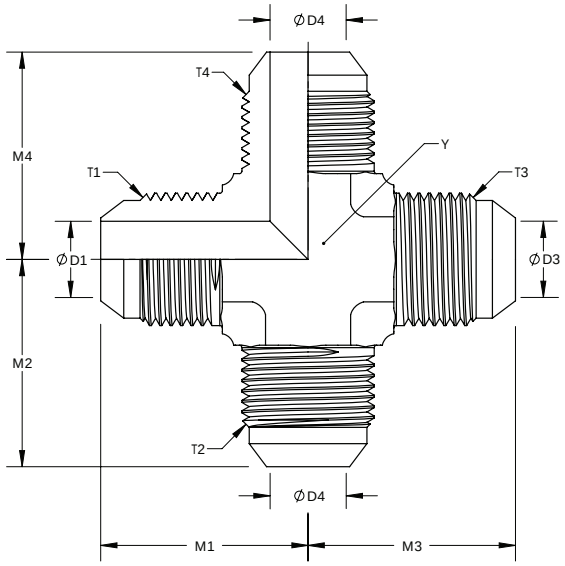
WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
F5805X03X02X03	0.563	3/8-24	1.030	0.125	1/8-27	0.660	0.332	3/8-24	1.030	0.125
F5805X04X02X04	0.563	7/16-20	1.080	0.172	1/8-27	0.660	0.332	7/16-20	1.080	0.172
F5805X04X04X04	0.750	7/16-20	1.220	0.172	1/4-18	0.880	0.438	7/16-20	1.220	0.172
F5805X06X04X06	0.750	9/16-18	1.230	0.297	1/4-18	0.880	0.438	9/16-18	1.230	0.297
F5805X06X06X06	0.875	9/16-18	1.310	0.297	3/8-18	1.020	0.563	9/16-18	1.310	0.297
F5805X08X06X08	0.875	3/4-16	1.420	0.391	3/8-18	1.020	0.563	3/4-16	1.420	0.391
F5805X10X08X10	1.063	7/8-14	1.640	0.484	1/2-14	1.230	0.703	7/8-14	1.640	0.484
F5805X12X12X12	1.313	1-1/16-12	1.890	0.609	3/4-14	1.360	0.906	1-1/16-12	1.890	0.609
F5805X14X12X14	1.313	1-3/16-12	1.860	0.719	3/4-14	1.420	0.906	1-3/16-12	1.860	0.719
F5805X16X16X16	1.625	1-5/16-12	2.170	0.844	1-11-1/2	1.620	1.141	1-5/16-12	2.170	0.844
F5805X20X20X20	1.875	1-5/8-12	2.330	1.078	1-1/4-11-1/2	1.700	1.484	1-5/8-12	2.330	1.078

Description: **Bulkhead Locknut**
WWF Part No.: **5924**
WWF Stainless Part No.: **0306-SS**
SAE: **070118**

Air-Way: 0306
Parker: WLN
Aeroquip: 210212
Gates: LN



WWF	Y HEX	T	L
5924X02	0.563	5/16-24	0.220
5924X03	0.625	3/8-24	0.220
5924X04CF	0.688	7/16-20	0.280
5924X05CF	0.750	1/2-20	0.280
5924X06CF	0.813	9/16-18	0.270
5924X08CF	1.000	3/4-16	0.310
5924X10CF	1.125	7/8-14	0.360
5924X12CF	1.375	1-1/16-12	0.410
5924X14	1.500	1-3/16-12	0.410
5924X16CF	1.625	1-5/16-12	0.410
5924X20	1.875	1-5/8-12	0.410
5924X24	2.125	1-7/8-12	0.410
5924X32	2.750	2-1/2-12	0.410



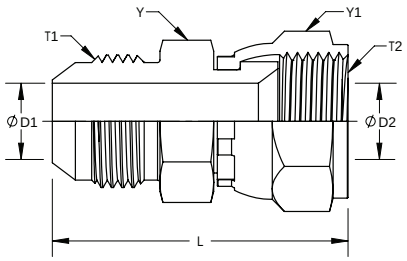
Description: **Cross**
WWF Part No.: **F5955**
WWF Stainless Part No.: **2650-SS**
SAE: **070501**

Air-Way: 2650
Parker: KTX
Aeroquip: 2020
Gates: /

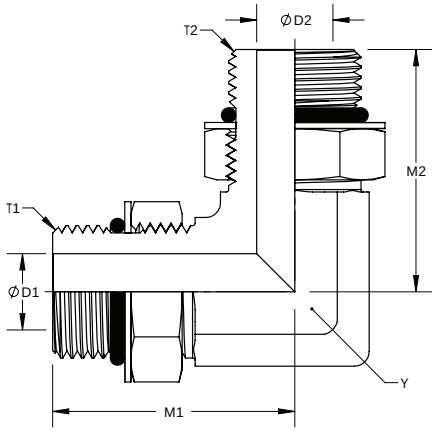
WWF	Y HEX	T1 / T3	M1 / M3	D1 / D3	T2 /T4	M2 / M4	D2 / D4
F5955X02X02X02X02	0.438	5/16-24	0.770	0.063	5/16-24	0.770	0.063
F5955X04X04X04X04	0.438	7/16-20	0.890	0.172	7/16-20	0.890	0.172
F5955X05X05X05X05	0.563	1/2-20	0.950	0.234	1/2-20	0.950	0.234
F5955X06X06X06X06	0.563	9/16-18	1.060	0.297	9/16-18	1.060	0.297
F5955X06X08X06X08	0.750	9/16-18	1.140	0.297	3/4-16	1.250	0.391
F5955X08X08X08X08	0.750	3/4-16	1.250	0.391	3/4-16	1.250	0.391
F5955X10X10X10X10	0.875	7/8-14	1.450	0.484	7/8-14	1.450	0.484
F5955X12X12X12X12	1.063	1-1/16-12	1.660	0.609	1-1/16-12	1.660	0.609
F5955X14X14X14X14	1.313	1-3/16-12	1.800	0.719	1-3/16-12	1.800	0.719
F5955X16X16X16X16	1.313	1-5/16-12	1.810	0.844	1-5/16-12	1.810	0.844
F5955X20X20X20X20	1.625	1-5/8-12	2.060	1.078	1-5/8-12	2.060	1.078
F5955X24X24X24X24	1.875	1-7/8-12	2.330	1.313	1-7/8-12	2.330	1.313

Description: **Female Swivel to Male JIC**
WWF Part No.: **6504**
WWF Stainless Part No.: **6504-SS**
SAE: **/**

Air-Way: 6504
Parker: XHX6
Aeroquip: /
Gates: MJ-FJX



WWF	Y HEX	Y1 HEX	T1	D1	T2	D2	L
6504X04X04	0.500	0.563	7/16-20	0.172	7/16-20	0.172	1.530
6504X06X06	0.625	0.688	9/16-18	0.297	9/16-18	0.297	1.590
6504X08X08	0.813	0.875	3/4-16	0.391	3/4-16	0.391	1.830
6504X10X10	0.938	1.000	7/8-14	0.484	7/8-14	0.484	2.170
6504X12X12	1.125	1.250	1-1/16-12	0.609	1-1/16-12	0.609	2.370
6504X16X16	1.375	1.500	1-5/16-12	0.844	1-5/16-12	0.844	2.495
6504X20X20	1.688	2.000	1-5/8-12	1.078	1-5/8-12	1.078	2.760

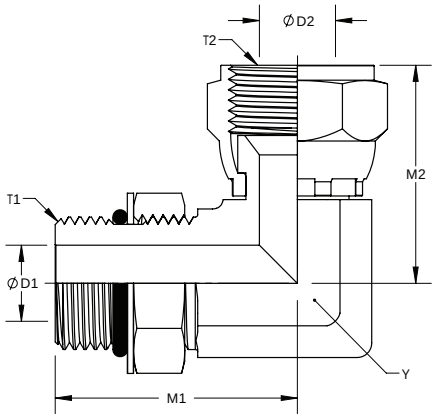


Description: **Adjustable ORB Union Elbow**
WWF Part No.: **6807**
WWF Stainless Part No.: **6807-SS**
SAE: **/**

Air-Way: 6807
Parker: /
Aeroquip: /
Gates: /

C

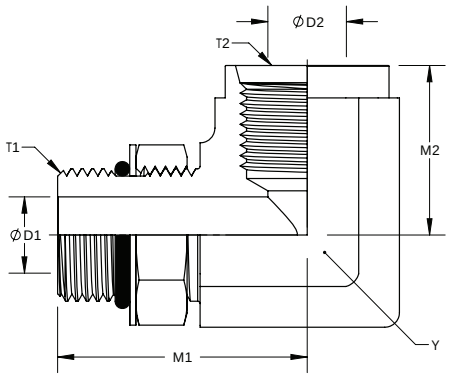
WWF	Y HEX	T1	M1	D1	T2	M2	D2
6807X04X04	0.438	7/16-20	1.030	0.172	7/16-20	1.030	0.172
6807X06X06	0.563	9/16-18	1.250	0.297	9/16-18	1.250	0.297
6807X08X06	0.750	3/4-16	1.450	0.391	9/16-18	1.320	0.297
6807X08X08	0.750	3/4-16	1.450	0.391	3/4-16	1.450	0.391
6807X10X08	0.875	7/8-14	1.700	0.484	3/4-16	1.540	0.391
6807X10X10	0.875	7/8-14	1.700	0.484	7/8-14	1.700	0.484
6807X12X12	1.063	1-1/16-12	1.940	0.609	1-1/16-12	1.940	0.609
6807X16X16	1.313	1-5/16-12	2.050	0.844	1-5/16-12	2.050	0.844
6807X20X20	1.625	1-5/8-12	2.250	1.078	1-5/8-12	2.250	1.078
6807X24X24	1.875	1-7/8-12	2.390	1.313	1-7/8-12	2.390	1.313



Description: **90° Female Swivel to Male ORB**
WWF Part No.: **6809**
WWF Stainless Part No.: **6809-SS**
SAE: **/**

Air-Way: 6809
Parker: AOEX6
Aeroquip: /
Gates: /

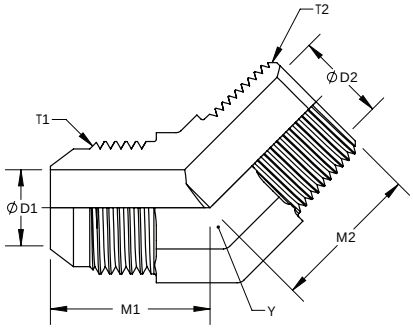
WWF	Y HEX	T1	M1	D1	T2	M2	D2
6809X04X04	0.438	7/16-20	1.030	0.172	7/16-20	1.000	0.172
6809X06X06	0.563	9/16-18	1.250	0.297	9/16-18	1.250	0.297
6809X08X08	0.750	3/4-16	1.450	0.391	3/4-16	1.380	0.391
6809X10X10	0.875	7/8-14	1.700	0.484	7/8-14	1.620	0.484
6809X12X12	1.063	1-1/16-12	1.940	0.609	1-1/16-12	1.750	0.609
6809X16X16	1.313	1-5/16-12	2.050	0.844	1-5/16-12	2.000	0.844



Description: **90° Male ORB to Female ORB**
WWF Part No.: **6815**
WWF Stainless Part No.: **6815-SS**
SAE: **/**

Air-Way: 6815
Parker: /
Aeroquip: /
Gates: /

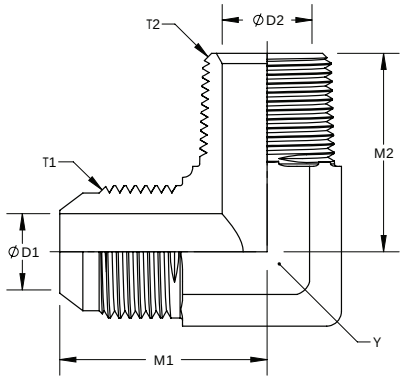
WWF	Y HEX	T1	M1	D1	T2	M2	D2
6815X04X04	0.750	7/16-20	1.260	0.172	7/16-20	0.830	0.172
6815X06X06	0.875	9/16-18	1.410	0.297	9/16-18	1.020	0.297
6815X08X08	1.063	3/4-16	1.620	0.391	3/4-16	1.230	0.391
6815X10X10	1.063	7/8-14	1.780	0.484	7/8-14	1.230	0.492
6815X12X12	1.313	1-1/16-12	2.000	0.609	1-1/16-12	1.360	0.609
6815X16X16	1.625	1-5/16-12	2.250	0.844	1-5/16-12	1.620	0.827



Description: **45° Male Elbow**
WWF Part No.: **7100**
WWF Stainless Part No.: **/**
SAE: **/**

Air-Way: 7100
Parker: /
Aeroquip: /
Gates: MJ-MBSPT 45° Elbow

WWF	Y HEX	T1	M1	D1	T2	M2	D2
7100X04X02	0.438	7/16-20	0.720	0.172	R 1/8-28	0.642	0.188
7100X04X04	0.563	7/16-20	0.807	0.172	R 1/4-19	0.858	0.281
7100X06X04	0.563	9/16-18	0.831	0.297	R 1/4-19	0.858	0.281
7100X06X06	0.748	9/16-18	0.870	0.297	R 3/8-19	0.949	0.406
7100X08X06	0.748	3/4-16	0.980	0.391	R 3/8-19	0.949	0.406
7100X08X08	0.874	3/4-16	0.992	0.391	R 1/2-14	1.169	0.531
7100X10X08	0.874	7/8-14	1.110	0.484	R 1/2-14	1.169	0.531
7100X12X12	1.063	1-1/16-12	1.280	0.609	R 3/4-14	1.201	0.719



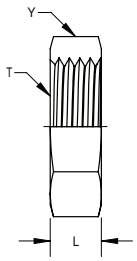
Description: **90° Male Elbow**
WWF Part No.: **7200**
WWF Stainless Part No.: **/**
SAE: **/**

Air-Way: 7200
Parker: /
Aeroquip: /
Gates: MJ-MBSPT 90° Elbow

C

WWF	Y HEX	T1	M1	D1	T2	M2	D2
7200X04X02	0.438	7/16-20	0.890	0.172	R 1/8-28	0.780	0.188
7200X04X04	0.563	7/16-20	1.047	0.172	R 1/4-19	1.091	0.281
7200X06X04	0.563	9/16-18	1.059	0.297	R 1/4-19	1.091	0.281
7200X06X06	0.748	9/16-18	1.142	0.297	R 3/8-19	1.220	0.406
7200X08X06	0.748	3/4-16	1.252	0.391	R 3/8-19	1.220	0.406
7200X08X08	0.874	3/4-16	1.331	0.391	R 1/2-14	1.469	0.531
7200X12X12	1.063	1-1/16-12	1.660	0.609	R 3/4-14	1.590	0.719

Description: **Straight Thread Locknut**
WWF Part No.: **8924**
WWF Stainless Part No.: **0306-N-SS**
SAE: **070117**



Air-Way: 0306-N
Parker: /
Aeroquip: 210295
Gates: /

WWF	Y HEX	T	L
8924X02	0.438	5/16-24	0.220
8924X03	0.500	3/8-24	0.220
8924X04	0.563	7/16-20	0.280
8924X05	0.625	1/2-20	0.280
8924X06	0.688	9/16-18	0.270
8924X08	0.875	3/4-16	0.310
8924X10	1.000	7/8-14	0.360
8924X12	1.250	1-1/16-12	0.410
8924X14	1.375	1-3/16-12	0.410
8924X16	1.500	1-5/16-12	0.410
8924X20	1.875	1-5/8-12	0.410
8924X24	2.125	1-7/8-12	0.410
8924X32	2.750	2-1/2-12	0.410

NOTES

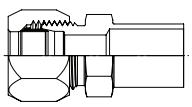
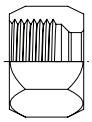
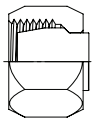
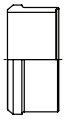
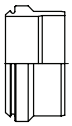
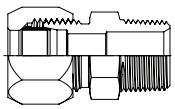
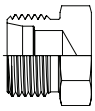
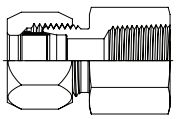
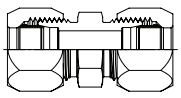
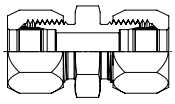
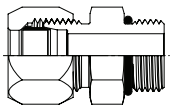
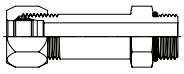
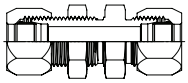
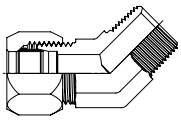
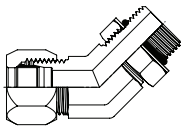
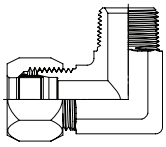
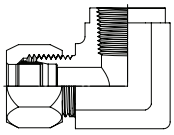
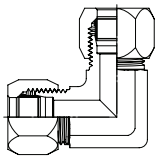
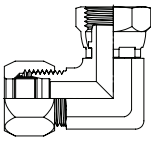
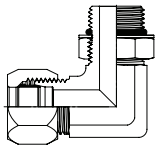
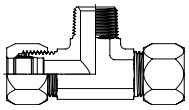
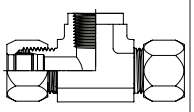
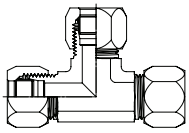
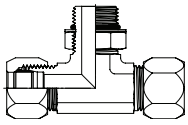
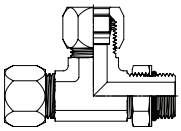
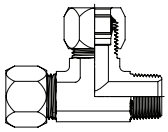
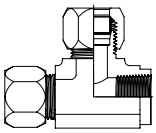
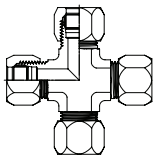
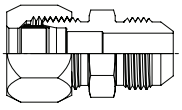
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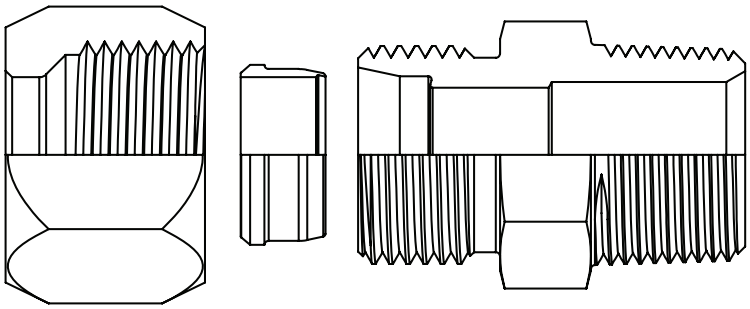
Steel Flareless Fittings

7000 SERIES

7000 SERIES - STEEL FLARELESS FITTINGS

C2406 Page 152	**C0318** Page 152	**C0304-C** Page 153	Page 153	**C0319** Page 154	**C2404** Page 154	**C2408** Page 156
						
7015	7105	7129	7165	7165A	7205	7229
Reducer	Nut	Cap Assembly	Style “B” Ferrule	Style “A” Ferrule	Male Connector	Plug
C2405 Page 156	**C2403** Page 157	**C2403-LH** Page 157	**C6400** Page 158	**C6400-L** Page 159	**C2700** Page 159	**C2503** Page 160
						
7255	7305	7306	7315	7316	7325	7355
Female Connector	Union	Large Hex Union	Straight Thread Connector Short	Straight Thread Connector Long	Bulkhead Union	45º Male Elbow
C6802 Page 160	**C2501** Page 161	**C2502** Page 162	**C2500** Page 163	**C6500** Page 164	**C6801** Page 164	**C2601** Page 165
						
7365	7405	7455	7505	7506	7515	7605
45º Straight Thread Elbow	90º Male Elbow	90º Female Elbow	90º Union Elbow	90º Swivel Elbow	90º Straight Thread Elbow	Male Branch Tee
Page 165	Page 166	**C2602** Page 166	**C2603** Page 167	**C6803** Page 167	**C6804** Page 168	**C2605** Page 168
						
7629	7269M	7655	7705	7715	7716	7755
90 Durometer “O” Ring	90 Durometer Metric “O” Ring	Female Branch Tee	Union Tee	Straight Thread Branch Tee	Straight Thread Run Tee	Male Run Tee
C2606 Page 169	**C2650** Page 169	**C2402** Page 170				
						
7805	7955	C2402				
Female Run Tee	Cross	Male Connector to Male JIC				

7000 SERIES - STEEL FLARELESS FITTINGS



7000 Series Assembly

CONSTRUCTION

7000 Series Fittings consist of three main components: Bodies, Nuts, and Sleeves.

Bodies – Straight bodies are machined from bar stock. Shape fittings (elbows, tees, & crosses) are machined from forgings.

7000 Series fittings are machined with NPTF - Dryseal Pipe Threads and SAE straight threads for easy installation.

Tube Nuts – Tube nuts in sizes 1/4", 5/16 ', 3/8", 1/2", 5/8", 3/4", 1" are Cold Formed in 1010 steel. Tube nuts in sizes 1 1/4", 1 1/2", & 2" are hot forged from 1045.

