

OPERATING INSTRUCTIONS

M 6

VALVE DURABILITY TESTING MACHINE

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INSTRUCTION MANUAL
FOR
M6 SIX-VALVE DURABILITY TESTING MACHINE

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UNPACKING INSTRUCTIONS

Unpack machine carefully. The control box is in the smaller shipping crate. Place the machine on a sturdy table at a convenient height for valve observation. It is a good idea to place a rubber mat under the machine to reduce any vibration or "walking" of the machine to the edge of the table. Shim the table legs as necessary to prevent rocking.

The tools, heater, sensor, stopcock, tubing connector, bubble tube, etc., are packed together.

The DC motor cord is inside the motor case (bottom part of the machine). It may be taken out through one of the top or bottom scallops.

DESCRIPTION

This six-valve durability/fatigue testing machine has been designed to provide years of continuous testing with little or no maintenance, and with very little attention.

A swashplate drive is used to compress bellows that supply each valve compartment. A common inlet flow chamber is used to provide a common fluid passage for pressure and temperature stabilization. There is some vibration with this drive arrangement but it is much less than with a reciprocating oscillator. This machine has one large ball bearing in its drive system.

There are three modules that make up its assembly: the motor drive with the proximity sensor, the pumping unit with the bottom plate, and the valve blocks with the capacitance tank (Fig. 1A).

Motor Drive and Proximity Sensor

A quarter-horsepower DC motor is hung vertically from the motor plate. This plate is 1/2 inch nickel-plated steel for a mass-inertia base. A thrust bearing is installed in the plate and secured with a collar to provide positive positioning and to remove thrust load from the motor bearings.

The aluminum base cylinder is scalloped to provide air circulation to cool the motor.

The proximity sensor which sends signals to both the speed indicator and the Photoswitch counter is mounted on the motor plate pointing toward the rotating shaft. If adjustment is found to be necessary, the tip should be 0.008" from the foil strip located on the rotating shaft.

Pumping Unit

The pumping module consists of an adjustable tilt angle swashplate, bellows and the bottom acrylic plate.

*Reglage
Amplitude*
A socket head setscrew in the cut out step in the lower half of the tilt coupling is used to change the tilt angle of the swashplate (Fig. 1B). Loosen the nylon thumb screw, and the three cap screws about 1/2 to 1 turn and turn the jack screw to raise or lower the tilt angle. The tilt-drive amplitude is measured at the periphery of the swashplate. To measure the swashplate deflection, turn the coupling by hand and measure the min-max deflection for one revolution.

The bellows are secured to the swashplate with stainless steel disks and 1/4-20 socket head cap screws. Positive sealing is maintained by a silicone gasket under the disks and silicone sealant around the cap screws at the time of initial assembly. Bellows should not be removed except for replacement in case of failure. The bellows are secured to the top plate with clamping rings and sealed with silicone rubber O-rings. The clamping ring screws are accessible through holes in the swashplate. A 7/64" ball driver is supplied for these screws.

The bottom plate is ported from the valve discharge region into the center return reservoir. The inertial pressure drop across these ports, plus the resistance and inertial effect of flow through the center reservoir supply the closing pressure to load the valves.

Pressure transducer ports are provided in the top and bottom manifolds at each valve block position. These ports are 10-32 tapped for miniature transducers (e.g. Endevco 8510-5). If desired, a series of stopcocks can be used to facilitate easy transfer of pressure transducers from one valve position to the next.

Valve Blocks and Capacitance Tank

Individual valve blocks allow insertion and removal of any one valve at a time. Two or three different sizes and/or types of valve may be installed simultaneously if appropriate blocks are used and similar pressures are obtainable.

When two types or sizes of valves are to be run simultaneously, their positions should be alternated. If three different pairs of valves are to be run, each pair should be run in diametrically opposite positions.

The square shape of the block allows for minimal optical distortion from three sides. Valves are installed in a shoulder recess in the top of the blocks. O-rings may be used to facilitate installation, to provide a good fit, and to adapt different types and/or sizes of valves to a given set of blocks. Valve blocks are usually ordered for specific valve sizes.

The blocks are sealed between the top and bottom plates with O-rings.

The top plate contains the inlet flow passages and the heater and temperature sensor ports. The cartridge heater is installed in the center tapped hole and the sensor is installed in the adjacent tapped hole.

Pressure transducer ports (and plug screws) are near the end of the flow passages in the top plate with a matching set in the bottom plate. The tubing connector or stopcock and adapter may be removed and its port used for a pressure transducer.

A throttle valve is used to adjust the closing back pressure on the valve. It may be adjusted without emptying the system by turning the cap screw at the base of the throttle with the supplied ball driver. If any binding or resistance is encountered, the following procedure should be implemented: With the capacitance tank depressurized (see Fig. 1A), loosen the 1/2" nylon bolts in pairs going around the top of the M6 sequentially, loosening about 1/2 turn then retighten to finger tight. This relieves pressure on the throttle valve just enough to be able to move it, but not enough to cause leakage. After all pairs have been loosened the throttle may be adjusted by turning the cap screw at the base of the throttle with the supplied ball driver. Retighten the head, pressurize the capacitance tank (see below) and check the closing pressures. There are three different throttle valves available. A 3/4" bypass hole is supplied for tissue valves, a 17/32" bypass hole is supplied for mechanical valves and a 5/16" bypass hole is supplied for biomaterial test sections.

An acrylic capacitance tank is used to buffer small variations in the systemic pressure which arise from transient small leakage and thermal effects. It is installed (see Preparation For Run Mode And Capacitance Tank Installation) between the controller box and the testing unit via Tygon tubing. Whenever the system pressure is adjusted or released it should be done through the stopcock on the capacitance tank.

Theory of Operation

As the motor shaft turns, the adjustable tilting coupler rotates and pulls the swashplate down, extending the bellows. This draws fluid down into the bellows through the now opened valve being tested. As rotation continues the swashplate is returned upward, compressing the bellows, causing fluid to reverse direction and close the valve. Further bellows compression increases the pressure behind the valve, loading the leaflets or occluders. Fluid now escapes through the bypass port, through the throttle and into the central reservoir where it is now available to the upper head above the valves for another cycle. Closing pressure is a function of motor speed, swashplate deflection and throttle position.

CONTROL MODULE

The control module (see Figure 2) is designed to control speed, temperature, systemic pressure operating range, and cycle count for the M6.

Speed Control

The speed of the M6 is regulated by a closed loop feedback system which can maintain relatively constant speed while line voltage and motor temperature vary.

Adjustment of speed is performed via a 10 turn locking dial (E) on the front panel of the M6 controller. Directly above is the digital speed readout (A); this meter reads in revolutions per minute or cycles per minute, and is updated once every second. The range of the speed control is approximately 70-2000 rpm depending on load, line voltage, and motor temperature.

Temperature Control (See Watlow Controller Manual)

The temperature of the M6 is maintained by a Watlow Model 985 time proportioning controller (C) with matched RTD temperature sensor, and a 20 or 100 watt cool top heater. The sensor and cartridge heater are inserted into the upper head and plugged into the controller. Note that the sensor must be in the head when the temperature controller is on or the cartridge heater will be uncontrolled. Leave heater unplugged during set up.

Adjustment of temperature is performed by programming the controller as follows.

- 1) Press the up and down arrow keys simultaneously and hold for approximately 5 seconds until upper display reads 3 and lower display reads "LOC."
- 2) Press down arrow so upper display reads 2, then press mode key several times until setpoint and actual temperature are displayed.
- 3) Use arrow keys to adjust lower display to desired setpoint.
- 4) Press the up and down arrow keys simultaneously and hold for approximately 5 seconds until upper display reads 2 and lower reads "LOC."
- 5) Press up arrow key so upper display reads 3 then press mode several times till setpoint and actual temperature are displayed.

Note: If desired, temperature controller may be left in LOC 2 level. To do so, skip steps 4 and 5. There are four levels of lockout for the Model 985; see page 25 of the Watlow manual for their descriptions.

The model 985 controller is equipped with high and low alarm circuits. If either one is exceeded, the machine will shut down if in the Run mode.