Tube Sleeves – Flareless tube sleeves are machined from cold drawn12L14 bar stock and are available in both SAE "A" and "B" styles (see tube sleeve drawings to view the "A" and "B" style sleeves). After machining and inspection the tube sleeves are heat treated to provide them with the necessary hardness.

CAUTION:

Stainless steel sleeves must be preset into tubing during installation.

MATERIAL

- Steel – Forged Bodies 1045
- Straight Bodies 12L14, 1045
- Cold Formed Nuts 1010
- Bar Stock Nut 12L14
- Flareless Sleeves 12L14
- Stainless Steel – Forged Bodies 316
- Stainless Steel – Straight Bodies 316
- Stainless Steel –Bar Stock Nuts 316
- Stainless Steel –Flareless Sleeves 17-4PH

PLATING

Clear Zinc Trivalent

Alternate plating finishes are available upon request. Contact World Wide Fittings for details.

APPLICATIONS

For use with applications such as: Construction machinery, Textile machinery, Machine tools, Chemical, Marine, Military, and most other high pressure hydraulic applications. Applications using thick wall tubing where flaring is not practical.

CAUTION:

7000 Flareless Fittings are NOT RECOMMENDED for use in instrumentation applications where toxic and noxious gases are present.

TEMPERATURE RANGE

-30 Degrees Fahrenheit to +450 Degrees Fahrenheit

Straight thread fittings which use "O" Rings to seal are restricted to the temperature range of the material used to construct the "O" Ring.

PRESSURE RATINGS

Working Pressure up to 8000 PSI.

CAUTION:

Working pressures will vary depending on tube and fitting size. (For applications using extreme pressures at 5000 PSI or above (or) for application with extreme pressure fluctuations, contact World Wide Fittings.)

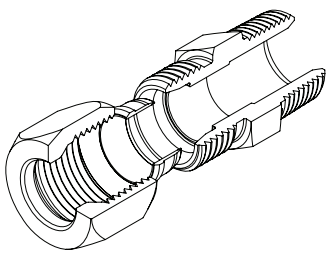
HOW TO ORDER

Tubing sizes are measured in sixteenths of an inch. Available sizes are 1/8" through 2". When ordering, the tube end of the fitting must be specified first followed by the pipe thread or straight thread end. All fittings in this section are ordered as assemblies only unless otherwise specified by customers when ordering.

(Contact World Wide Fittings when ordering fittings as bodies only or configurations which are non-standard.)

CONFORMANCE

7000 Series fittings meet SAE J514 and MS (Military Specifications).



7000 SERIES - STEEL FLARELESS FITTINGS

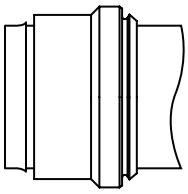
ASSEMBLY INSTRUCTIONS

Using a presetting tool, the flareless sleeve should be preset and inspected before final assembly of the fittings is made. All Stainless Sleeves must be preset before final installation.

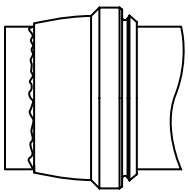
1. Cut the tubing to the desired length making sure the ends are square. (Refer to the tube penetration chart when measuring tube length.)
   Remove all burrs and foreign matter from the end of the tubing and clean thoroughly.
2. Lubricate the threads of the preset body, tube nut, and outer edge of both ends of the flareless sleeve.
3. Slide the tube nut and the flareless sleeve onto the tubing making sure the open end of the nut and the leading "bite" edge of the sleeve are facing the end of the tubing.
4. Insert the tubing into the preset body until it hits the bottom or shoulder of the tool. Bring the flareless sleeve and tube nut down to the preset tool and tighten the nut to the finger-tight position.
5. Using a marker make a reference line on the tubing and tube nut. Holding the tubing firmly in the preset tool and using a wrench, tighten the tube nut an additional 1-3/4 turns past the finger-tight position. Disassemble the nut from the preset tool and inspect the flareless sleeve for the proper bite into the tube. (Refer to example drawings for correct and incorrect preset sleeves.)
6. Should the preset sleeve look acceptable, insert the tube with the preset sleeve into the fitting body to be assembled. Tighten the tube nut to the finger-tight position. Then using a wrench tighten the nut until a sudden rise in torque is felt. From the point where the sudden rise in torque started turn the nut an additional 1/3 to 1/4 turn. Your assembly is now ready for use.

   (Refer to the assembly torque charts during installation of 7000 series fittings from the port and thread assemblies section.)

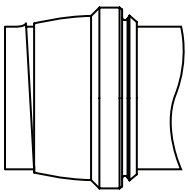
Incorrect tube / sleeve assembly



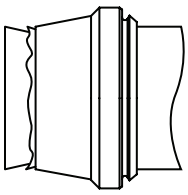
Shallow bite



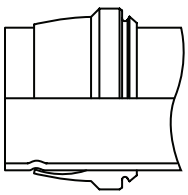
Tube not bottomed in fitting



Sleeve was cocked



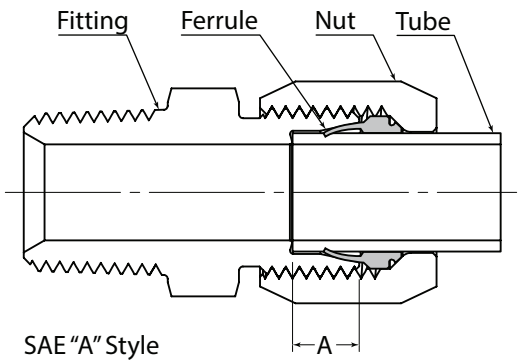
Over set sleeve



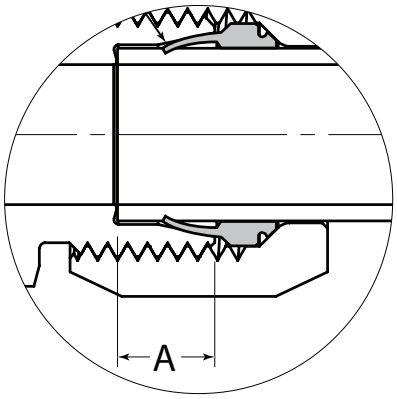
No bite

7000 SERIES - STEEL FLARELESS FITTINGS

Correct assembly



SAE "A" Style

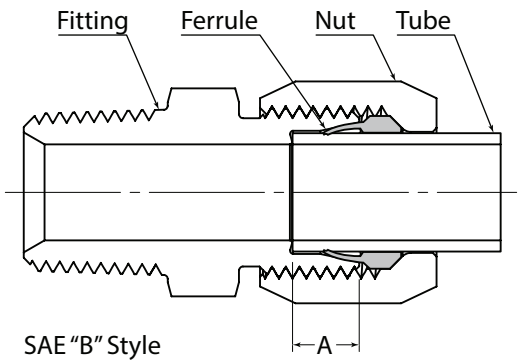


Tube length allowance

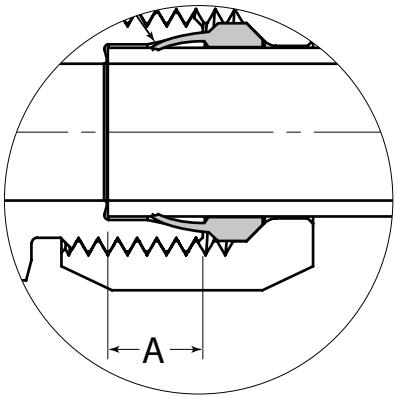
Nominal Tube O.D.	A
1/8	0.19
3/16	0.23
1/4	0.23
5/16	0.25
3/8	0.25
1/2	0.31
5/8	0.35
3/4	0.35
7/8	0.35
1	042
1-1/4	0.42
1-1/2	0.49
2	0.49

Tube length allowance table

Correct assembly



SAE "B" Style



Tube length allowance

The above example shows an assembly using the **SAE "A" Style** flareless sleeve. When assembled properly the SAE "A"style flareless sleeve assembly will exhibit the following characteristics.

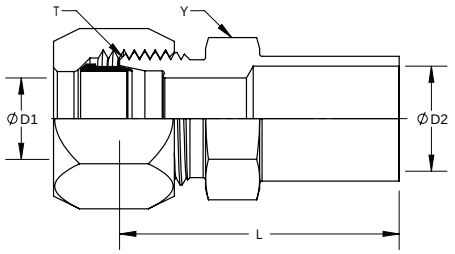
1. A slight indentation around the end of the tube which indicates that the tube was fully inserted during installation.
2. A visible metal lip will have been raised 75% to 100% of the thickness of the sleeves lead biting edge all the way around the tube. (See illustration above.)
3. The midsection of the sleeve behind the leading edge has a slight bow to provide contact with the internal taper of the fitting body and form a sealing point.
4. The back (tail) end of the sleeve will be in firm contact with the O.D. of the tube.

The above example shows an assembly using the **SAE "B" Style** flareless sleeve. When assembled properly the SAE "B" style flareless sleeve assembly will exhibit the following characteristics.

1. A slight indentation around the end of the tube which indicates that the tube was fully inserted during installation.
2. A metal lip will have been raised 75% to 100% of the thickness of the sleeves biting edge which is hidden under the leading end of the sleeve. (See illustration above.)
3. The midsection of the sleeve behind the leading edge has a slight bow to provide contact with the internal taper of the fitting body and form a sealing point.
4. The back (tail) end of the sleeve will be in firm contact with the O.D. of the tube.

Description**:** **Reducer**
WWF Part No.: **7015**
WWF Stainless Part No.: **C2406-SS**
SAE: **080123**

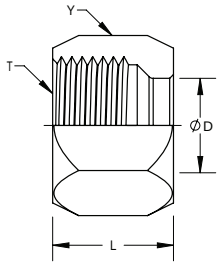
Air-Way: C2406
Parker: TRBU
Aeroquip: /
Gates: /



WWF	Y HEX	T	D1	D2	L
7015X06X04	0.500	7/16-20	0.203	0.250	1.610
7015X06X12	1.125	1-1/16-12	0.656	0.250	2.000
7015X08X04	0.563	7/16-20	0.203	0.375	1.730
7015X08X06	0.625	9/16-18	0.281	0.375	1.770
7015X10X04	0.688	7/16-20	0.203	0.500	1.850
7015X10X08	0.813	3/4-16	0.422	0.500	1.960
7015X12X06	0.813	9/16-18	0.281	0.625	1.930
7015X12X08	0.813	3/4-16	0.422	0.625	2.030
7015X16X12	1.125	1-1/16-12	0.656	0.844	2.240
7015X20X16	1.375	1-5/16-12	0.875	1.031	2.280

Description**:** **Nut**
WWF Part No.: **7105**
WWF Stainless Part No.: **C0318-SS**
SAE: **080110**

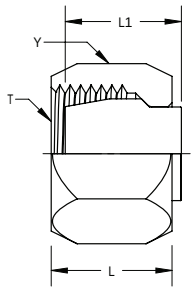
Air-Way: C0318
Parker: BU
Aeroquip: /
Gates: FFN



WWF	Y HEX	T	D	L
7105X02	0.375	5/16-24	0.130	0.530
7105X03	0.438	3/8-24	0.193	0.610
7105X04	0.563	7/16-20	0.255	0.700
7105X05	0.625	1/2-20	0.318	0.720
7105X06	0.688	9/16-18	0.380	0.750
7105X08	0.875	3/4-16	0.505	0.840
7105X10	1.000	7/8-14	0.631	0.920
7105X12	1.250	1-1/16-12	0.756	0.970
7105X14	1.375	1-3/16-12	0.881	1.000
7105X16	1.500	1-5/16-12	1.006	1.050
7105X20	2.000	1-5/8-12	1.260	1.050
7105X24	2.250	1-7/8-12	1.510	1.030
7105X32	2.875	2-1/2-12	2.014	1.120

Description**:** **Cap Assembly**
WWF Part No.: **7129**
WWF Stainless Part No.: **C0304-C-SS**
SAE: **080112**

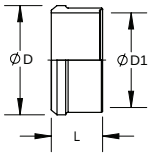
Air-Way: C0304-C
Parker: FNU
Aeroquip: /
Gates: /



WWF	Y HEX	T	L	L1
7129X02	0.375	5/16-24	0.530	0.580
7129X04	0.563	7/16-20	0.700	0.720
7129X06	0.688	9/16-18	0.750	0.770
7129X08	0.875	3/4-16	0.840	0.930
7129X10	1.000	7/8-14	0.920	0.940
7129X12	1.250	1-1/16-12	0.970	0.930
7129X14	1.375	1-3/16-12	1.000	0.960
7129X16	1.500	1-5/16-12	1.050	1.080
7129X20	2.000	1-5/8-12	1.050	1.190

Description**:** **Style “B” Ferrule**
WWF Part No.: **7165**
WWF Stainless Part No.: ***/***
SAE: **080115B**

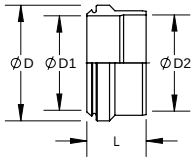
Air-Way: /
Parker: /
Aeroquip: /
Gates: FFS



WWF	D	D1	L
7165X02	0.203	0.129	0.278
7165X03	0.313	0.190	0.278
7165X04	0.359	0.255	0.336
7165X05	0.422	0.318	0.336
7165X06	0.484	0.380	0.375
7165X08	0.625	0.506	0.375
7165X10	0.750	0.633	0.415
7165X12	0.875	0.758	0.415
7165X14	1.000	0.883	0.415
7165X16	1.125	1.008	0.415
7165X20	1.406	1.260	0.415
7165X24	1.656	1.511	0.415
7165X32	2.188	2.014	0.453

Description**:** **Style “A” Ferrule**
WWF Part No.: **7165A**
WWF Stainless Part No.: **C0319-SS**
SAE: **080115A**

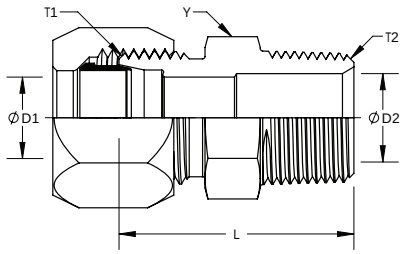
Air-Way: C0319
Parker: TU
Aeroquip: /
Gates: /



WWF	D	D1	D2	L
7165AX02	0.237	0.130	0.140	0.288
7165AX03	0.307	0.193	0.205	0.329
7165AX04	0.367	0.255	0.268	0.363
7165AX05	0.430	0.318	0.330	0.367
7165AX06	0.492	0.380	0.393	0.393
7165AX08	0.663	0.505	0.521	0.429
7165AX10	0.780	0.631	0.647	0.442
7165AX12	0.925	0.756	0.772	0.475
7165AX14	1.063	0.881	0.897	0.475
7165AX16	1.188	1.006	1.022	0.475
7165AX20	1.446	1.260	1.275	0.475
7165AX24	1.694	1.510	1.524	0.475
7165AX32	2.210	2.014	2.026	0.509

Description**:** **Male Connector**
WWF Part No.: **7205**
WWF Stainless Part No.: **C2404-SS**
SAE: **080102**

Air-Way: C2404
Parker: FBU
Aeroquip: /
Gates: /



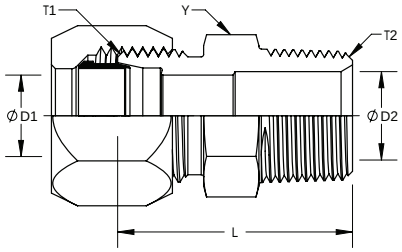
WWF	Y HEX	T1	D1	T2	D2	L
7205X02X02	0.438	5/16-24	0.094	1/8-27	0.188	1.040
7205X02X04	0.563	5/16-24	0.094	1/4-18	0.281	1.240
7205X03X02	0.438	3/8-24	0.125	1/8-27	0.188	1.090
7205X03X04	0.563	3/8-24	0.125	1/4-18	0.281	1.290
7205X04X02	0.500	7/16-20	0.203	1/8-27	0.188	1.120
7205X04X04	0.563	7/16-20	0.203	1/4-18	0.281	1.320
7205X04X06	0.750	7/16-20	0.203	3/8-18	0.406	1.330

Continued on page 155

Continued from page 154

Description**:** **Male Connector**
WWF Part No.: **7205**
WWF Stainless Part No.: **C2404-SS**
SAE: **080102**

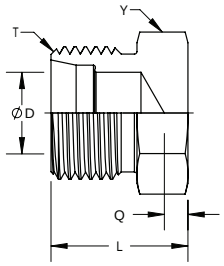
Air-Way: C2404
Parker: FBU
Aeroquip: /
Gates: /



WWF	Y HEX	T1	D1	T2	D2	L
7205X04X08	0.875	7/16-20	0.203	1/2-14	0.531	1.580
7205X05X02	0.563	1/2-20	0.234	1/8-27	0.188	1.120
7205X05X04	0.563	1/2-20	0.234	1/4-18	0.281	1.320
7205X06X02	0.625	9/16-18	0.281	1/8-27	0.188	1.150
7205X06X04	0.625	9/16-18	0.281	1/4-18	0.281	1.340
7205X06X06	0.750	9/16-18	0.281	3/8-18	0.406	1.350
7205X06X08	0.875	9/16-18	0.281	1/2-14	0.531	1.600
7205X08X02	0.813	3/4-16	0.422	1/8-27	0.188	1.250
7205X08X04	0.813	3/4-16	0.422	1/4-18	0.281	1.440
7205X08X06	0.813	3/4-16	0.422	3/8-18	0.406	1.440
7205X08X08	0.875	3/4-16	0.422	1/2-14	0.531	1.690
7205X08X12	1.125	3/4-16	0.422	3/4-14	0.719	1.760
7205X08X16	1.375	3/4-16	0.422	1-11-1/2	0.938	1.950
7205X10X06	0.938	7/8-14	0.500	3/8-18	0.406	1.560
7205X10X08	0.938	7/8-14	0.500	1/2-14	0.531	1.750
7205X10X12	1.125	7/8-14	0.500	3/4-14	0.719	1.820
7205X12X08	1.125	1-1/16-12	0.656	1/2-14	0.531	1.880
7205X12X12	1.125	1-1/16-12	0.656	3/4-14	0.719	1.880
7205X14X12	1.250	1-3/16-12	0.719	3/4-14	0.719	1.880
7205X16X12	1.375	1-5/16-12	0.875	3/4-14	0.719	1.880
7205X16X16	1.375	1-5/16-12	0.875	1-11-1/2	0.938	2.070
7205X20X20	1.688	1-5/8-12	1.094	1-1/4-11-1/2	1.250	2.180
7205X24X24	2.000	1-7/8-12	1.344	1-1/2-11-1/2	1.500	2.280
7205X32X32	2.625	2-1/2-12	1.813	2-11-1/2	1.938	2.460

Description**:** **Plug**
WWF Part No.: **7229**
WWF Stainless Part No.: **C2408-SS**
SAE: **080109**

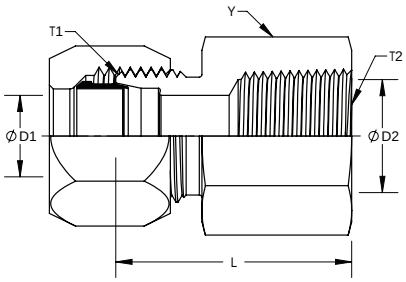
Air-Way: C2408
Parker: PNU
Aeroquip: /
Gates: /



WWF	Y HEX	T	Q	D	L
7229X02	0.438	5/16-24	0.110	0.094	0.630
7229X04	0.500	7/16-20	0.110	0.203	0.710
7229X05	0.563	1/2-20	0.120	0.234	0.710
7229X06	0.625	9/16-18	0.120	0.281	0.750
7229X08	0.813	3/4-16	0.160	0.422	0.850
7229X10	0.938	7/8-14	0.160	0.500	0.970
7229X12	1.125	1-1/16-12	0.190	0.656	1.100
7229X16	1.375	1-5/16-12	0.190	0.875	1.100

Description**:** **Female Connector**
WWF Part No.: **7255**
WWF Stainless Part No.: **C2405-SS**
SAE: **080103**

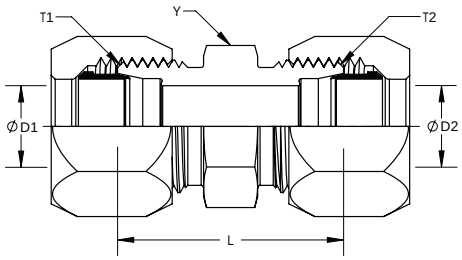
Air-Way: C2405
Parker: GBU
Aeroquip: /
Gates: /



WWF	Y HEX	T1	D1	T2	D2	L
7255X02X02	0.563	5/16-24	0.094	1/8-27	0.332	1.050
7255X03X02	0.563	3/8-24	0.125	1/8-27	0.332	1.080
7255X04X02	0.563	7/16-20	0.203	1/8-27	0.332	1.090
7255X04X04	0.750	7/16-20	0.203	1/4-18	0.438	1.290
7255X05X02	0.563	1/2-20	0.234	1/8-27	0.332	1.080
7255X05X04	0.750	1/2-20	0.234	1/4-18	0.438	1.290
7255X06X04	0.750	9/16-18	0.281	1/4-18	0.438	1.310
7255X06X06	0.875	9/16-18	0.281	3/8-18	0.563	1.380
7255X06X08	1.125	9/16-18	0.281	1/2-14	0.703	1.610
7255X08X04	0.875	3/4-16	0.422	1/4-18	0.438	1.460
7255X08X06	0.875	3/4-16	0.422	3/8-18	0.563	1.470
7255X08X08	1.125	3/4-16	0.422	1/2-14	0.703	1.700
7255X10X08	1.125	7/8-14	0.500	1/2-14	0.703	1.760
7255X12X12	1.375	1-1/16-12	0.656	3/4-14	0.906	1.890
7255X14X12	1.375	1-3/16-12	0.719	3/4-14	0.906	1.860
7255X16X12	1.625	1-5/16-12	0.875	3/4-14	0.906	1.900
7255X16X16	1.625	1-5/16-12	0.875	1-11-1/2	1.141	2.130
7255X20X20	2.000	1-5/8-12	1.094	1-1/4-11-1/2	1.484	2.220

Description**:** **Union**
WWF Part No.: **7305**
WWF Stainless Part No.: **C2403-SS**
SAE: **080101**

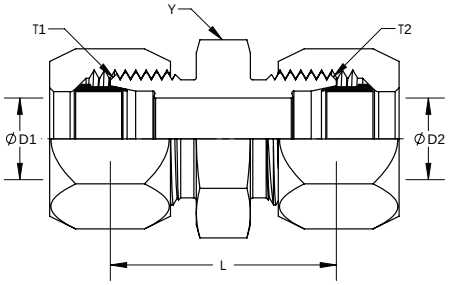
Air-Way: C2403
Parker: HBU
Aeroquip: /
Gates: /



WWF	Y HEX	T1	D1	T2	D2	L
7305X02X02	0.438	5/16-24	0.094	5/16-24	0.094	1.020
7305X03X03	0.438	3/8-24	0.125	3/8-24	0.125	1.110
7305X04X04	0.500	7/16-20	0.203	7/16-20	0.203	1.180
7305X05X05	0.563	1/2-20	0.234	1/2-20	0.234	1.180
7305X06X04	0.625	9/16-18	0.281	7/16-20	0.203	1.220
7305X06X06	0.625	9/16-18	0.281	9/16-18	0.281	1.240
7305X08X06	0.813	3/4-16	0.422	9/16-18	0.281	1.330
7305X08X08	0.813	3/4-16	0.422	3/4-16	0.422	1.420
7305X10X10	0.938	7/8-14	0.500	7/8-14	0.500	1.610
7305X12X12	1.125	1-1/16-12	0.656	1-1/16-12	0.656	1.810
7305X14X14	1.250	1-3/16-12	0.719	1-3/16-12	0.719	1.810
7305X16X16	1.375	1-5/16-12	0.875	1-5/16-12	0.875	1.810
7305X20X20	1.688	1-5/8-12	1.094	1-5/8-12	1.094	1.890
7305X24X24	2.000	1-7/8-12	1.344	1-7/8-12	1.344	1.960
7305X32X32	2.625	2-1/2-12	1.813	2-1/2-12	1.813	2.110

Description**:** **Large Hex Union**
WWF Part No.: **7306**
WWF Stainless Part No.: **C2403-LH-SS**
SAE: **080119**

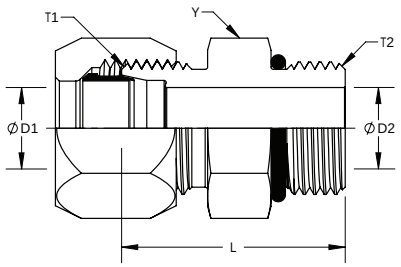
Air-Way: C2403-LH
Parker: LHBU
Aeroquip: /
Gates: /



WWF	Y HEX	T1	D1	T2	D2	L
7306X04X04	0.688	7/16-20	0.203	7/16-20	0.203	1.180
7306X06X06	0.813	9/16-18	0.281	9/16-18	0.281	1.240
7306X08X08	1.000	3/4-16	0.422	3/4-16	0.422	1.420
7306X12X12	1.375	1-1/16-12	0.656	1-1/16-12	0.656	1.810
7306X16X16	1.625	1-5/16-12	0.875	1-5/16-12	0.875	1.810

Description**:** **Straight Thread Connector Short**
WWF Part No.: **7315**
WWF Stainless Part No.: **C6400-SS**
SAE: **080120**

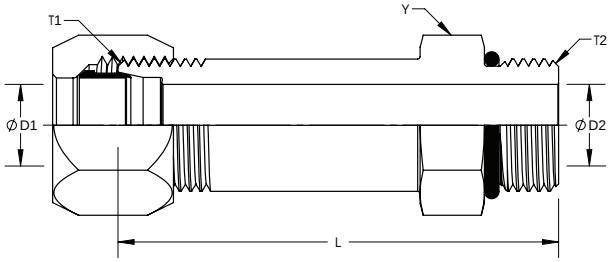
Air-Way: C6400
Parker: F5BU
Aeroquip: /
Gates: /



WWF	Y HEX	T1	D1	T2	D2	L
7315X03X03	0.500	3/8-24	0.125	3/8-24	0.125	1.040
7315X04X04	0.563	7/16-20	0.203	7/16-20	0.203	1.130
7315X04X05	0.625	7/16-20	0.203	1/2-20	0.234	1.130
7315X04X06	0.688	7/16-20	0.203	9/16-18	0.281	1.190
7315X05X05	0.625	1/2-20	0.234	1/2-20	0.234	1.130
7315X06X06	0.688	9/16-18	0.281	9/16-18	0.281	1.210
7315X06X08	0.875	9/16-18	0.281	3/4-16	0.422	1.290
7315X08X06	0.813	3/4-16	0.422	9/16-18	0.281	1.340
7315X08X08	0.875	3/4-16	0.422	3/4-16	0.422	1.380
7315X08X10	1.000	3/4-16	0.422	7/8-14	0.500	1.510
7315X08X12	1.250	3/4-16	0.422	1-1/16-12	0.656	1.670
7315X10X08	1.000	7/8-14	0.500	3/4-16	0.422	1.510
7315X10X10	1.000	7/8-14	0.500	7/8-14	0.500	1.570
7315X12X06	1.125	1-1/16-12	0.656	9/16-18	0.281	1.680
7315X12X10	1.125	1-1/16-12	0.656	7/8-14	0.500	1.700
7315X12X12	1.250	1-1/16-12	0.656	1-1/16-12	0.656	1.790
7315X12X16	1.500	1-1/16-12	0.656	1-5/16-12	0.875	1.820
7315X14X14	1.375	1-3/16-12	0.719	1-3/16-12	0.719	1.790
7315X16X12	1.375	1-5/16-12	0.875	1-1/16-12	0.656	1.820
7315X16X16	1.500	1-5/16-12	0.875	1-5/16-12	0.875	1.820
7315X20X20	1.875	1-5/8-12	1.094	1-5/8-12	1.094	1.900
7315X24X24	2.125	1-7/8-12	1.344	1-7/8-12	1.344	1.970
7315X32X32	2.750	2-1/2-12	1.813	2-1/2-12	1.813	2.130

Description**:** **Straight Thread Connector Long**
WWF Part No.: **7316**
WWF Stainless Part No.: **C6400-L-SS**
SAE: **081720**

Air-Way: C6400-L
Parker: /
Aeroquip: /
Gates: /

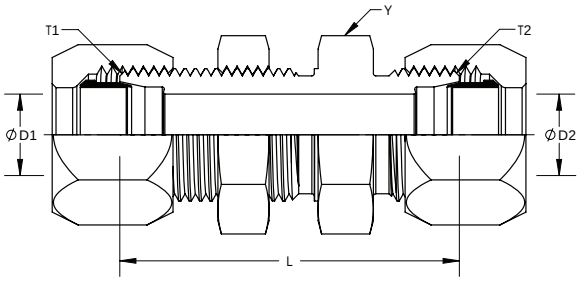


WWF	Y HEX	T1	D1	T2	D2	L
7316X04X04	0.563	7/16-20	0.203	7/16-20	0.203	2.020
7316X06X06	0.688	9/16-18	0.281	9/16-18	0.281	2.230
7316X08X08	0.875	3/4-16	0.422	3/4-16	0.422	2.620
7316X10X10	1.000	7/8-14	0.500	7/8-14	0.500	2.980

D

Description**:** **Bulkhead Union**
WWF Part No.: **7325**
WWF Stainless Part No.: **C2700-SS**
SAE: **080601**

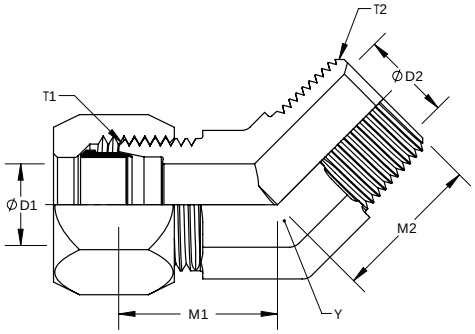
Air-Way: C2700
Parker: WBU
Aeroquip: /
Gates: /



WWF	Y HEX	T1	D1	T2	D2	L
7325X03X03	0.625	3/8-24	0.125	3/8-24	0.125	1.800
7325X04X04	0.688	7/16-20	0.203	7/16-20	0.203	1.890
7325X05X05	0.750	1/2-20	0.234	1/2-20	0.234	1.890
7325X06X06	0.813	9/16-18	0.281	9/16-18	0.281	1.980
7325X08X08	1.000	3/4-16	0.422	3/4-16	0.422	2.220
7325X10X10	1.125	7/8-14	0.500	7/8-14	0.500	2.480
7325X12X12	1.375	1-1/16-12	0.656	1-1/16-12	0.656	2.720
7325X14X14	1.500	1-3/16-12	0.719	1-3/16-12	0.719	2.720
7325X16X16	1.625	1-5/16-12	0.875	1-5/16-12	0.875	2.720

Description**:** **45° Male Elbow**
WWF Part No.: **7355**
WWF Stainless Part No.: **C2503-SS**
SAE: **080302**

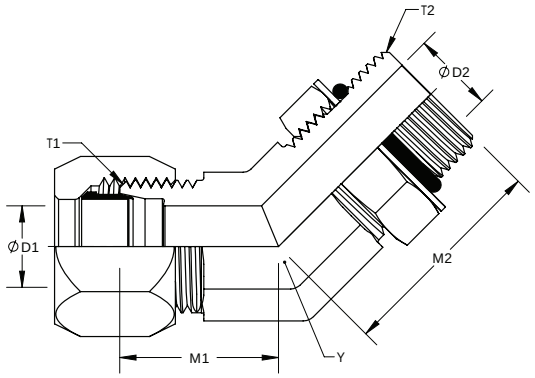
Air-Way: C2503
Parker: VBU
Aeroquip: /
Gates: /



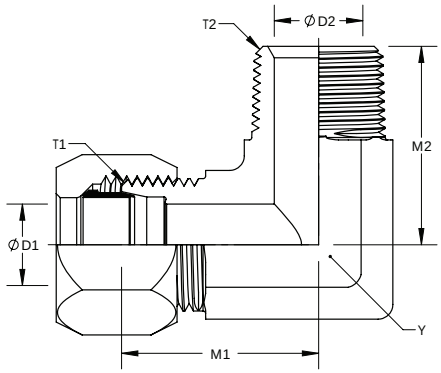
WWF	Y HEX	T1	M1	D1	T2	M2	D2
7355X04X02	0.438	7/16-20	0.700	0.203	1/8-27	0.640	0.188
7355X04X04	0.563	7/16-20	0.810	0.203	1/4-18	0.860	0.281
7355X05X02	0.563	1/2-20	0.750	0.234	1/8-27	0.640	0.188
7355X06X04	0.563	9/16-18	0.830	0.281	1/4-18	0.860	0.281
7355X08X06	0.750	3/4-16	0.980	0.422	3/8-18	0.950	0.406
7355X08X08	0.875	3/4-16	1.010	0.422	1/2-14	1.170	0.531
7355X08X16	1.313	3/4-16	1.210	0.422	1-11-1/2	1.480	0.938
7355X10X08	0.875	7/8-14	1.080	0.500	1/2-14	1.170	0.531
7355X12X12	1.063	1-1/16-12	1.270	0.656	3/4-14	1.200	0.719
7355X14X12	1.313	1-3/16-12	1.340	0.719	3/4-14	1.300	0.719
7355X16X16	1.313	1-5/16-12	1.360	0.875	1-11-1/2	1.480	0.938

Description**:** **45° Straight Thread Elbow**
WWF Part No.: **7365**
WWF Stainless Part No.: **C6802-SS**
SAE: **080320**

Air-Way: C6802
Parker: V5BU
Aeroquip: /
Gates: /



WWF	Y HEX	T1	M1	D1	T2	M2	D2
7365X08X08	0.750	3/4-16	0.980	0.422	3/4-16	1.300	0.422
7365X12X12	1.063	1-1/16-12	1.270	0.656	1-1/16-12	1.730	0.656
7365X16X16	1.313	1-5/16-12	1.360	0.875	1-5/16-12	1.860	0.875
7365X20X20	1.625	1-5/8-12	1.450	1.094	1-5/8-12	1.910	1.094



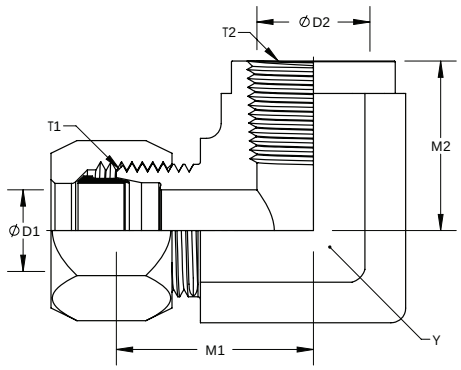
Description**:** **90° Male Elbow**
WWF Part No.: **7405**
WWF Stainless Part No.: **C2501-SS**
SAE: **080202**

Air-Way: C2501
Parker: CBU
Aeroquip: /
Gates: /

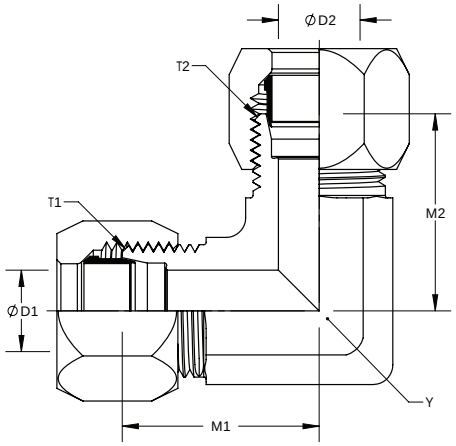
WWF	Y HEX	T1	M1	D1	T2	M2	D2
7405X02X02	0.438	5/16-24	0.770	0.094	1/8-27	0.720	0.188
7405X03X02	0.438	3/8-24	0.830	0.125	1/8-27	0.720	0.188
7405X04X02	0.438	7/16-20	0.890	0.203	1/8-27	0.780	0.188
7405X04X04	0.563	7/16-20	1.030	0.203	1/4-18	1.090	0.281
7405X05X02	0.563	1/2-20	0.950	0.234	1/8-27	0.810	0.188
7405X05X04	0.563	1/2-20	1.030	0.234	1/4-18	1.090	0.281
7405X06X02	0.563	9/16-18	1.050	0.281	1/8-27	0.900	0.188
7405X06X04	0.563	9/16-18	1.050	0.281	1/4-18	1.090	0.281
7405X06X06	0.750	9/16-18	1.140	0.281	3/8-18	1.220	0.406
7405X06X08	0.875	9/16-18	1.240	0.281	1/2-14	1.470	0.531
7405X08X04	0.750	3/4-16	1.250	0.422	1/4-18	1.220	0.281
7405X08X06	0.750	3/4-16	1.250	0.422	3/8-18	1.220	0.406
7405X08X08	0.875	3/4-16	1.350	0.422	1/2-14	1.470	0.531
7405X08X12	1.063	3/4-16	1.430	0.422	3/4-14	1.590	0.719
7405X08X16	1.313	3/4-16	1.580	0.422	1-11-1/2	1.970	0.938
7405X10X06	0.875	7/8-14	1.420	0.500	3/8-18	1.280	0.406
7405X10X08	0.875	7/8-14	1.420	0.500	1/2-14	1.470	0.531
7405X12X08	1.063	1-1/16-12	1.580	0.656	1/2-14	1.590	0.531
7405X12X12	1.063	1-1/16-12	1.580	0.656	3/4-14	1.590	0.719
7405X14X12	1.313	1-3/16-12	1.660	0.719	3/4-14	1.690	0.719
7405X16X12	1.313	1-5/16-12	1.730	0.875	3/4-14	1.780	0.719
7405X16X16	1.313	1-5/16-12	1.730	0.875	1-11-1/2	1.970	0.938
7405X20X20	1.625	1-5/8-12	1.890	1.094	1-1/4-11-1/2	2.380	1.250
7405X24X24	1.875	1-7/8-12	2.020	1.344	1-1/2-11-1/2	2.640	1.500
7405X32X32	2.500	2-1/2-12	2.450	1.813	2-11-1/2	3.000	1.938

Description**:** **90° Female Elbow**
WWF Part No.: **7455**
WWF Stainless Part No.: **C2502-SS**
SAE: **080203**

Air-Way: C2502
Parker: DBU
Aeroquip: /
Gates: /



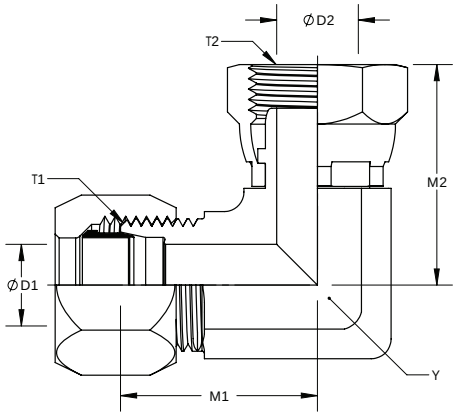
WWF	Y HEX	T1	M1	D1	T2	M2	D2
7455X03X02	0.563	3/8-24	0.830	0.125	1/8-27	0.660	0.332
7455X04X02	0.563	7/16-20	0.890	0.203	1/8-27	0.660	0.332
7455X04X04	0.750	7/16-20	1.030	0.203	1/4-18	0.880	0.438
7455X05X02	0.563	1/2-20	0.950	0.234	1/8-27	0.660	0.332
7455X06X04	0.750	9/16-18	1.050	0.281	1/4-18	0.880	0.438
7455X06X06	0.875	9/16-18	1.120	0.281	3/8-18	1.020	0.563
7455X08X04	0.875	3/4-16	1.230	0.422	1/4-18	1.010	0.438
7455X08X06	0.875	3/4-16	1.230	0.422	3/8-18	1.020	0.563
7455X08X08	1.063	3/4-16	1.350	0.422	1/2-14	1.230	0.703
7455X10X08	1.063	7/8-14	1.420	0.500	1/2-14	1.230	0.703
7455X12X12	1.313	1-1/16-12	1.580	0.656	3/4-14	1.360	0.906
7455X14X12	1.313	1-3/16-12	1.620	0.719	3/4-14	1.420	0.906
7455X16X16	1.625	1-5/16-12	1.730	0.875	1-11-1/2	1.620	1.141
7455X24X24	2.562	1-7/8-12	2.580	1.344	1-1/2-11-1/2	2.080	1.744



Description**:** **90° Union Elbow**
WWF Part No.: **7505**
WWF Stainless Part No.: **C2500-SS**
SAE: **080201**

Air-Way: C2500
Parker: EBU
Aeroquip: /
Gates: /

WWF	Y HEX	T1	M1	D1	T2	M2	D2
7505X03X03	0.438	3/8-24	0.830	0.125	3/8-24	0.830	0.125
7505X04X04	0.438	7/16-20	0.890	0.203	7/16-20	0.890	0.203
7505X05X05	0.563	1/2-20	0.950	0.234	1/2-20	0.950	0.234
7505X06X06	0.563	9/16-18	1.050	0.281	9/16-18	1.050	0.281
7505X08X04	0.750	3/4-16	1.250	0.422	7/16-20	1.120	0.203
7505X08X08	0.750	3/4-16	1.250	0.422	3/4-16	1.250	0.422
7505X10X10	0.875	7/8-14	1.420	0.500	7/8-14	1.420	0.500
7505X12X12	1.063	1-1/16-12	1.580	0.656	1-1/16-12	1.580	0.656
7505X14X14	1.313	1-3/16-12	1.660	0.719	1-3/16-12	1.660	0.719
7505X16X16	1.313	1-5/16-12	1.730	0.875	1-5/16-12	1.730	0.875
7505X20X20	1.625	1-5/8-12	1.890	1.094	1-5/8-12	1.890	1.094
7505X24X24	1.875	1-7/8-12	2.020	1.344	1-7/8-12	2.020	1.344