NOTE: Alarm circuits are programmed to a deviation of -5°C (low) and +3°C (high) from setpoint and will reset when temperature returns to this range. Therefore, it is not necessary to manually reset the temperature controller when the "start" button is pushed.

Systemic Pressure Range/Safety Shut Off

Systemic operating pressure is displayed on the front panel gauge (G2), and is monitored by a high/low pressure switch which is connected to the capacitance tank. Should a leak in the system occur or overheating increase the pressure, the switch will remove power from the motor controller and must be manually reset. The pressure operating range is factory set to 1.5 psig (low) and 5 psig (high). These levels may be changed by opening the cabinet and adjusting the pressure switch. This will be discussed later.

SET UP/RUN Switch

If the operator chooses to temporarily run the machine with no systemic pressure (e.g. during set up), the safety switch may be overridden by flipping the SET UP/RUN switch on the back panel to "SET UP". This causes the set-up light on the front panel to be illuminated, serving as a reminder that the safety switches are being bypassed. Under no circumstances should the instrument be operated unattended in this configuration. Terrible things could happen.

Start/Stop

Not only do these switches perform the standard function of turning the machine on and off, but they also serve to reset the safety switches if they are activated or if power is temporarily removed from the unit. This means that if the operation of the instrument is interrupted for any reason while unattended, it will not go back on by itself. We have found this to be the best way to keep from damaging valves during a rapid restart. Note: When restarting, always begin by setting motor speed dial to 0. The start button must be depressed for 2-3 seconds to engage.

Cycle Count

Cycle counting is done on a Photoswitch Series 8000 Type 80 DLU Programmable Dual Preset Count/Rate Meter (B), with a proximity sensor (also used to drive the digital speed readout).

The 80 DLU comes preprogrammed for its most flexible uses with the M6. The counter has a six digit display, but is programmed for two display modes, one scaled and one not scaled. The scaled mode displays three digits to the left of the decimal point and three to the right and is read as millions of cycles.

Example: $(378.621 = 378.621 \times 1,000,000 = 378,621,000)$. The other display mode (not scaled) displays the six least significant digits, and would display 621.917 in the above example if the count was 378,621,917 cycles.

The 80 DLU is a very versatile device, and users are here urged to familiarize themselves with its operation; a user's manual is included with shipped documentation. As an example of its capacities, one may set the instrument to shut off at a preset number of cycles. By setting Preset 1 to the number of cycles you wish to test to, the counter will remove power from the motor speed controller when that number of cycles is reached. The motor must be restarted manually by pushing the green start button (D) on the front panel if Preset 1 is changed. It is also possible to lock the keyboard to prevent accidental zeroing of the total cycle count. Again, the user is referred to the 80 DLU manual for a full description of its uses. The 80 DLU's nonvolatile memory will hold the count indefinitely.

CONNECTIONS TO EXTERNAL DEVICES

Power: Plug the black power cord (L) to line stabilizer/conditioner LS600 (which is supplied with M6) and plug line stabilizer/conditioner into a 115 VAC 60 Hz outlet and switch on.

Drive Motor: Plug the orange DC OUT (M) into orange motor power cord.

Proximity Sensor: Plug the proximity sensor cable from the M6 to its input (N), and tighten locking ring.

The following connections should be made after set up (chamber filled and debubbled, desired cycling speed and operating pressures selected, external capacitance tank filled, controller in the run mode).

Pressure Tube: Connect the pressure tube (H) which exits the rear of the controller cabinet to the plastic fitting at the top of the capacitance tank.

Heater: The heater is plugged into socket (O). Note: Machine must be filled before connection is made.

Temperature Sensor: The temperature sensor is plugged into socket (P).

GENERAL OPERATION

Power

The main power switch (K) is located at the lower left of the rear panel.