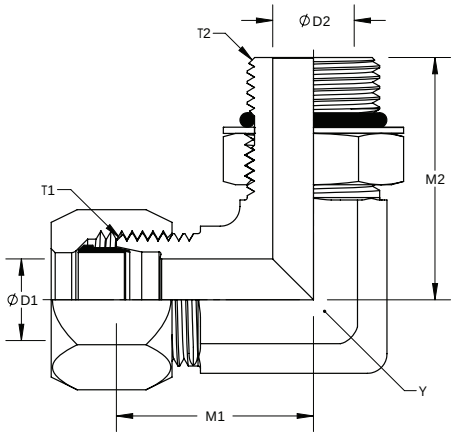


Description**:** **90° Swivel Elbow**
WWF Part No.: **7506**
WWF Stainless Part No.: **C6500-SS**
SAE: **080221**

Air-Way: C6500
Parker: C6X
Aeroquip: 2071-[R]
Gates: MJ-FJX90

WWF	Y HEX	T1	M1	D1	T2	M2	D2
7506X04X04	0.438	7/16-20	0.890	0.203	7/16-20	1.050	0.203
7506X06X06	0.563	9/16-18	1.050	0.281	9/16-18	1.280	0.281
7506X08X08	0.750	3/4-16	1.250	0.422	3/4-16	1.470	0.422

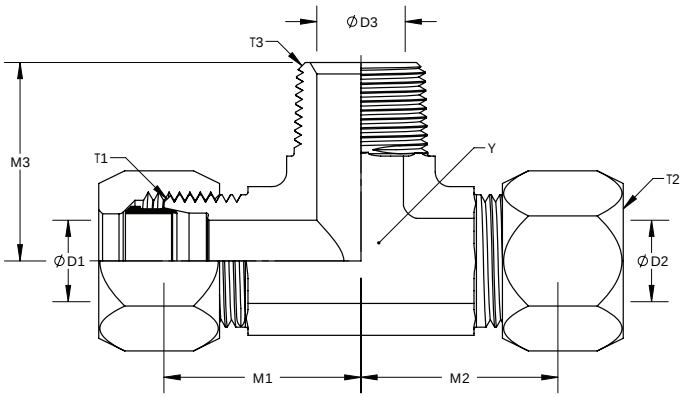
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Description**:** **90° Straight Thread Elbow**
WWF Part No.: **7515**
WWF Stainless Part No.: **C6801-SS**
SAE: **080220**

Air-Way: C6801
Parker: C5BU
Aeroquip: /
Gates: /

WWF	Y HEX	T1	M1	D1	T2	M2	D2
7515X02X02	0.438	5/16-24	0.770	0.094	5/16-24	0.910	0.094
7515X04X04	0.438	7/16-20	0.890	0.203	7/16-20	1.030	0.203
7515X04X06	0.563	7/16-20	1.030	0.203	9/16-18	1.250	0.281
7515X05X05	0.563	1/2-20	0.950	0.234	1/2-20	1.130	0.234
7515X06X05	0.563	9/16-18	1.050	0.281	1/2-20	1.190	0.234
7515X06X06	0.563	9/16-18	1.050	0.281	9/16-18	1.250	0.281
7515X06X08	0.750	9/16-18	1.140	0.281	3/4-16	1.450	0.422
7515X06X10	0.875	9/16-18	1.240	0.281	7/8-14	1.700	0.500
7515X08X06	0.750	3/4-16	1.250	0.422	9/16-18	1.320	0.281
7515X08X08	0.750	3/4-16	1.250	0.422	3/4-16	1.450	0.422
7515X08X10	0.875	3/4-16	1.350	0.422	7/8-14	1.700	0.500
7515X08X12	1.063	3/4-16	1.430	0.422	1-1/16-12	1.940	0.656
7515X10X10	0.875	7/8-14	1.420	0.500	7/8-14	1.700	0.500
7515X10X12	1.063	7/8-14	1.500	0.500	1-1/16-12	1.940	0.656
7515X12X08	1.063	1-1/16-12	1.580	0.656	3/4-16	1.620	0.422
7515X12X12	1.063	1-1/16-12	1.580	0.656	1-1/16-12	1.940	0.656
7515X16X16	1.313	1-5/16-12	1.730	0.875	1-5/16-12	2.050	0.875
7515X20X20	1.625	1-5/8-12	1.890	1.094	1-5/8-12	2.250	1.094
7515X24X24	1.875	1-7/8-12	2.020	1.344	1-7/8-12	2.390	1.344



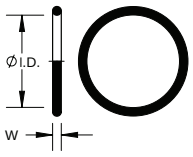
Description**:** **Male Branch Tee**
WWF Part No.: **7605**
WWF Stainless Part No.: **C2601-SS**
SAE: **080425**

Air-Way: C2601
Parker: SBU
Aeroquip: /
Gates: /

WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
7605X02X02X02	0.438	5/16-24	0.770	0.094	5/16-24	0.770	0.094	1/8-27	0.720	0.188
7605X04X04X02	0.438	7/16-20	0.890	0.203	7/16-20	0.890	0.203	1/8-27	0.780	0.188
7605X04X04X04	0.563	7/16-20	1.030	0.203	7/16-20	1.030	0.203	1/4-18	1.090	0.281
7605X05X05X02	0.563	1/2-20	0.950	0.234	1/2-20	0.950	0.234	1/8-27	0.810	0.188
7605X06X06X04	0.563	9/16-18	1.050	0.281	9/16-18	1.050	0.281	1/4-18	1.090	0.281
7605X08X08X06	0.750	3/4-16	1.250	0.422	3/4-16	1.250	0.422	3/8-18	1.220	0.406
7605X08X08X08	0.875	3/4-16	1.350	0.422	3/4-16	1.350	0.422	1/2-14	1.470	0.531
7605X10X08X08	0.875	7/8-14	1.420	0.500	3/4-16	1.350	0.422	1/2-14	1.470	0.531
7605X10X10X08	0.875	7/8-14	1.420	0.500	7/8-14	1.420	0.500	1/2-14	1.470	0.531
7605X12X12X12	1.063	1-1/16-12	1.580	0.656	1-1/16-12	1.580	0.656	3/4-14	1.590	0.719
7605X14X14X12	1.313	1-3/16-12	1.660	0.719	1-3/16-12	1.660	0.719	3/4-14	1.690	0.719
7605X16X16X16	1.313	1-5/16-12	1.730	0.875	1-5/16-12	1.730	0.875	1-11-1/2	1.970	0.938
7605X20X20X20	1.625	1-5/8-12	1.890	1.094	1-5/8-12	1.890	1.094	1-1/4-11-1/2	2.380	1.250

Description**:** **90 Durometer “O” Ring**
WWF Part No.: **7629**
WWF Stainless Part No.: ***/***
SAE: ***/***

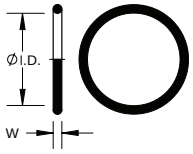
Air-Way: /
Parker: “O” - Ring
Aeroquip: /
Gates: OR



WWF	I.D.	W
7629X02	0.239	0.064
7629X03	0.301	0.064
7629X04	0.351	0.072
7629X05	0.414	0.072
7629X06	0.468	0.078
7629X08	0.644	0.087
7629X10	0.755	0.097
7629X12	0.924	0.116
7629X14	1.048	0.116
7629X16	1.171	0.116
7629X20	1.475	0.118
7629X24	1.720	0.118
7629X32	2.337	0.118

Description**:** **90 Durometer Metric “O” Ring**
WWF Part No.: **7629M**
WWF Stainless Part No.: **/**
SAE: **/**

Air-Way: /
Parker: /
Aeroquip: /
Gates: /

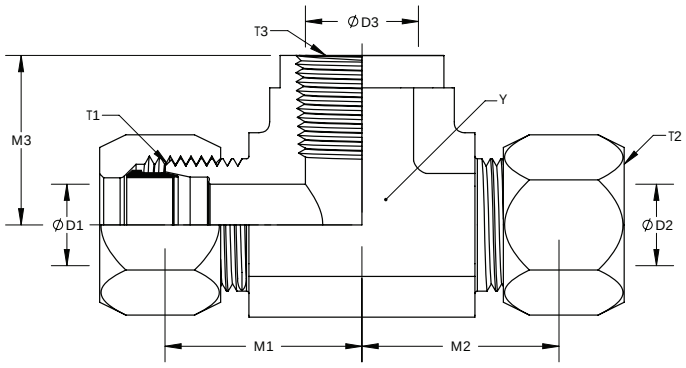


WWF	I.D.	W
7629XM08	0.240	0.063
7629XM10	0.319	0.063
7629XM12	0.366	0.087
7629XM14	0.445	0.087
7629XM16	0.524	0.087
7629XM18	0.602	0.087
7629XM22	0.760	0.087
7629XM27	0.929	0.114
7629XM33	1.165	0.114
7629XM42	1.520	0.114
7629XM48	1.756	0.114

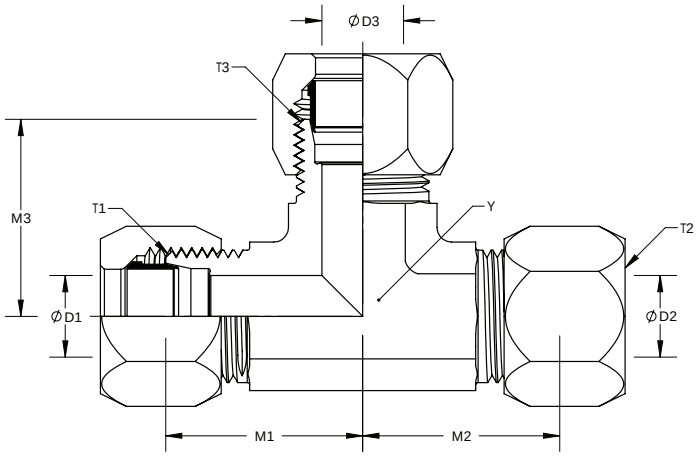
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Description**:** **Female Branch Tee**
WWF Part No.: **7655**
WWF Stainless Part No.: **C2602-SS**
SAE: **080427**

Air-Way: C2602
Parker: OBU
Aeroquip: /
Gates: /



WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
7655X04X04X02	0.563	7/16-20	0.890	0.203	7/16-20	0.890	0.203	1/8-27	0.660	0.322
7655X04X04X04	0.750	7/16-20	1.030	0.203	7/16-20	1.030	0.203	1/4-18	0.880	0.438
7655X06X06X04	0.750	9/16-18	1.050	0.281	9/16-18	1.050	0.281	1/4-18	0.880	0.438
7655X06X06X06	0.875	9/16-18	1.120	0.281	9/16-18	1.120	0.281	3/8-18	1.020	0.563
7655X08X08X06	0.875	3/4-16	1.230	0.422	3/4-16	1.230	0.422	3/8-18	1.020	0.563
7655X08X08X08	1.063	3/4-16	1.350	0.422	3/4-16	1.350	0.422	1/2-14	1.230	0.703
7655X10X10X08	1.063	7/8-14	1.420	0.500	7/8-14	1.420	0.500	1/2-14	1.230	0.703
7655X12X12X12	1.313	1-1/16-12	1.580	0.656	1-1/16-12	1.580	0.656	3/4-14	1.360	0.906
7655X16X16X16	1.625	1-5/16-12	1.730	0.875	1-5/16-12	1.730	0.875	1-11-1/2	1.620	1.141
7655X20X20X20	1.875	1-5/8-12	2.080	1.094	1-5/8-12	2.080	1.094	1-1/4-11-1/2	1.700	1.484

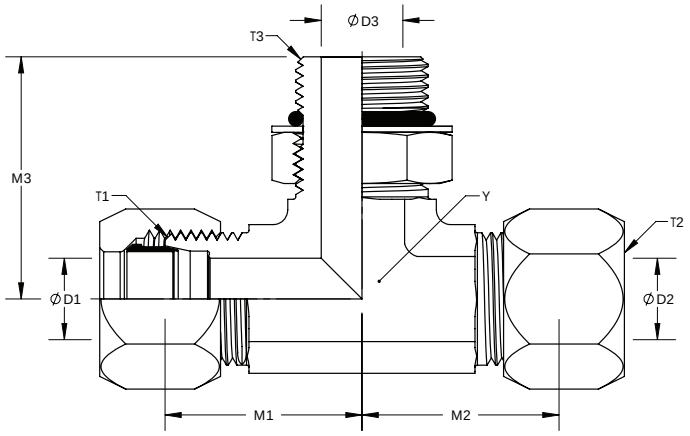


Description**:** **Union Tee**
WWF Part No.: **7705**
WWF Stainless Part No.: **C2603-SS**
SAE: **080401**

Air-Way: C2603
Parker: JBU
Aeroquip: /
Gates: /

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WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
7705X02X02X02	0.438	5/16-24	0.770	0.094	5/16-24	0.770	0.094	5/16-24	0.770	0.094
7705X03X03X03	0.438	3/8-24	0.830	0.125	3/8-24	0.830	0.125	3/8-24	0.830	0.125
7705X04X04X04	0.438	7/16-20	0.890	0.203	7/16-20	0.890	0.203	7/16-20	0.890	0.203
7705X05X05X05	0.563	1/2-20	0.950	0.234	1/2-20	0.950	0.234	1/2-20	0.950	0.234
7705X06X06X06	0.563	9/16-18	1.050	0.281	9/16-18	1.050	0.281	9/16-18	1.050	0.281
7705X08X08X06	0.750	3/4-16	1.250	0.422	3/4-16	1.250	0.422	9/16-18	1.140	0.281
7705X08X08X08	0.750	3/4-16	1.250	0.422	3/4-16	1.250	0.422	3/4-16	1.250	0.422
7705X10X10X08	0.875	7/8-14	1.420	0.500	7/8-14	1.420	0.500	3/4-16	1.350	0.422
7705X10X10X10	0.875	7/8-14	1.420	0.500	7/8-14	1.420	0.500	7/8-14	1.420	0.500
7705X12X12X12	1.063	1-1/16-12	1.580	0.656	1-1/16-12	1.580	0.656	1-1/16-12	1.580	0.656
7705X14X14X14	1.313	1-3/16-12	1.660	0.719	1-3/16-12	1.660	0.719	1-3/16-12	1.660	0.719
7705X16X16X16	1.313	1-5/16-12	1.730	0.875	1-5/16-12	1.730	0.875	1-5/16-12	1.730	0.875
7705X20X20X20	1.625	1-5/8-12	1.890	1.094	1-5/8-12	1.890	1.094	1-5/8-12	1.890	1.094
7705X24X24X24	1.875	1-7/8-12	2.020	1.344	1-7/8-12	2.020	1.344	1-7/8-12	2.020	1.344
7705X32X32X32	2.500	2-1/2-12	2.450	1.813	2-1/2-12	2.450	1.813	2-1/2-12	2.450	1.813



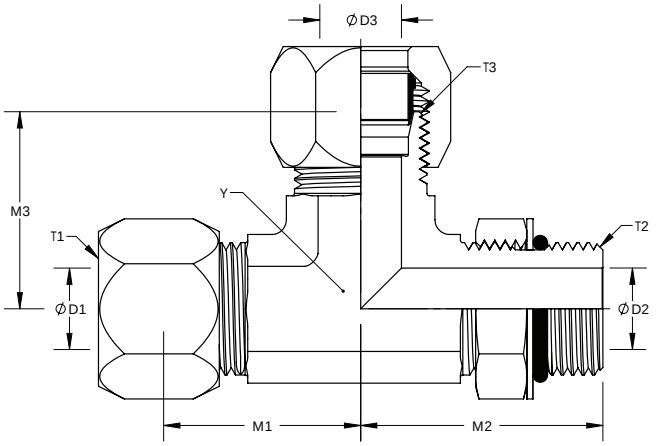
Description**:** **Straight Thread Branch Tee**
WWF Part No.: **7715**
WWF Stainless Part No.: **C6803-SS**
SAE: **080429**

Air-Way: C6803
Parker: S5BU
Aeroquip: /
Gates: /

WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
7715X04X04X04	0.438	7/16-20	0.890	0.203	7/16-20	0.890	0.203	7/16-20	1.030	0.203
7715X06X06X06	0.563	9/16-18	1.050	0.281	9/16-18	1.050	0.281	9/16-18	1.250	0.281
7715X08X08X08	0.750	3/4-16	1.250	0.422	3/4-16	1.250	0.422	3/4-16	1.450	0.422

Description**:** **Straight Thread Run Tee**
WWF Part No.: **7716**
WWF Stainless Part No.: **C6804-SS**
SAE: **080428**

Air-Way: C6804
Parker: R5BU
Aeroquip: /
Gates: /

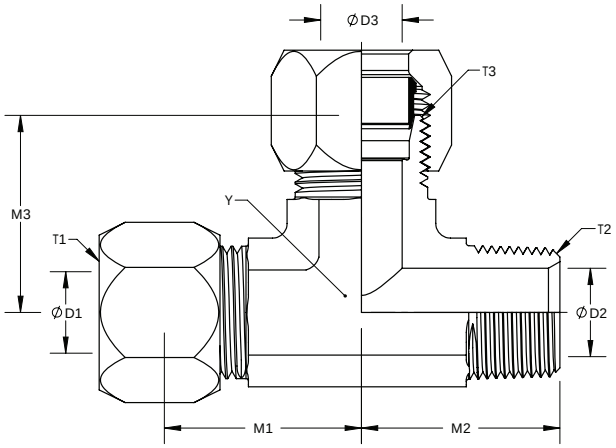


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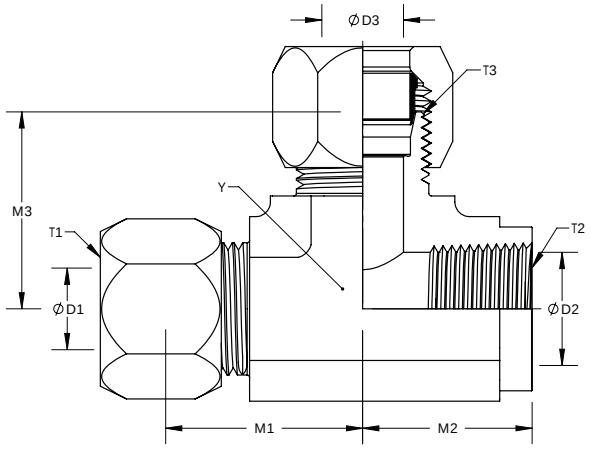
WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
7716X04X04X04	0.438	7/16-20	0.890	0.203	7/16-20	1.030	0.203	7/16-20	0.890	0.203
7716X06X06X06	0.563	9/16-18	1.050	0.281	9/16-18	1.250	0.281	9/16-18	1.050	0.281
7716X08X08X08	0.750	3/4-16	1.250	0.422	3/4-16	1.450	0.422	3/4-16	1.250	0.422

Description**:** **Male Run Tee**
WWF Part No.: **7755**
WWF Stainless Part No.: **C2605-SS**
SAE: **080424**

Air-Way: C2605
Parker: RBU
Aeroquip: /
Gates: /



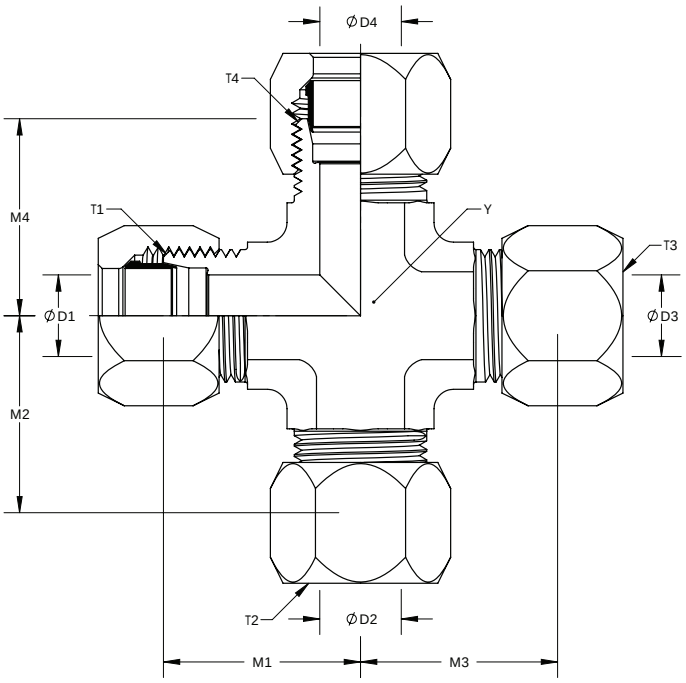
WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
7755X04X02X04	0.438	7/16-20	0.890	0.203	1/8-27	0.780	0.188	7/16-20	0.890	0.203
7755X04X04X04	0.563	7/16-20	1.030	0.203	1/4-18	1.090	0.281	7/16-20	1.030	0.203
7755X05X02X05	0.563	1/2-20	0.950	0.234	1/8-27	0.810	0.188	1/2-20	0.950	0.234
7755X06X04X06	0.563	9/16-18	1.050	0.281	1/4-18	1.090	0.281	9/16-18	1.050	0.281
7755X06X06X06	0.750	9/16-18	1.140	0.281	3/8-18	1.220	0.406	9/16-18	1.140	0.281
7755X08X06X08	0.750	3/4-16	1.250	0.422	3/8-18	1.220	0.406	3/4-16	1.250	0.422
7755X08X08X08	0.875	3/4-16	1.350	0.422	1/2-14	1.470	0.531	3/4-16	1.350	0.422
7755X10X08X10	0.875	7/8-14	1.420	0.500	1/2-14	1.470	0.531	7/8-14	1.420	0.500
7755X12X12X12	1.063	1-1/16-12	1.580	0.656	3/4-14	1.590	0.719	1-1/16-12	1.580	0.656
7755X14X12X14	1.313	1-3/16-12	1.660	0.719	3/4-14	1.690	0.719	1-3/16-12	1.660	0.719
7755X16X16X16	1.313	1-5/16-12	1.730	0.875	1-11-1/2	1.970	0.938	1-5/16-12	1.730	0.875
7755X24X24X24	1.875	1-7/8-12	2.020	1.344	1-1/2-11-1/2	2.640	1.500	1-7/8-12	2.020	1.344