Set Up Mode (Refer to Figure 2)

As mentioned previously, while setting up the M6 it is sometimes desirable to run the drive motor without systemic pressure. Therefore, a SET UP/RUN switch (I) is provided. When the switch is in the SET UP position, the automatic shut down of the drive motor is bypassed, allowing the drive motor to run regardless of the condition set by the controlling devices. That is, the drive motor will run whether or not the operating pressure is outside of the range set by the pressure switches and regardless of the state of the cycle counter. The Watlow temperature controller limit (alarm) switches are bypassed in SET UP mode. The limits are factory preset to a deviation of -5°C and +3°C of the setpoint. For example, if the temperature setpoint is 37°C, the lower limit is 32°C and the upper limit is 40°C. If the temperature goes outside these limits while in RUN mode, the M6 drive motor will shut down. In SET UP mode, however, the M6 will continue to run when the temperature is outside the limits. When in SET UP mode, red lamp (G) will be on to indicate selection.

REMEMBER, DO NOT LEAVE THE M6 UNATTENDED IN THIS MODE.

Starting and Stopping Drive Motor

When starting the drive motor, it is best to set the speed control dial (E) to the zero setting, then depress the green start button (D), and slowly increase the speed control dial (E) to desired speed. Stopping the drive motor is done by depressing the red stop button (F). It is a good habit to now return the speed control dial (E) to zero.

Preparation For Run Mode and Capacitance Tank Installation

The capacitance tank may be installed in the following way: When the valves have been installed, fluid has been added and debubbled, the M6 has been returned to level position with heater and sensor installed, and the temperature is within the temperature range defined by the controller limit switches, set the speed control to 0 and switch from SET UP to RUN mode. Next, install stopcock and adaptor fitting into the top center of capacitance tank, then install two (2) plastic tube fittings into remaining holes on capacitance tank, one on top and the other on the side. When all tube fittings are in place, connect the four foot length of 1/8" ID tubing to the capacitance tank and fill with 70-100 cc of fluid. Connect this Tygon tube from the side of the capacitance tank to the plastic fitting on the M6. Place capacitance tank behind the M6 and connect the pressure tube exiting the back of the controller cabinet to the tubing adaptor on the top of the capacitance tank. Using a syringe or rubber bulb, adjust the systemic pressure by pressurizing the capacitance tank to 2-3 psig as indicated on the pressure gauge. Start drive and bring up to speed and check running pressure. Adjust capacitance tank pressure to obtain desired running pressure. Return speed to zero. You are now ready to start testing. To do so follow the procedure below.

- 1) Set the Counter: (see Photoswitch 80 DLU Manual)

The counter is preprogrammed before shipping to show the six most significant digits. The keypad is shipped unlocked for all functions.

If interested in locking the keypad, see: Setting Security Lock (see page 40 of 80 DLU Manual).

If interested in choosing a preset number of cycles see: Setting Preset (see page 40 of 80 DLU Manual).

To Zero Counter

STEP	DEPRESS	DISPLAY WILL SHOW
1	CE then PGM	F.C 2
2	6 then ENT	6.1 1
3	2 then ENT	0000
4	1 then 2 then 3 then 4 then ENT*	9.1 0
5	9 then ENT	Present Count
6	RA	0.000
7	CE then PGM	F.C 2
8	6 then ENT	6.1 2
9	1 then ENT	6.2 6
10	ENT	0000
11	1 then 2 then 3 then 4 then ENT	0.000

* 1234 is the lock code chosen by Dynatek. Any combination of four digits can be used. If code is changed when locking, the same code must be used to unlock. If code is forgotten, see page 24 of Photoswitch manual, paragraph entitled "Lost Code Protection".

Note: At the end of Step 5, counter is in the RUN mode and now unlocked. Step 6 resets counter to zero. Steps 7 to 11 rellock counter.

- 2) Set temperature. Allow the temperature to come up into the setpoint deviation range.
- 3) With capacitance tank pressurized and count zeroed, you should now be able to keep the SET UP/RUN switch (I) on RUN.
- 4) Set the speed. Turn speed control dial (E) to zero and depress green start button (D) and slowly bring up to correct speed. If drive will not engage, check capacitance tank pressure. If the capacitance tank pressure proves to be correct, switch to SET UP and start. If drive starts, it may be possible that the pressure switch needs to be adjusted (see Pressure Switch Adjustment). You're off!!

Once drive is engaged, the M6 will run until a preset is reached or pressure is lost.