Description**:** **Female Run Tee**
WWF Part No.: **7805**
WWF Stainless Part No.: **C2606-SS**
SAE: **080426**

Air-Way: C2606
Parker: MBU
Aeroquip: /
Gates: /

WWF	Y HEX	T1	M1	D1	T2	M2	D2	T3	M3	D3
7805X04X02X04	0.563	7/16-20	0.890	0.203	1/8-27	0.660	0.322	7/16-20	0.890	0.203
7805X04X04X04	0.750	7/16-20	1.030	0.203	1/4-18	0.880	0.438	7/16-20	1.030	0.203
7805X06X04X06	0.750	9/16-18	1.050	0.281	1/4-18	0.880	0.438	9/16-18	1.050	0.281
7805X08X06X08	0.875	3/4-16	1.230	0.422	3/8-18	1.020	0.563	3/4-16	1.230	0.422
7805X10X08X10	1.063	7/8-14	1.420	0.500	1/2-14	1.230	0.703	7/8-14	1.420	0.500
7805X12X12X12	1.313	1-1/16-12	1.580	0.656	3/4-14	1.360	0.906	1-1/16-12	1.580	0.656
7805X14X12X14	1.313	1-3/16-12	1.620	0.719	3/4-14	1.420	0.906	1-3/16-12	1.620	0.719



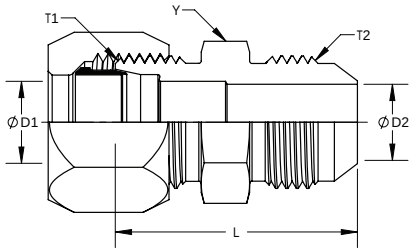
Description**:** **Cross**
WWF Part No.: **7955**
WWF Stainless Part No.: **C2650-SS**
SAE: **080501**

Air-Way: C2650
Parker: KBU
Aeroquip: /
Gates: /

WWF	Y HEX	T1 / T3	M1 / M3	D1 / D3	T2 / T4	M2 / M4	D2 / D4
7955X04X04X04X04	0.438	7/16-20	0.890	0.203	7/16-20	0.890	0.203
7955X05X05X05X05	0.563	1/2-20	0.950	0.234	1/2-20	0.950	0.234
7955X06X06X06X06	0.563	9/16-18	1.050	0.281	9/16-18	1.050	0.281
7955X08X08X08X08	0.750	3/4-16	1.250	0.422	3/4-16	1.250	0.422
7955X10X10X10X10	0.875	7/8-14	1.420	0.500	7/8-14	1.420	0.500
7955X12X12X12X12	1.063	1-1/16-12	1.580	0.656	1-1/16-12	1.580	0.656

Description**:** **Male Connector to Male JIC**
WWF Part No.: **C2402**
WWF Stainless Part No.: **C2402-SS**
SAE: ***/***

Air-Way: C2402
Parker: /
Aeroquip: /
Gates: /



WWF	Y HEX	T1	D1	T2	D2	L
C2402X04X04	0.500	7/16-20	0.203	7/16-20	0.172	1.230
C2402X06X06	0.625	9/16-18	0.281	9/16-18	0.297	1.280
C2402X08X08	0.813	3/4-16	0.422	3/4-16	0.391	1.470

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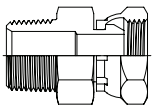
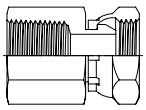
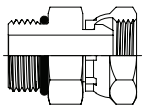
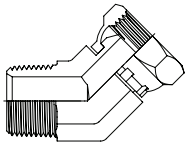
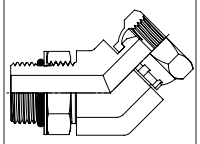
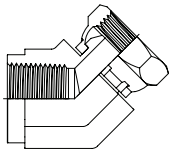
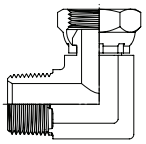
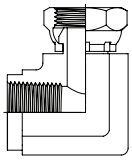
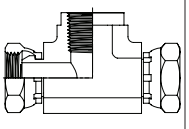
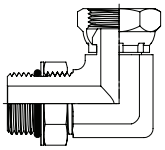
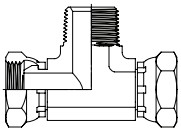
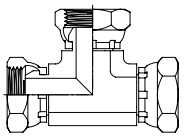


Steel Swivel Adapters

9000 SERIES

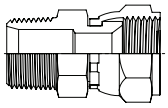
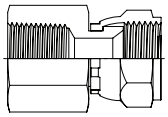
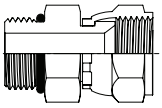
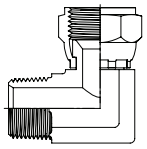
9000 SERIES - STEEL SWIVEL ADAPTERS

FEMALE PIPE SWIVEL ENDS

1404 Page 176	**1405** Page 177	**6900** Page 178	**1503** Page 179	**6902** Page 180	**1504** Page 181	**1501** Page 182
						
9205	9255	9315	9355	9365	9385	9405
Female Adapter Union to Male Pipe	Female Adapter Union to Female Pipe	Female Adapter Union to Male Straight Thread	45º Female Adapter Union to Male Pipe	45º Female Adapter Union to Adjustable Male Straight Thread	45º Female Adapter Union to Female Pipe	90º Female Adapter Union to Male Pipe
1502 Page 183	**1602** Page 184	**6901** Page 185	**1601** Page 186	**1603** Page 187	Page 165	
						
9455	9456	9515	9605	9705	7629	
90º Female Adapter Union to Female Pipe	Female Pipe to Female Pipe Sw. Branch Tee	90º Female Adapter Union to Adjustable Male Straight Thread	Male Pipe to Female Pipe Sw. Branch Tee	Swivel Union Tee	90 Durometer "O" Ring	

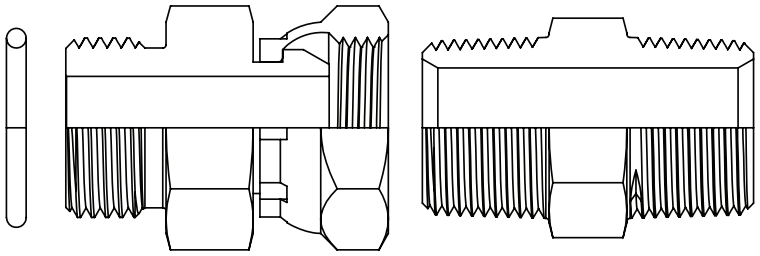
E

FEMALE 37° FLARE SWIVEL ENDS

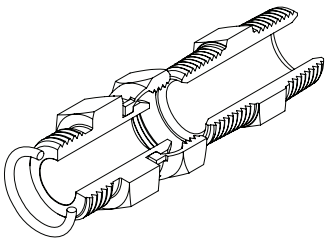
6505 Page 187	**6506** Page 188	**6402** Page 188	**6501** Page 189			
						
9100	9256	9316	9406			
Male Pipe to Female 37º JIC Swivel	Female Pipe to Female 37º JIC Swivel	Str. Thr. "O" Ring to Female 37º JIC Swivel	90º Male Pipe to Female 37º JIC Swivel			

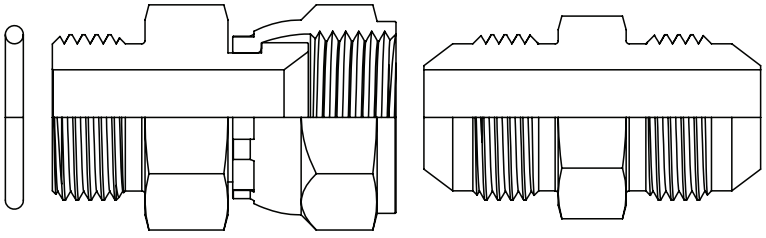
** All 9000 Series items are listed with the swivel ends last. Please check your requirements before ordering.

9000 SERIES - STEEL SWIVEL ADAPTERS

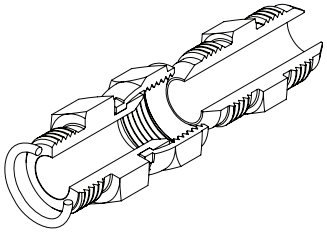


9000 Series Assembly (Female Pipe Swivel Ends)



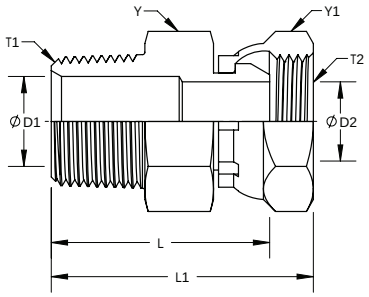


9000 Series Assembly (Female 37° Flare Swivel Ends)



Description**:** **Female Adapter Union to Male Pipe**
WWF Part No.: **9205**
WWF Stainless Part No.: **1404-SS**
SAE: **140130**

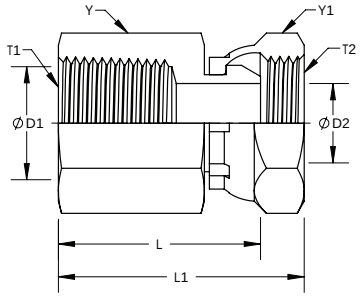
Air-Way: 1404
Parker: 0107
Aeroquip: 2045-[R]
Gates: MP-FPX



WWF	Y HEX	Y1 HEX	T1	D1	T2	D2	L	L1
9205X02X02	0.563	0.563	1/8-27	0.188	1/8-27	0.150	0.940	1.080
9205X02X04	0.688	0.688	1/8-27	0.188	1/4-18	0.220	1.050	1.240
9205X04X02	0.688	0.563	1/4-18	0.281	1/8-27	0.150	1.180	1.320
9205X04X04	0.688	0.688	1/4-18	0.281	1/4-18	0.220	1.230	1.420
9205X04X06	0.813	0.875	1/4-18	0.281	3/8-18	0.340	1.310	1.520
9205X04X08	1.000	1.000	1/4-18	0.281	1/2-14	0.460	1.420	1.700
9205X06X04	0.750	0.688	3/8-18	0.406	1/4-18	0.220	1.300	1.490
9205X06X06	0.875	0.875	3/8-18	0.406	3/8-18	0.340	1.300	1.520
9205X06X08	1.000	1.000	3/8-18	0.406	1/2-14	0.460	1.420	1.700
9205X08X04	0.875	0.688	1/2-14	0.531	1/4-18	0.220	1.520	1.710
9205X08X06	0.875	0.875	1/2-14	0.531	3/8-18	0.340	1.560	1.770
9205X08X08	1.000	1.000	1/2-14	0.531	1/2-14	0.460	1.610	1.890
9205X08X12	1.250	1.250	1/2-14	0.531	3/4-14	0.635	1.740	2.090
9205X12X06	1.125	0.875	3/4-14	0.719	3/8-18	0.340	1.560	1.770
9205X12X08	1.125	1.000	3/4-14	0.719	1/2-14	0.460	1.650	1.930
9205X12X12	1.250	1.250	3/4-14	0.719	3/4-14	0.635	1.750	2.100
9205X12X16	1.500	1.500	3/4-14	0.719	1-11-1/2	0.831	1.810	2.160
9205X12X20	1.875	1.875	3/4-14	0.719	1-1/4-11-1/2	1.087	1.860	2.280
9205X16X06	1.375	0.875	1-11-1/2	0.938	3/8-18	0.340	1.810	2.020
9205X16X12	1.500	1.250	1-11-1/2	0.938	3/4-14	0.635	1.940	2.290
9205X16X16	1.500	1.500	1-11-1/2	0.938	1-11-1/2	0.831	2.000	2.350
9205X16X20	1.875	1.875	1-11-1/2	0.938	1-1/4-11-1/2	1.087	2.050	2.470
9205X16X24	2.125	2.125	1-11-1/2	0.938	1-1/2-11-1/2	1.317	2.210	2.630
9205X20X16	1.875	1.500	1-1/4-11-1/2	1.250	1-11-1/2	0.831	2.050	2.400
9205X20X20	1.875	1.875	1-1/4-11-1/2	1.250	1-1/4-11-1/2	1.087	2.100	2.520
9205X20X24	2.125	2.125	1-1/4-11-1/2	1.250	1-1/2-11-1/2	1.317	2.090	2.510
9205X24X20	2.125	1.875	1-1/2-11-1/2	1.500	1-1/4-11-1/2	1.087	2.120	2.540
9205X24X24	2.125	2.125	1-1/2-11-1/2	1.500	1-1/2-11-1/2	1.317	2.270	2.690
9205X32X32	2.625	2.625	2-11-1/2	1.938	2-11-1/2	1.802	2.370	2.790

Description**:** **Female Adapter Union to Female Pipe**
WWF Part No.: **9255**
WWF Stainless Part No.: **/**
SAE: **140131**

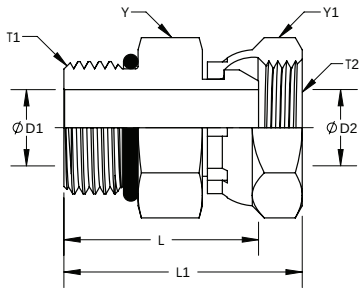
Air-Way: 1405
Parker: 0207
Aeroquip: 2046-[R]
Gates: FP-FPX



WWF	Y HEX	Y1 HEX	T1	D1	T2	D2	L	L1
9255X02X02	0.563	0.563	1/8-27	0.332	1/8-27	0.150	0.880	1.020
9255X02X04	0.688	0.688	1/8-27	0.332	1/4-18	0.220	1.100	1.290
9255X04X04	0.688	0.688	1/4-18	0.438	1/4-18	0.220	1.230	1.420
9255X04X06	0.688	0.875	1/4-18	0.438	3/8-18	0.340	1.270	1.480
9255X06X04	0.875	0.688	3/8-18	0.563	1/4-18	0.220	1.290	1.480
9255X06X06	0.875	0.875	3/8-18	0.563	3/8-18	0.340	1.310	1.520
9255X06X08	1.000	1.000	3/8-18	0.563	1/2-14	0.460	1.500	1.780
9255X08X04	1.000	0.688	1/2-14	0.703	1/4-18	0.220	1.560	1.750
9255X08X06	0.875	0.875	1/2-14	0.703	3/8-18	0.340	1.450	1.660
9255X08X08	1.000	1.000	1/2-14	0.703	1/2-14	0.460	1.560	1.840
9255X08X12	1.250	1.250	1/2-14	0.703	3/4-14	0.635	1.620	1.970
9255X12X08	1.250	1.000	3/4-14	0.906	1/2-14	0.460	1.630	1.910
9255X12X12	1.250	1.250	3/4-14	0.906	3/4-14	0.635	1.620	1.970
9255X12X16	1.500	1.500	3/4-14	0.906	1-11-1/2	0.831	1.830	2.180
9255X16X12	1.500	1.250	1-11-1/2	1.141	3/4-14	0.635	1.900	2.250
9255X16X16	1.500	1.500	1-11-1/2	1.141	1-11-1/2	0.831	2.000	2.350
9255X20X20	1.875	1.875	1-1/4-11-1/2	1.484	1-1/4-11-1/2	1.087	1.980	2.400
9255X24X24	2.125	2.125	1-1/2-11-1/2	1.744	1-1/2-11-1/2	1.317	2.100	2.520
9255X32X32	2.625	2.625	2-11-1/2	2.213	2-11-1/2	1.802	2.130	2.550

Description**:** **Female Adapter Union to Male Straight Thread**
WWF Part No.: **9315**
WWF Stainless Part No.: **/**
SAE: **140157**

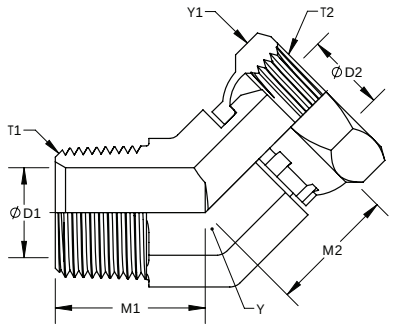
Air-Way: 6900
Parker: 0507
Aeroquip: 2066-[R]
Gates: MB-FPX



WWF	Y HEX	Y1 HEX	T1	D1	T2	D2	L	L1
9315X04X04	0.563	0.688	7/16-20	0.172	1/4-18	0.220	1.110	1.300
9315X04X06	0.688	0.875	7/16-20	0.172	3/8-18	0.340	1.150	1.360
9315X05X04	0.625	0.688	1/2-20	0.234	1/4-18	0.220	1.090	1.280
9315X06X04	0.688	0.688	9/16-18	0.297	1/4-18	0.220	1.070	1.260
9315X06X06	0.875	0.875	9/16-18	0.297	3/8-18	0.340	1.250	1.460
9315X06X08	0.813	1.000	9/16-18	0.297	1/2-14	0.460	1.290	1.570
9315X08X04	0.875	0.688	3/4-16	0.391	1/4-18	0.220	1.170	1.360
9315X08X06	0.875	0.875	3/4-16	0.391	3/8-18	0.340	1.190	1.400
9315X08X08	0.875	1.000	3/4-16	0.391	1/2-14	0.460	1.270	1.550
9315X08X12	1.000	1.250	3/4-16	0.391	3/4-14	0.635	1.410	1.760
9315X10X06	1.000	0.875	7/8-14	0.484	3/8-18	0.340	1.260	1.470
9315X10X08	1.000	1.000	7/8-14	0.484	1/2-14	0.460	1.330	1.610
9315X10X12	1.000	1.250	7/8-14	0.484	3/4-14	0.635	1.370	1.720
9315X12X06	1.250	0.875	1-1/16-12	0.609	3/8-18	0.340	1.410	1.620
9315X12X08	1.250	1.000	1-1/16-12	0.609	1/2-14	0.460	1.450	1.730
9315X12X12	1.250	1.250	1-1/16-12	0.609	3/4-14	0.635	1.600	1.950
9315X12X16	1.250	1.500	1-1/16-12	0.609	1-11-1/2	0.831	1.700	2.050
9315X14X12	1.375	1.250	1-3/16-12	0.719	3/4-14	0.635	1.610	1.960
9315X16X12	1.500	1.250	1-5/16-12	0.844	3/4-14	0.635	1.730	2.080
9315X16X16	1.500	1.500	1-5/16-12	0.844	1-11-1/2	0.831	1.710	2.060
9315X16X20	1.875	1.875	1-5/16-12	0.844	1-1/4-11-1/2	1.087	1.900	2.320
9315X20X16	1.875	1.500	1-5/8-12	1.078	1-11-1/2	0.831	1.790	2.140
9315X20X20	1.875	1.875	1-5/8-12	1.078	1-1/4-11-1/2	1.087	1.790	2.210
9315X24X20	2.125	1.875	1-7/8-12	1.313	1-1/4-11-1/2	1.087	1.750	2.170
9315X24X24	2.125	2.125	1-7/8-12	1.313	1-1/2-11-1/2	1.317	1.950	2.370
9315X32X32	2.750	2.625	2-1/2-12	1.781	2-11-1/2	1.802	2.000	2.420

Description**:** **45° Female Adapter Union to Male Pipe**
WWF Part No.: **9355**
WWF Stainless Part No.: **/**
SAE: **140330**

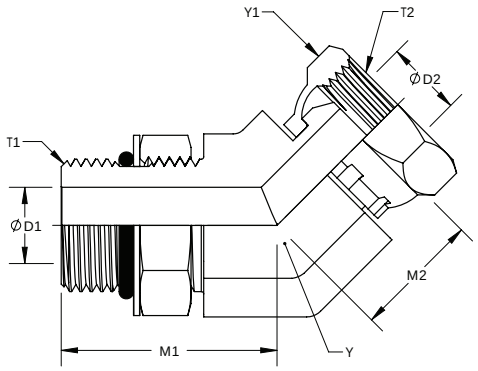
Air-Way: 1503
Parker: 3107
Aeroquip: 2049-[R]
Gates: MP-FPX45



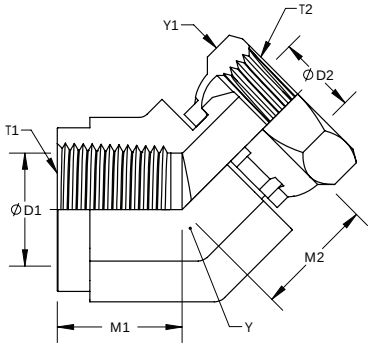
WWF	Y HEX	Y1 HEX	T1	M1	D1	T2	M2	D2
9355X02X02	0.438	0.563	1/8-27	0.520	0.188	1/8-27	0.620	0.150
9355X02X04	0.563	0.688	1/8-27	0.670	0.188	1/4-18	0.730	0.220
9355X04X04	0.563	0.688	1/4-18	0.860	0.281	1/4-18	0.730	0.220
9355X04X06	0.750	0.875	1/4-18	0.950	0.281	3/8-18	0.810	0.340
9355X06X04	0.750	0.688	3/8-18	0.950	0.406	1/4-18	0.790	0.220
9355X06X06	0.750	0.875	3/8-18	0.950	0.406	3/8-18	0.810	0.340
9355X06X08	0.875	1.000	3/8-18	0.980	0.406	1/2-14	0.880	0.460
9355X08X04	0.875	0.688	1/2-14	1.170	0.531	1/4-18	0.790	0.220
9355X08X06	0.875	0.875	1/2-14	1.170	0.531	3/8-18	0.810	0.340
9355X08X08	0.875	1.000	1/2-14	1.170	0.531	1/2-14	0.880	0.460
9355X08X12	1.063	1.250	1/2-14	1.200	0.531	3/4-14	1.020	0.635
9355X12X08	1.063	1.000	3/4-14	1.200	0.719	1/2-14	1.020	0.460
9355X12X12	1.063	1.250	3/4-14	1.200	0.719	3/4-14	1.020	0.635
9355X12X16	1.313	1.500	3/4-14	1.290	0.719	1-11-1/2	1.150	0.831
9355X16X12	1.313	1.250	1-11-1/2	1.480	0.938	3/4-14	1.040	0.635
9355X16X16	1.313	1.500	1-11-1/2	1.480	0.938	1-11-1/2	1.150	0.831
9355X16X20	1.625	1.875	1-11-1/2	1.640	0.938	1-1/4-11-1/2	1.230	1.087
9355X20X16	1.625	1.500	1-1/4-11-1/2	1.670	1.250	1-11-1/2	1.200	0.831
9355X20X20	1.625	1.875	1-1/4-11-1/2	1.670	1.250	1-1/4-11-1/2	1.230	1.087
9355X24X24	1.875	2.125	1-1/2-11-1/2	1.770	1.500	1-1/2-11-1/2	1.350	1.317
9355X32X32	2.500	2.625	2-11-1/2	2.110	1.938	2-11-1/2	1.802	1.460

Description**:** **45° Female Adapter Union to Adjustable Male Straight Thread**
WWF Part No.: **9365**
WWF Stainless Part No.: ***/***
SAE: **140357**

Air-Way: 6902
Parker: 3507
Aeroquip: 2067-[R]
Gates: MB-FPX45



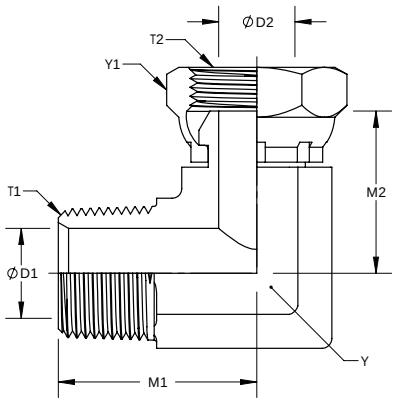
WWF	Y HEX	Y1 HEX	T1	M1	D1	T2	M2	D2
9365X04X04	0.563	0.688	7/16-20	1.080	0.172	1/4-18	0.610	0.220
9365X06X04	0.563	0.688	9/16-18	1.140	0.297	1/4-18	0.730	0.220
9365X06X06	0.750	0.875	9/16-18	1.170	0.297	3/8-18	0.810	0.340
9365X06X08	0.875	1.000	9/16-18	1.230	0.297	1/2-14	0.880	0.460
9365X08X06	0.750	0.875	3/4-16	1.300	0.391	3/8-18	0.810	0.340
9365X08X08	0.875	1.000	3/4-16	1.360	0.391	1/2-14	0.880	0.460
9365X08X12	1.063	1.250	3/4-16	1.410	0.391	3/4-14	1.020	0.635
9365X10X06	0.875	0.875	7/8-14	1.520	0.484	3/8-18	0.810	0.340
9365X10X08	0.875	1.000	7/8-14	1.520	0.484	1/2-14	0.880	0.460
9365X10X12	1.063	1.250	7/8-14	1.570	0.484	3/4-14	1.020	0.635
9365X12X06	1.063	0.875	1-1/16-12	1.730	0.609	3/8-18	0.980	0.340
9365X12X08	1.063	1.000	1-1/16-12	1.730	0.609	1/2-14	1.020	0.460
9365X12X12	1.063	1.250	1-1/16-12	1.730	0.609	3/4-14	1.020	0.635
9365X16X16	1.313	1.500	1-5/16-12	1.860	0.844	1-11-1/2	1.150	0.831
9365X20X20	1.625	1.875	1-5/8-12	1.910	1.078	1-1/4-11-1/2	1.230	1.087
9365X24X24	1.875	2.125	1-7/8-12	1.910	1.313	1-1/2-11-1/2	1.350	1.317



Description**:** **45° Female Adapter Union to Female Pipe**
WWF Part No.: **9385**
WWF Stainless Part No.: **/**
SAE: **140331**

Air-Way: 1504
Parker: 3207
Aeroquip: 2050-[R]
Gates: FP-FPX45

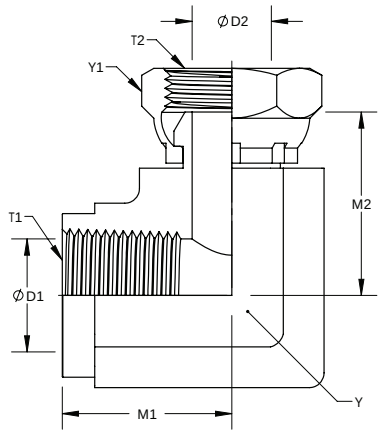
WWF	Y HEX	Y1 HEX	T1	M1	D1	T2	M2	D2
9385X02X02	0.563	0.563	1/8-27	0.500	0.332	1/8-27	0.620	0.150
9385X04X04	0.750	0.688	1/4-18	0.690	0.438	1/4-18	0.760	0.220
9385X06X04	0.875	0.688	3/8-18	0.750	0.563	1/4-18	0.770	0.220
9385X06X06	0.875	0.875	3/8-18	0.750	0.563	3/8-18	0.770	0.340
9385X08X06	1.063	0.875	1/2-14	0.940	0.703	3/8-18	0.830	0.340
9385X08X08	1.063	1.000	1/2-14	0.940	0.703	1/2-14	0.830	0.460
9385X12X12	1.313	1.250	3/4-14	1.000	0.906	3/4-14	0.960	0.635
9385X16X12	1.625	1.250	1-11-1/2	1.190	1.141	3/4-14	1.070	0.635
9385X16X16	1.625	1.500	1-11-1/2	1.190	1.141	1-11-1/2	1.180	0.831
9385X20X20	1.875	1.875	1-1/4-11-1/2	1.440	1.484	1-1/4-11-1/2	1.230	1.087
9385X24X24	2.562	2.125	1-1/2-11-1/2	1.460	1.744	1-1/2-11-1/2	1.460	1.317



Description**:** **90° Female Adapter Union to Male Pipe**
WWF Part No.: **9405**
WWF Stainless Part No.: **1501-SS**
SAE: **140230**

Air-Way: 1501
Parker: 2107
Aeroquip: 2047-[R]
Gates: MP-FPX90

WWF	Y HEX	Y1 HEX	T1	M1	D1	T2	M2	D2
9405X02X02	0.438	0.563	1/8-27	0.720	0.188	1/8-27	0.700	0.150
9405X02X04	0.563	0.688	1/8-27	0.900	0.188	1/4-18	0.880	0.220
9405X04X02	0.563	0.563	1/4-18	1.090	0.281	1/8-27	0.770	0.150
9405X04X04	0.563	0.688	1/4-18	1.090	0.281	1/4-18	0.880	0.220
9405X04X06	0.750	0.875	1/4-18	1.220	0.281	3/8-18	0.990	0.340
9405X04X08	0.875	1.000	1/4-18	1.280	0.281	1/2-14	1.110	0.460
9405X06X04	0.750	0.688	3/8-18	1.220	0.406	1/4-18	0.990	0.220
9405X06X06	0.750	0.875	3/8-18	1.220	0.406	3/8-18	0.990	0.340
9405X06X08	0.875	1.000	3/8-18	1.280	0.406	1/2-14	1.110	0.460
9405X08X04	0.875	0.688	1/2-14	1.470	0.531	1/4-18	1.020	0.220
9405X08X06	0.875	0.875	1/2-14	1.470	0.531	3/8-18	1.040	0.340
9405X08X08	0.875	1.000	1/2-14	1.470	0.531	1/2-14	1.110	0.460
9405X08X12	1.063	1.250	1/2-14	1.590	0.531	3/4-14	1.300	0.635
9405X12X06	1.063	0.875	3/4-14	1.590	0.719	3/8-18	1.240	0.340
9405X12X08	1.063	1.000	3/4-14	1.590	0.719	1/2-14	1.240	0.460
9405X12X12	1.063	1.250	3/4-14	1.590	0.719	3/4-14	1.300	0.640
9405X12X16	1.313	1.500	3/4-14	1.780	0.719	1-11-1/2	1.540	0.831
9405X16X08	1.313	1.000	1-11-1/2	1.970	0.938	1/2-14	1.430	0.460
9405X16X12	1.313	1.250	1-11-1/2	1.970	0.938	3/4-14	1.430	0.640
9405X16X16	1.313	1.500	1-11-1/2	1.970	0.938	1-11-1/2	1.540	0.831
9405X16X20	1.625	1.875	1-11-1/2	2.350	0.938	1-1/4-11-1/2	1.730	1.087
9405X20X16	1.625	1.500	1-1/4-11-1/2	2.380	1.250	1-11-1/2	1.700	0.831
9405X20X20	1.625	1.875	1-1/4-11-1/2	2.380	1.250	1-1/4-11-1/2	1.730	1.087
9405X20X24	1.875	2.125	1-1/4-11-1/2	2.610	1.250	1-1/2-11-1/2	1.890	1.317
9405X24X20	1.875	1.875	1-1/2-11-1/2	2.640	1.500	1-1/4-11-1/2	1.770	1.087
9405X24X24	1.875	2.125	1-1/2-11-1/2	2.640	1.500	1-1/2-11-1/2	1.890	1.317
9405X32X32	2.500	2.625	2-11-1/2	3.000	1.938	2-11-1/2	2.270	1.802



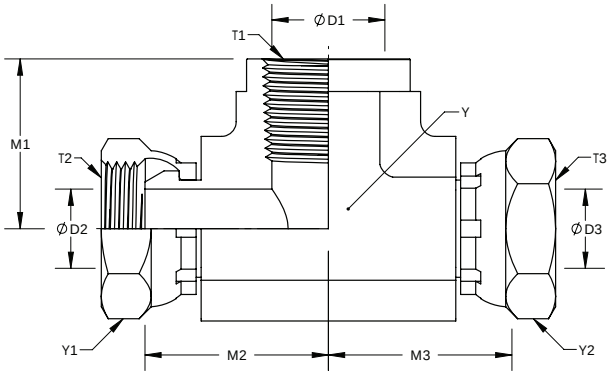
Description**:** **90° Female Adapter Union to Female Pipe**
WWF Part No.: **9455**
WWF Stainless Part No.: **/**
SAE: **140231**

Air-Way: 1502
Parker: 2207
Aeroquip: 2048-[R]
Gates: FP-FPX90

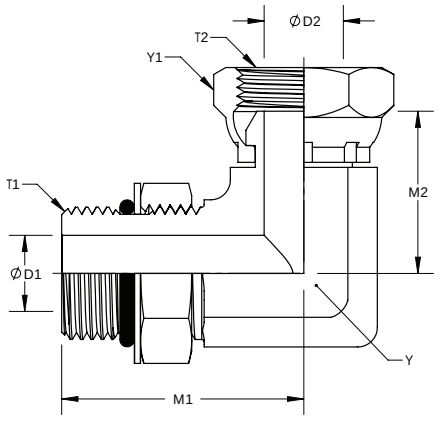
WWF	Y HEX	Y1 HEX	T1	M1	D1	T2	M2	D2
9455X02X02	0.563	0.563	1/8-27	0.660	0.332	1/8-27	0.800	0.150
9455X04X02	0.750	0.563	1/4-18	0.880	0.438	1/8-27	0.880	0.150
9455X04X04	0.750	0.688	1/4-18	0.880	0.438	1/4-18	0.990	0.220
9455X04X06	0.750	0.875	1/4-18	0.880	0.438	1/4-18	1.010	0.340
9455X06X04	0.875	0.688	3/8-18	1.020	0.563	1/4-18	1.040	0.220
9455X06X06	0.875	0.875	3/8-18	1.020	0.563	3/8-18	1.060	0.340
9455X06X08	0.875	1.000	3/8-18	1.020	0.563	1/2-14	1.130	0.460
9455X08X04	1.063	0.688	1/2-14	1.230	0.703	1/4-18	1.150	0.220
9455X08X06	1.063	0.875	1/2-14	1.230	0.703	3/8-18	1.170	0.340
9455X08X08	1.063	1.000	1/2-14	1.230	0.703	1/2-14	1.240	0.460
9455X08X12	1.063	1.250	1/2-14	1.230	0.703	3/4-14	1.240	0.635
9455X12X08	1.313	1.000	3/4-14	1.360	0.906	1/2-14	1.470	0.460
9455X12X12	1.313	1.250	3/4-14	1.360	0.906	3/4-14	1.470	0.635
9455X12X16	1.313	1.500	3/4-14	1.360	0.906	1-11-1/2	1.580	0.831
9455X16X12	1.625	1.250	1-11-1/2	1.620	1.141	3/4-14	1.620	0.635
9455X16X16	1.625	1.500	1-11-1/2	1.620	1.141	1-11-1/2	1.730	0.831
9455X20X20	1.875	1.875	1-1/4-11-1/2	1.700	1.484	1-1/4-11-1/2	1.830	1.087
9455X24X24	2.562	2.125	1-1/2-11-1/2	2.080	1.744	1-1/2-11-1/2	2.410	1.317
9455X32X32	2.812	2.625	2-11-1/2	2.390	2.213	2-11-1/2	2.570	1.802

Description**:** **Female Pipe to Female Pipe Swivel Branch Tee**
WWF Part No.: **9456**
WWF Stainless Part No.: **/**
SAE: **/**

Air-Way: 1602
Parker: /
Aeroquip: 2253-[R]
Gates: /



WWF	Y HEX	Y1 / Y2 HEX	T1	M1	D1	T2 / T3	M2 / M3	D2 / D3
9456X02X02X02	0.563	0.563	1/8-27	0.660	0.332	1/8-27	0.800	0.150
9456X04X04X04	0.750	0.688	1/4-18	0.880	0.438	1/4-18	0.990	0.220
9456X06X06X06	0.875	0.875	3/8-18	1.020	0.563	3/8-18	1.060	0.340
9456X08X06X06	1.063	0.875	1/2-14	1.230	0.703	3/8-18	1.170	0.340
9456X08X08X08	1.063	1.000	1/2-14	1.230	0.703	1/2-14	1.240	0.460
9456X12X08X08	1.313	1.000	3/4-14	1.360	0.906	1/2-14	1.470	0.460
9456X12X12X12	1.313	1.250	3/4-14	1.360	0.906	3/4-14	1.470	0.635
9456X16X16X16	1.625	1.500	1-11-1/2	1.620	1.141	1-11-1/2	1.730	0.831
9456X20X20X20	1.875	1.875	1-1/4-11-1/2	1.700	1.484	1-1/4-11-1/2	1.830	1.087



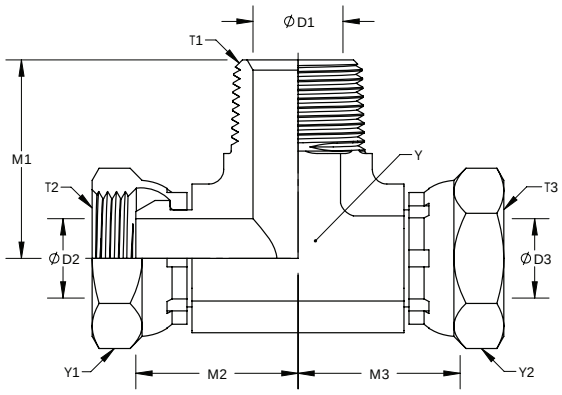
Description**:** **90° Female Adapter Union to Adjustable Male Straight Thread**
WWF Part No.: **9515**
WWF Stainless Part No.: **/**
SAE: **140257**

Air-Way: 6901
Parker: 2507
Aeroquip: 2068-[R]
Gates: MB-FPX90

WWF	Y HEX	Y1 HEX	T1	M1	D1	T2	M2	D2
9515X04X04	0.563	0.688	7/16-20	1.190	0.172	1/4-18	0.880	0.220
9515X04X06	0.750	0.875	7/16-20	1.260	0.172	3/8-18	0.990	0.340
9515X06X04	0.563	0.688	9/16-18	1.250	0.297	1/4-18	0.880	0.220
9515X06X06	0.563	0.875	9/16-18	1.250	0.297	3/8-18	0.900	0.340
9515X06X08	0.750	1.000	9/16-18	1.320	0.297	1/2-14	1.110	0.460
9515X08X04	0.750	0.688	3/4-16	1.450	0.391	1/4-18	0.970	0.220
9515X08X06	0.750	0.875	3/4-16	1.450	0.391	3/8-18	0.990	0.340
9515X08X08	0.750	1.000	3/4-16	1.450	0.391	1/2-14	1.110	0.460
9515X08X12	1.063	1.250	3/4-16	1.620	0.391	3/4-14	1.300	0.635
9515X10X06	0.875	0.875	7/8-14	1.700	0.484	3/8-18	1.040	0.340
9515X10X08	0.875	1.000	7/8-14	1.700	0.484	1/2-14	1.110	0.460
9515X10X12	1.063	1.250	7/8-14	1.780	0.484	3/4-14	1.300	0.635
9515X12X06	1.063	0.875	1-1/16-12	1.940	0.609	3/8-18	1.260	0.340
9515X12X08	1.063	1.000	1-1/16-12	1.940	0.609	1/2-14	1.300	0.460
9515X12X12	1.063	1.250	1-1/16-12	1.940	0.609	3/4-14	1.300	0.635
9515X12X16	1.313	1.500	1-1/16-12	2.050	0.609	1-11-1/2	1.540	0.831
9515X14X12	1.313	1.250	1-3/16-12	2.000	0.719	3/4-14	1.430	0.635
9515X16X12	1.313	1.250	1-5/16-12	2.050	0.844	3/4-14	1.430	0.635
9515X16X16	1.313	1.500	1-5/16-12	2.050	0.844	1-11-1/2	1.540	0.831
9515X16X20	1.625	1.875	1-5/16-12	2.250	0.844	1-1/4-11-1/2	1.730	1.087
9515X20X12	1.625	1.250	1-5/8-12	2.250	1.078	3/4-14	1.560	0.635
9515X20X16	1.625	1.500	1-5/8-12	2.250	1.078	1-11-1/2	1.700	0.831
9515X20X20	1.625	1.875	1-5/8-12	2.250	1.078	1-1/4-11-1/2	1.730	1.087
9515X24X20	1.875	1.875	1-7/8-12	2.390	1.313	1-1/4-11-1/2	1.770	1.087
9515X24X24	1.875	2.125	1-7/8-12	2.390	1.313	1-1/2-11-1/2	1.890	1.317
9515X32X32	2.500	2.625	2-1/2-12	2.890	1.781	2-11-1/2	2.270	1.802

Description: **Male Pipe to Female Pipe Swivel Branch Tee**
WWF Part No.: **9605**
WWF Stainless Part No.: **/**
SAE: **/**

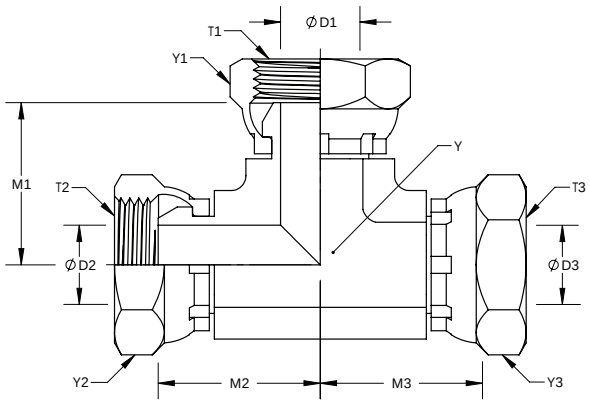
Air-Way: 1601
Parker: 217T
Aeroquip: 2254-[R]
Gates: FPX-FPX-MP



WWF	Y HEX	Y1 / Y2 HEX	T1	M1	D1	T2 / T3	M2 / M3	D2 / D3
9605X02X02X02	0.438	0.563	1/8-27	0.720	0.188	1/8-27	0.700	0.150
9605X04X04X04	0.563	0.688	1/4-18	1.090	0.281	1/4-18	0.880	0.220
9605X04X06X06	0.750	0.875	1/4-18	1.220	0.281	3/8-18	0.990	0.340
9605X06X04X04	0.750	0.688	3/8-18	1.220	0.406	1/4-18	0.990	0.220
9605X06X06X06	0.750	0.875	3/8-18	1.220	0.406	3/8-18	0.990	0.340
9605X08X04X04	0.875	0.688	1/2-14	1.470	0.531	1/4-18	1.020	0.220
9605X08X06X06	0.875	0.875	1/2-14	1.470	0.531	3/8-18	1.040	0.340
9605X08X08X08	0.875	1.000	1/2-14	1.470	0.531	1/2-14	1.110	0.460
9605X12X08X08	1.063	1.000	3/4-14	1.590	0.719	1/2-14	1.240	0.460
9605X12X12X12	1.063	1.250	3/4-14	1.590	0.719	3/4-14	1.300	0.635
9605X12X16X16	1.313	1.500	3/4-14	1.780	0.719	1-11-1/2	1.540	0.831
9605X16X12X12	1.313	1.250	1-11-1/2	1.970	0.938	3/4-14	1.430	0.635
9605X16X16X16	1.313	1.500	1-11-1/2	1.970	0.938	1-11-1/2	1.540	0.831
9605X20X20X20	1.625	1.875	1-1/4-11-1/2	2.380	1.250	1-1/4-11-1/2	1.730	1.087
9605X24X24X24	1.875	2.125	1-1/2-11-1/2	2.640	1.500	1-1/2-11-1/2	1.890	1.317

Description: **Swivel Union Tee**
WWF Part No.: **9705**
WWF Stainless Part No.: **/**
SAE: **/**

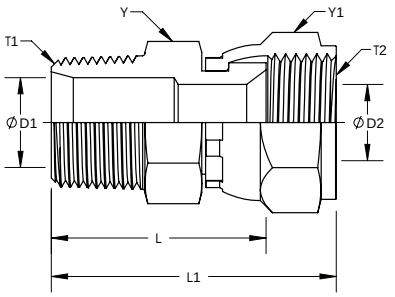
Air-Way: 1603
Parker: 077T
Aeroquip: 2255
Gates: FPX-FPX-FPX



WWF	Y HEX	Y1 / Y2 / Y3 HEX	T1 / T2 / T3	M1 / M2 / M3	D1 / D2 / D3
9705X02X02X02	0.438	0.563	1/8-27	0.700	0.150
9705X04X04X04	0.563	0.688	1/4-18	0.880	0.220
9705X06X06X06	0.750	0.875	3/8-18	0.990	0.340
9705X08X08X08	0.750	1.000	1/2-14	1.110	0.460
9705X12X12X12	1.063	1.250	3/4-14	1.300	0.635
9705X16X16X16	1.313	1.500	1-11-1/2	1.540	0.831
9705X20X20X20	1.625	1.875	1-1/4-11-1/2	1.730	1.087

Description: **Male Pipe to Female 37° JIC Swivel**
WWF Part No.: **9100**
WWF Stainless Part No.: **/**
SAE: **/**

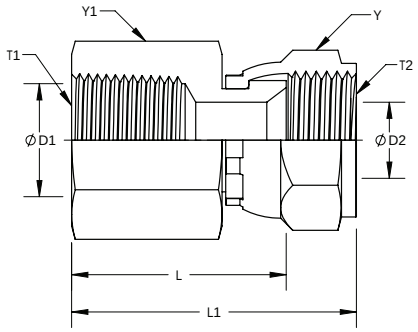
Air-Way: 6505
Parker: F6X
Aeroquip: 2018
Gates: FJX-MP



WWF	Y HEX	Y1 HEX	T1	D1	T2	D2	L	L1
9100X02X04	0.500	0.563	1/8-27	0.188	7/16-20	0.172	0.990	1.340
9100X04X04	0.563	0.563	1/4-18	0.281	7/16-20	0.172	1.200	1.550
9100X04X05	0.563	0.625	1/4-18	0.281	1/2-20	0.234	1.260	1.640
9100X04X06	0.563	0.688	1/4-18	0.281	9/16-18	0.297	1.300	1.680
9100X06X06	0.750	0.688	3/8-18	0.406	9/16-18	0.297	1.260	1.640
9100X06X08	0.875	0.875	3/8-18	0.406	3/4-16	0.391	1.310	1.740
9100X08X08	0.875	0.875	1/2-14	0.531	3/4-16	0.391	1.560	1.990
9100X08X10	1.000	1.000	1/2-14	0.531	7/8-14	0.484	1.600	2.100
9100X08X12	1.000	1.250	1/2-14	0.531	1-1/16-12	0.609	1.580	2.150
9100X12X12	1.125	1.250	3/4-14	0.719	1-1/16-12	0.609	1.720	2.290
9100X16X16	1.375	1.500	1-11-1/2	0.938	1-5/16-12	0.844	1.970	2.570
9100X20X20	1.688	2.000	1-1/4-11-1/2	1.250	1-5/8-12	1.078	2.210	2.000
9100X24X24	2.000	2.250	1-1/2-11-1/2	1.500	1-7/8-12	1.313	2.270	2.990

Description: **Female Pipe to Female 37° JIC Swivel**
WWF Part No.: **9256**
WWF Stainless Part No.: **/**
SAE: **/**

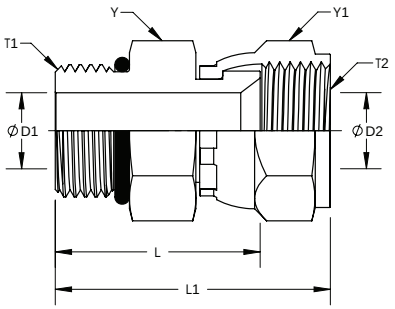
Air-Way: 6506
Parker: G6X
Aeroquip: 2242
Gates: FJX-FP



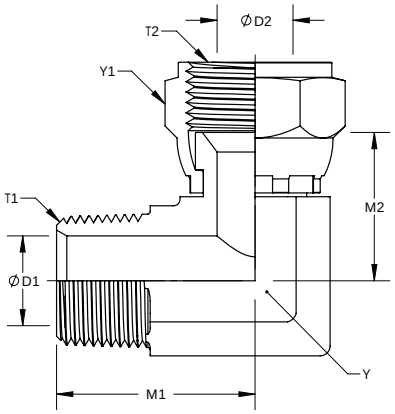
WWF	Y HEX	Y1 HEX	T1	D1	T2	D2	L	L1
9256X04X04	0.563	0.750	1/4-18	0.438	7/16-20	0.172	1.170	1.520
9256X04X06	0.688	0.750	1/4-18	0.438	9/16-18	0.297	1.260	1.640
9256X06X06	0.688	0.875	3/8-18	0.563	9/16-18	0.297	1.320	1.700
9256X06X08	0.875	0.875	3/8-18	0.563	3/4-16	0.391	1.370	1.800
9256X08X06	0.688	1.125	1/2-14	0.703	9/16-18	0.297	1.540	1.920
9256X08X08	0.875	1.125	1/2-14	0.703	3/4-16	0.391	1.590	2.020
9256X08X10	1.000	1.125	1/2-14	0.703	7/8-14	0.484	1.620	2.120
9256X12X10	1.000	1.375	3/4-14	0.906	7/8-14	0.484	1.680	2.180
9256X12X12	1.250	1.375	3/4-14	0.906	1-1/16-12	0.609	1.720	2.290
9256X16X16	1.500	1.625	1-11-1/2	1.141	1-5/16-12	0.844	2.030	2.630
9256X20X20	2.000	2.000	1-1/4-11-1/2	1.484	1-5/8-12	1.078	2.200	2.840

Description: **Straight Thread "O" Ring to Female 37° JIC Swivel**
WWF Part No.: **9316**
WWF Stainless Part No.: **/**
SAE: **/**

Air-Way: 6402
Parker: F65OX
Aeroquip: 2266
Gates: /



WWF	Y HEX	Y1 HEX	T1	D1	T2	D2	L	L1
9316X04X04	0.563	0.563	7/16-20	0.172	7/16-20	0.172	1.020	1.310
9316X04X06	0.563	0.688	7/16-20	0.172	9/16-18	0.297	1.090	1.420
9316X06X06	0.688	0.688	9/16-18	0.297	9/16-18	0.297	1.150	1.480
9316X06X08	0.813	0.875	9/16-18	0.297	3/4-16	0.391	1.200	1.580
9316X08X08	0.875	0.875	3/4-16	0.391	3/4-16	0.391	1.280	1.650
9316X10X10	1.000	1.000	7/8-14	0.484	7/8-14	0.484	1.430	1.880
9316X12X12	1.250	1.250	1-1/16-12	0.609	1-1/16-12	0.609	1.630	2.150
9316X16X16	1.500	1.500	1-5/16-12	0.844	1-5/16-12	0.844	1.720	2.270
9316X20X20	1.875	2.000	1-5/8-12	1.078	1-5/8-12	1.078	1.850	2.400
9316X24X24	2.125	2.250	1-7/8-12	1.313	1-7/8-12	1.313	1.990	2.670
9316X32X32	2.750	2.875	2-1/2-12	1.781	2-1/2-12	1.781	2.180	3.070

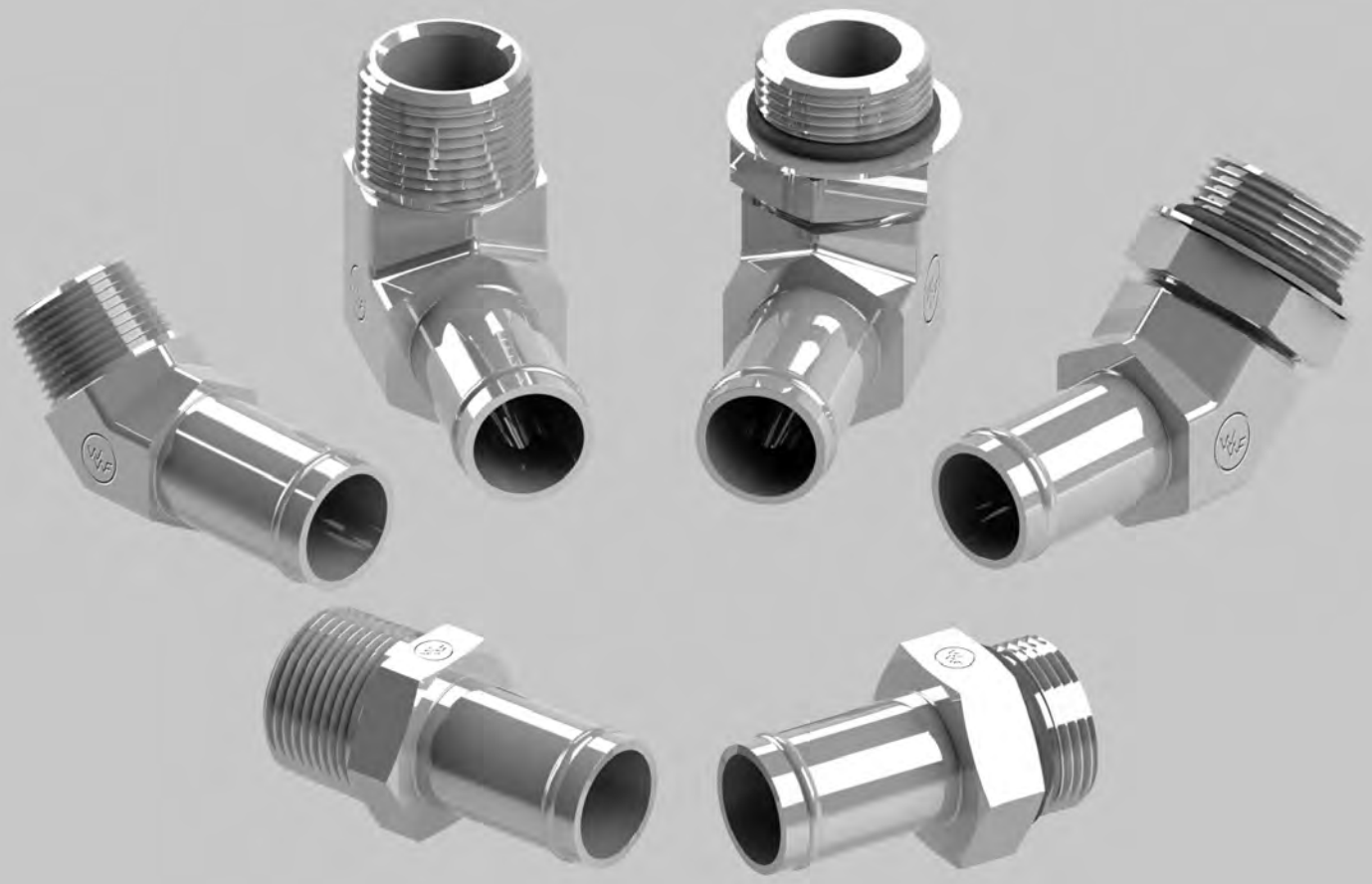


Description: **90° Male Pipe to Female 37° JIC Swivel**
WWF Part No.: **9406**
WWF Stainless Part No.: **/**
SAE: **/**

Air-Way: 6501
Parker: X6EF
Aeroquip: 2250
Gates: /

WWF	Y HEX	Y1 HEX	T1	M1	D1	T2	M2	D2
9406X02X04	0.438	0.563	1/8-27	1.000	0.188	7/16-20	0.410	0.172
9406X04X04	0.563	0.563	1/4-18	1.150	0.281	7/16-20	0.740	0.172
9406X04X06	0.563	0.688	1/4-18	1.250	0.281	9/16-18	0.710	0.297
9406X06X04	0.750	0.563	3/8-18	1.180	0.406	7/16-20	0.870	0.172
9406X06X06	0.750	0.688	3/8-18	1.290	0.406	9/16-18	0.840	0.297
9406X06X08	0.750	0.875	3/8-18	1.380	0.406	3/4-16	0.790	0.391
9406X08X06	0.875	0.688	1/2-14	1.420	0.531	9/16-18	1.020	0.297
9406X08X08	0.875	0.875	1/2-14	1.520	0.531	3/4-16	1.040	0.391
9406X08X10	0.875	1.000	1/2-14	1.620	0.531	7/8-14	0.970	0.484
9406X12X08	1.063	0.875	3/4-14	1.750	0.719	3/4-16	1.040	0.391
9406X12X12	1.063	1.250	3/4-14	1.750	0.719	1-1/16-12	1.020	0.609
9406X16X16	1.313	1.500	1-11-1/2	2.000	0.938	1-5/16-12	1.370	0.844
9406X20X20	1.625	2.000	1-1/4-11-1/2	2.310	1.250	1-5/8-12	1.740	1.078
9406X24X24	1.875	2.250	1-1/2-11-1/2	2.590	1.500	1-7/8-12	1.920	1.313
9406X32X32	2.500	2.875	2-11-1/2	3.380	1.938	2-1/2-12	2.050	1.781

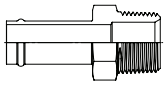
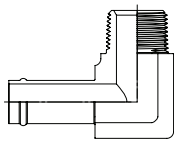
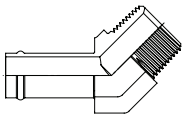
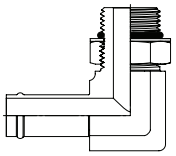
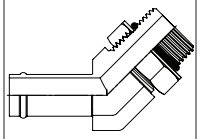
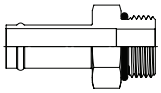
NOTES



Steel Beaded Hose Barbs

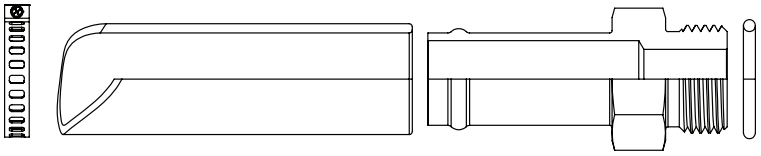
BARB END SERIES

STEEL BEADED HOSE BARBS

4404 Page 194	**4501** Page 195	**4503** Page 196	**4601** Page 197	**4603** Page 198	**4604** Page 199	Page 165
						
4404 Male Pipe Thread Hose Connector	4501 90º Male Pipe Hose Fitting	4503 45º Male Pipe Hose Fitting	4601 90º Straight Thread Hose Fitting	4603 45º Straight Thread Hose Fitting	4604 Male Straight Thread Hose Connector	7629 90 Durometer “O” Ring
Page 166						
						
7269M 90 Durometer Metric “O” Ring						

F

STEEL BEADED HOSE BARBS



Barb End Series Assembly

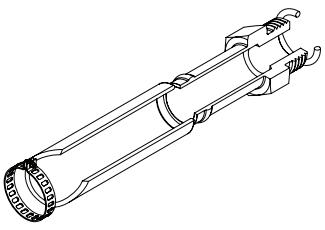
CONSTRUCTION
Straight Fittings are machined from bar stock.
Shaped Fittings (Elbows, Tees) are made from forgings.
Beaded Fittings meet SAE J1231 specifications.

APPLICATIONS
For use in low pressure automotive and hydraulic systems.

MATERIAL
Steel – 12L14, 1045

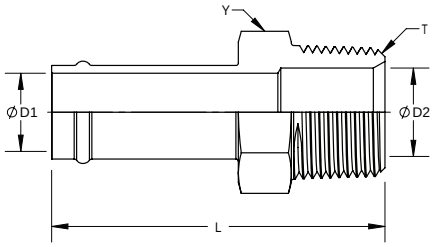
PLATING
Clear Zinc Trivalent

ASSEMBLY
Beaded Fittings are intended to be used with hose clamps. (See SAE J1508)

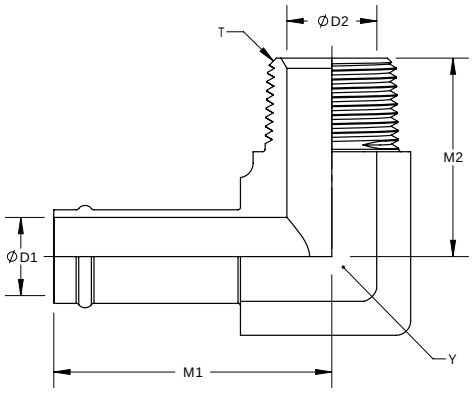


Description: **Male Pipe Thread Hose Connector**
WWF Part No.: **4404**
WWF Stainless Part No.: **/**
SAE: **430160**

Air-Way: 4404
Parker: /
Aeroquip: /
Gates: /



WWF	Y HEX	T	D1	D2	L
4404X04X02	0.438	1/8-27	0.189	0.189	2.080
4404X04X04	0.563	1/4-18	0.189	0.275	2.350
4404X06X02	0.625	1/8-27	0.295	0.189	2.130
4404X06X04	0.625	1/4-18	0.295	0.275	2.350
4404X06X06	0.750	3/8-18	0.295	0.405	2.350
4404X06X08	0.938	1/2-14	0.295	0.531	2.600
4404X08X04	0.750	1/4-18	0.405	0.275	2.350
4404X08X06	0.750	3/8-18	0.405	0.405	2.350
4404X08X08	0.938	1/2-14	0.405	0.531	2.600
4404X08X12	1.125	3/4-14	0.405	0.708	2.670
4404X10X06	0.875	3/8-18	0.500	0.405	2.350
4404X10X08	0.938	1/2-14	0.500	0.531	2.600
4404X10X16	1.375	1-11-1/2	0.500	0.938	2.860
4404X12X08	1.000	1/2-14	0.626	0.531	2.600
4404X12X12	1.125	3/4-14	0.626	0.708	2.670
4404X12X16	1.375	1-11-1/2	0.626	0.938	2.860
4404X16X12	1.250	3/4-14	0.842	0.708	2.670
4404X16X16	1.375	1-11-1/2	0.842	0.938	2.860
4404X20X16	1.500	1-11-1/2	1.094	0.938	2.860
4404X20X20	1.750	1-1/4-11-1/2	1.094	1.248	2.970
4404X20X24	2.000	1-1/2-11-1/2	1.094	1.496	3.070
4404X24X20	1.750	1-1/4-11-1/2	1.342	1.248	2.970
4404X24X24	2.000	1-1/2-11-1/2	1.342	1.496	3.070



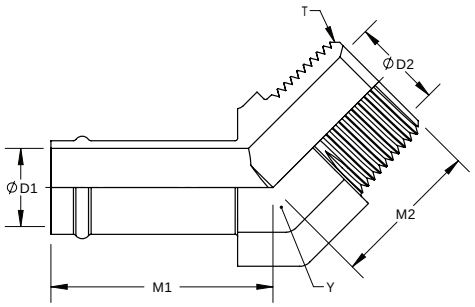
Description: **90° Male Pipe Hose Fitting**
WWF Part No.: **4501**
WWF Stainless Part No.: ***/***
SAE: **431460**

Air-Way: 4501
Parker: /
Aeroquip: FF1162-[R]
Gates: /

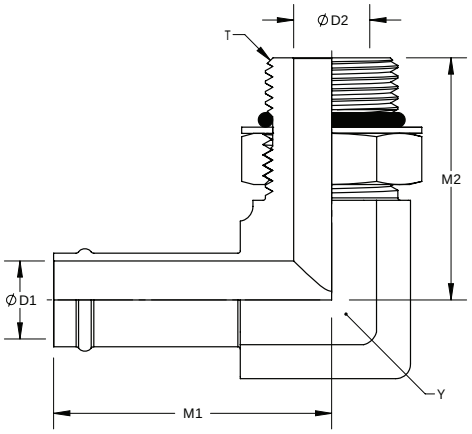
WWF	Y HEX	T	M1	D1	M2	D2
4501X04X02	0.500	1/8-27	1.887	0.189	0.779	0.189
4501X04X04	0.625	1/4-18	1.955	0.189	1.090	0.275
4501X05X04	0.625	1/4-18	1.955	0.251	1.090	0.275
4501X06X04	0.625	1/4-18	1.955	0.295	1.090	0.275
4501X06X06	0.750	3/8-18	2.023	0.295	1.220	0.405
4501X08X06	0.813	3/8-18	2.057	0.405	1.220	0.405
4501X08X08	0.938	1/2-14	2.125	0.405	1.469	0.531
4501X08X12	1.125	3/4-14	2.228	0.405	1.590	0.720
4501X10X08	0.938	1/2-14	2.125	0.500	1.469	0.531
4501X10X12	1.125	3/4-14	2.228	0.500	1.590	0.720
4501X12X08	0.938	1/2-14	2.125	0.626	1.469	0.531
4501X12X12	1.125	3/4-14	2.228	0.626	1.590	0.720
4501X12X16	1.375	1-11-1/2	2.364	0.626	1.969	0.938
4501X16X12	1.125	3/4-14	2.228	0.842	1.590	0.720
4501X16X16	1.375	1-11-1/2	2.364	0.842	1.969	0.938
4501X20X20	1.750	1-1/4-11-1/2	2.569	1.094	2.381	1.248
4501X24X24	2.000	1-1/2-11-1/2	2.705	1.342	2.641	1.496

Description: **45° Male Pipe Hose Fitting**
WWF Part No.: **4503**
WWF Stainless Part No.: ***/***
SAE: **430360**

Air-Way: 4503
Parker: /
Aeroquip: /
Gates: /



WWF	Y HEX	T	M1	D1	M2	D2
4503X04X02	0.500	1/8-27	1.680	0.189	0.633	0.189
4503X04X04	0.625	1/4-18	1.700	0.189	0.858	0.275
4503X06X04	0.625	1/4-18	1.670	0.295	0.858	0.275
4503X08X06	0.813	3/8-18	1.740	0.405	0.948	0.405
4503X08X08	0.938	1/2-14	1.720	0.405	1.173	0.531
4503X10X08	0.938	1/2-14	1.750	0.500	1.173	0.531
4503X10X12	1.125	3/4-14	1.810	0.500	1.200	0.720
4503X12X12	1.125	3/4-14	1.780	0.626	1.200	0.720
4503X12X16	1.375	1-11-1/2	1.980	0.626	1.480	0.938
4503X16X12	1.125	3/4-14	1.750	0.842	1.200	0.720
4503X16X16	1.375	1-11-1/2	1.850	0.842	1.480	0.938
4503X20X20	1.750	1-1/4-11-1/2	1.910	1.094	1.669	1.248
4503X24X24	2.000	1-1/2-11-1/2	1.950	1.342	1.771	1.496



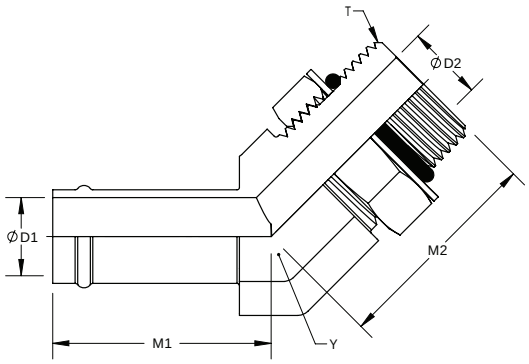
Description: **90° Straight Thread Hose Fitting**
WWF Part No.: **4601**
WWF Stainless Part No.: ***/***
SAE: **431492**

Air-Way: 4601
Parker: /
Aeroquip: FF1167-[R]
Gates: /

WWF	Y HEX	T	M1	D1	M2	D2
4601X04X04	0.500	7/16-20	1.752	0.188	1.031	0.172
4601X04X06	0.625	9/16-18	1.955	0.188	1.251	0.297
4601X06X04	0.500	7/16-20	1.887	0.296	1.192	0.172
4601X06X06	0.625	9/16-18	1.955	0.296	1.251	0.297
4601X06X08	0.813	3/4-16	2.057	0.296	1.448	0.391
4601X08XM22	0.984	M22X1.5	1.969	0.405	1.969	0.551
4601X08X06	0.625	9/16-18	1.955	0.406	1.251	0.297
4601X08X08	0.813	3/4-16	2.057	0.406	1.448	0.391
4601X08X10	0.938	7/8-14	2.125	0.406	1.700	0.484
4601X10XM14	0.875	M14X1.5	1.969	0.500	1.693	0.295
4601X10XM16	0.866	M16X1.5	2.000	0.500	1.431	0.354
4601X10X08	0.813	3/4-16	2.057	0.500	1.448	0.391
4601X10X10	0.938	7/8-14	2.125	0.500	1.700	0.484
4601X10X12	1.125	1-1/16-12	2.228	0.500	1.940	0.609
4601X12X08	0.938	3/4-16	2.125	0.625	1.448	0.391
4601X12X10	0.938	7/8-14	2.125	0.625	1.700	0.484
4601X12X12	1.125	1-1/16-12	2.228	0.625	1.940	0.609
4601X12X16	1.375	1-5/16-12	2.364	0.625	2.051	0.844
4601X16X10	1.125	7/8-14	2.228	0.844	1.889	0.484
4601X16X12	1.125	1-1/16-12	2.228	0.844	1.940	0.609
4601X16X16	1.375	1-5/16-12	2.364	0.844	2.051	0.844
4601X16X20	1.688	1-5/8-12	2.535	0.844	2.251	1.078
4601X20X16	1.375	1-5/16-12	2.364	1.094	2.051	0.844
4601X20X20	1.688	1-5/8-12	2.535	1.094	2.251	1.078
4601X24X20	1.688	1-5/8-12	2.535	1.344	2.251	1.078
4601X24X24	2.000	1-7/8-12	2.705	1.344	2.389	1.310

Description: **45° Straight Thread Hose Fitting**
WWF Part No.: **4603**
WWF Stainless Part No.: **/**
SAE: **430392**

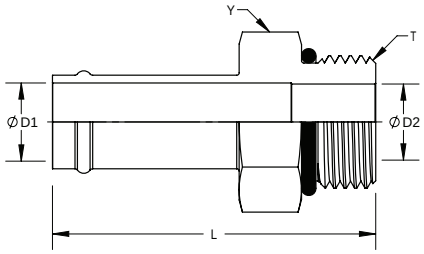
Air-Way: 4603
Parker: /
Aeroquip: /
Gates: /



WWF	Y HEX	T	M1	D1	M2	D2
4603X04X04	0.500	7/16-20	1.700	0.188	1.051	0.172
4603X04X06	0.625	9/16-18	1.700	0.188	1.141	0.297
4603X06X04	0.500	7/16-20	1.610	0.297	1.051	0.172
4603X06X06	0.625	9/16-18	1.690	0.297	1.141	0.297
4603X08X06	0.625	9/16-18	1.610	0.406	1.141	0.297
4603X08X08	0.813	3/4-16	1.690	0.406	1.299	0.391
4603X10XM18ZN	0.875	M18X1.5	1.893	0.500	1.460	0.354
4603X10X08	0.813	3/4-16	1.650	0.500	1.299	0.391
4603X10X10	0.938	7/8-14	1.700	0.500	1.519	0.484
4603X10X12	1.125	1-1/16-12	1.840	0.500	1.728	0.609
4603X12XM18ZN	1.063	M18X1.5	1.893	0.500	1.460	0.354
4603X12X08	0.813	3/4-16	1.620	0.625	1.299	0.391
4603X12X12	1.125	1-1/16-12	1.750	0.625	1.728	0.609
4603X12X16	1.375	1-5/16-12	1.900	0.625	1.858	0.844
4603X16X12	1.125	1-1/16-12	1.750	0.844	1.728	0.609
4603X16X16	1.375	1-5/16-12	1.860	0.844	1.858	0.844
4603X20X16	1.375	1-5/16-12	1.760	1.094	1.858	0.844
4603X20X20	1.688	1-5/8-12	1.920	1.094	1.909	1.078
4603X24X16	1.375	1-5/16-12	1.800	1.344	1.858	0.844
4603X24X20	1.688	1-5/8-12	1.920	1.344	1.909	1.078
4603X24X24	2.000	1-7/8-12	1.970	1.344	1.909	1.310

Description: **Male Straight Thread Hose Connector**
WWF Part No.: **4604**
WWF Stainless Part No.: **/**
SAE: **430192**

Air-Way: 4604
Parker: /
Aeroquip: /
Gates: /



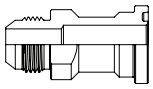
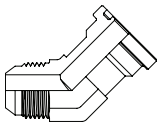
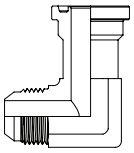
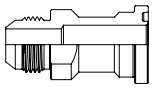
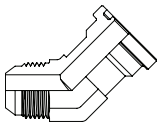
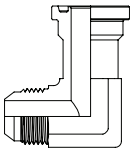
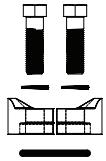
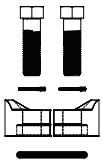
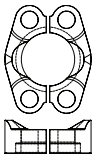
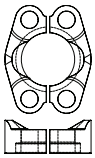
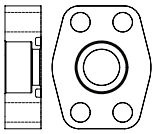
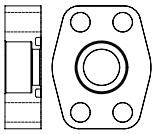
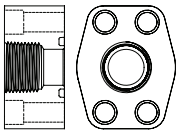
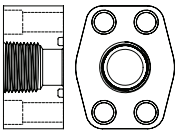
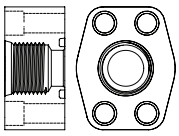
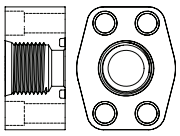
WWF	Y HEX	T	D1	D2	L
4604X04X04	0.563	7/16-20	0.189	0.173	2.170
4604X04X06	0.688	9/16-18	0.189	0.295	2.230
4604X06X04	0.563	7/16-20	0.295	0.173	2.170
4604X06X06	0.688	9/16-18	0.295	0.295	2.230
4604X06X08	0.875	3/4-16	0.295	0.389	2.300
4604X08X06	0.688	9/16-18	0.405	0.295	2.230
4604X08X08	0.875	3/4-16	0.405	0.389	2.300
4604X10X08	0.875	3/4-16	0.500	0.389	2.300
4604X10X10	1.000	7/8-14	0.500	0.484	2.430
4604X12X08	0.875	3/4-16	0.626	0.389	2.300
4604X12X10	1.000	7/8-14	0.626	0.484	2.430
4604X12X12	1.250	1-1/16-12	0.626	0.610	2.590
4604X12X16	1.500	1-5/16-12	0.626	0.846	2.620
4604X16X12	1.250	1-1/16-12	0.844	0.610	2.590
4604X16X16	1.500	1-5/16-12	0.844	0.846	2.620
4604X16X20	1.875	1-5/8-12	0.844	1.082	2.700
4604X20X16	1.500	1-5/16-12	1.094	0.846	2.620
4604X20X20	1.875	1-5/8-12	1.094	1.082	2.700
4604X20X24	2.125	1-7/8-12	1.094	1.299	2.770
4604X24X24	2.125	1-7/8-12	1.344	1.299	2.770
4604X32X32	2.750	2-1/2-12	1.482	1.772	2.930

NOTES



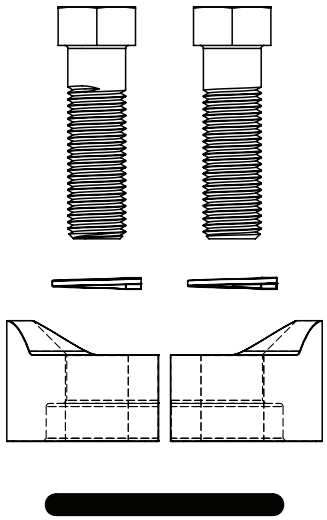
Code 61 & Code 62
Four Bolt Steel Flange Fittings

CODE 61 & CODE 62 - FOUR BOLT STEEL FLANGE FITTINGS

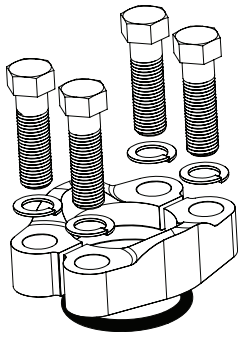
POR  1700 JIC Flange - Straight Code 61	POR  1703 JIC Flange 45° Elbow Code 61	POR  1704 JIC Flange 90° Elbow Code 61	POR  1800 JIC Flange - Straight Code 62	POR  1803 JIC Flange 45° Elbow Code 62	POR  1804 JIC Flange 90° Elbow Code 62	**1901** Page 204  1901 Flange Kit Code 61
1902 Page 204  1902 Flange Kit Code 62	**1951** Page 205  1951 Flange Half Code 61	**1952** Page 205  1952 Flange Half Code 62	POR  W4 Flat Socket Weld Pipe Code 61	POR  W42 Flat Socket Weld Pipe Code 62	POR  W43 NPTF Female Code 61	POR  W44 NPTF Female Code 62
POR  W46 SAE J 1926/1 Port Code 61	POR  W48 SAE J 1926/1 Port Code 62					

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CODE 61 & CODE 62 - FOUR BOLT STEEL FLANGE FITTINGS

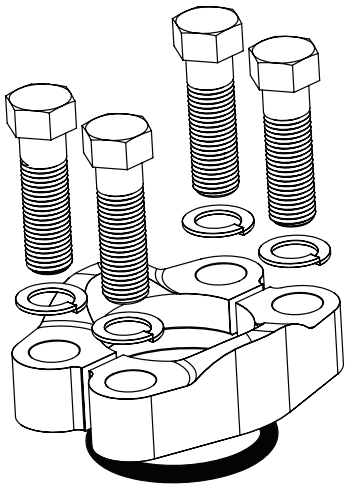


Flanges Series Assembly



Description**:** **Flange Kit - Code 61**
WWF Part No.: **1901**
WWF Stainless Part No.: ***/***
SAE: ***/***

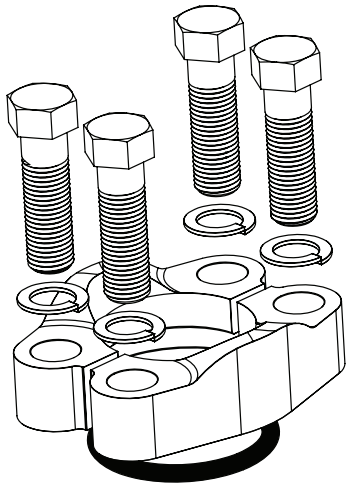
Air-Way: 1901
Parker: /
Aeroquip: /
Gates: /



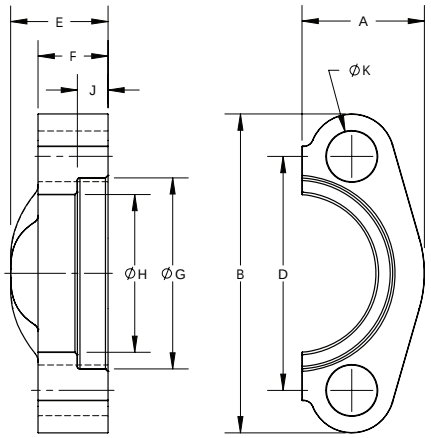
WWF	FLANGE SIZE
1901X08	1/2
1901X12	3/4
1901X16	1
1901X20	1-1/4
1901X24	1-1/2
1901X32	2
1901X40	2-1/2
1901X48	3

Description**:** **Flange Kit - Code 62**
WWF Part No.: **1902**
WWF Stainless Part No.: ***/***
SAE: ***/***

Air-Way: 1902
Parker: /
Aeroquip: /
Gates: /



WWF	FLANGE SIZE
1902X08	1/2
1902X12	3/4
1902X16	1
1902X20	1-1/4
1902X24	1-1/2
1902X32	2



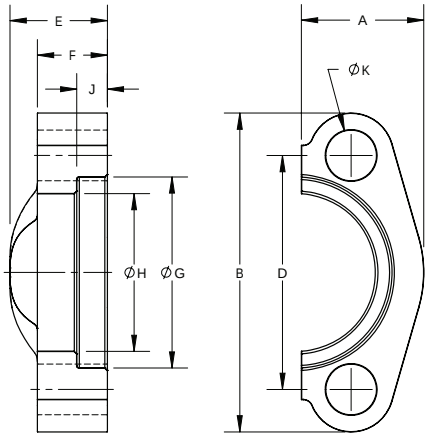
Description**:** **Flange Half - Code 61**
WWF Part No.: **1951**
WWF Stainless Part No.: **/**
SAE: **/**

Air-Way: 1951
Parker: /
Aeroquip: /
Gates: /

Flange Kit

WWF	WWF	FLANGE SIZE	A	B	D	E	F	G	H	J	K
1951X08	1901X08	1/2	0.860	2.125	1.500	0.750	0.500	1.219	0.955	0.245	0.344
1951X12	1901X12	3/4	0.980	2.560	1.875	0.780	0.560	1.531	1.265	0.245	0.406
1951X16	1901X16	1	1.110	2.750	2.062	0.940	0.620	1.781	1.515	0.295	0.406
1951X20	1901X20	1-1/4	1.390	3.125	2.312	0.880	0.560	2.031	1.720	0.295	0.469
1951X24	1901X24	1-1/2	1.580	3.690	2.750	1.000	0.620	2.406	2.000	0.295	0.531
1951X32	1901X32	2	1.860	4.000	3.062	1.030	0.620	2.844	2.470	0.355	0.531
1951X40	1901X40	2-1/2	2.090	4.500	3.500	1.500	0.750	3.344	2.950	0.355	0.531
1951X48	1901X48	3	2.530	5.315	4.188	1.620	0.880	4.031	3.580	0.355	0.656

G



Description**:** **Flange Half - Code 62**
WWF Part No.: **1952**
WWF Stainless Part No.: **/**
SAE: **/**

Air-Way: 1952
Parker: /
Aeroquip: /
Gates: /

Flange Kit

WWF	WWF	FLANGE SIZE	A	B	D	E	F	G	H	J	K
1952X08	1902X08	1/2	0.890	2.220	1.594	0.880	0.620	1.281	0.970	0.285	0.344
1952X12	1902X12	3/4	1.140	2.795	2.000	1.120	0.750	1.656	1.280	0.325	0.406
1952X16	1902X16	1	1.330	3.190	2.250	1.310	0.940	1.906	1.530	0.355	0.469
1952X20	1902X20	1-1/4	1.480	3.750	2.625	1.500	1.060	2.156	1.750	0.385	0.531
1952X24	1902X24	1-1/2	1.830	4.440	3.125	1.690	1.190	2.531	2.030	0.475	0.656
1952X32	1902X32	2	2.200	5.250	3.812	2.060	1.440	3.156	2.660	0.475	0.781



World Wide Fittings Corporate Headquarters & Manufacturing Facility, Niles, IL

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World Wide supplies over **300,000,000 tube and pipe fitting components annually** to the North American and foreign markets. World Wide has always been known as the best source in the industry for cold formed nuts and sleeves, forged steel flareless fittings, and SAE "O" Ring Boss plugs. The addition of steel forged JIC 37° flare, "O" Ring Face Seal, and Pipe fittings allows you to purchase multiple product lines from a **"Single Quality Source"**. This helps you to reduce your vendor base, reduce your freight cost by consolidating freight, and reduces your purchasing and accounting cost by placing a single order and paying a single invoice.

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