Filling and Debubbling

In our age of high tech testing it's interesting to note that bubble removal is one of the biggest challenges facing a valve tester. It must be stressed, however, that the presence of bubbles in the test fluid can erode both leaflet and occluder type valves. While setting up, be patient and the bubbles will leave. Also note during this time if any vibration is causing the instrument to "walk." If it does, padding, restraints or leveling may be necessary.

We have found that the most tenacious bubbles are within the convolutions of the bellows. As a result we recommend two separate set up procedures. The first is designed to initiate a dry machine or change the nature of the fluid in an already set up instrument. The second is to install the valves into an already initialized machine or change the valves in a completely set up instrument.

To Set Up a Dry Machine (SET UP mode):

- 1) Install a set of empty valve blocks and the temperature sensor.
- 2) Loosen all pressure port cap screws and replace one of them with the enclosed stopcock.
- 3) Place a tank full of your testing fluid above the M6 and start a syphon with the five foot length of 3/16" Tygon that is supplied. Put this tube into the heater port (largest hole) and feed it all the way to the bottom of the reservoir.
- 4) Let the machine fill slowly. As the level reaches the upper head retighten the pressure port cap screws after all air has been bled from their vicinity. Close the stopcock as well.
- 5) Remove the syphon tube from the M6 and fit the funnel/Tygon tube adaptor over the threads of the heater port. Add enough fluid to fill the funnel tube 2" deep.
- 6) Using the SET UP switch, turn on the machine (CAUTION: BE CERTAIN THE HEATER IS NOT PLUGGED IN) and increase the speed slowly to approximately 1000 rpm.
- 7) Maintain 1000 rpm for 5 seconds and then reduce speed to 500 rpm for 30 seconds. You will note that the released bubbles will have a tendency to vortex and exit through the funnel. Be sure to maintain the fluid level in the funnel during the procedure.
- 8) Repeat this speed cycling until most of the visible bubbles (larger than a period on this paper) are removed, perhaps 10 to 20 repeats.
- 9) Set the speed to 0 and remove any collected air via the stopcock or pressure port cap screws if possible.
- 10) Continue steps 8 and 9 until instrument is debubbled. Note that most of the very tiny bubbles will disappear as the machine heats up, so at this point install the heater and set controller to 98° F (37° C).

To Install Valves (SET UP mode):

- 1) Use the 3/16" syphon tube to remove fluid via the heater port. This will empty the upper and lower heads but will not empty the bellows.
- 2) Loosen the 1/2" nylon bolts to free the test sections. Remove lower pressure port cap screws and slide out the test sections. Install valves (see Valve Installation, next section).
- 3) Replace test sections with valves installed.
- 4) Retighten 1/2" nylon bolts. Tighten in a symmetrical sequence. If the bolts were numbered 1-6, tighten them 1,4,2,5,3 then 6. Keep going round gradually making the bolts tighter until test sections are snug and all O-rings seated. (Caution: Hand tighten only; use of wrenches could strip threads.)
- 5) Refill using the syphon tube.
- 6) Follow steps 4 - 10 in section "To Set Up A Dry Machine".

Note that leaflet valves have a tendency to trap bubbles. You will need to fine tune your procedure to match your valves. Sometimes a plastic applicator inserted through the pressure port can gently move leaflets to release trapped air.

Valve Installation

Valves are installed in each of the separate valve blocks using suitable silicone O-rings where necessary depending on the valve type and geometry. Valve test section blocks are tailored to the specific valve type and size. It may be possible to run two sizes of valves in the same valve block configuration. Adapters (often just O-rings) may be necessary.

If you have any questions contact Dynatek and we will evaluate your valve dimensions and recommend test sections or mounting procedures.

Loosen the six 1/2 inch nylon bolts 2 or 3 turns and lift top plate to free valve blocks so that they will clear the transducer plug screws.

Install valves with valve discharge downward. Valves 25 mm nominal size and smaller require inlet adapters (furnished with test sections on request). Small valves may also be adapted easily using thicker (3/16 or 1/4 inch) cross-section O-rings.

Replace valve blocks with their orange silicone O-rings. Note that the valve block bases may be slightly rectangular. The smaller dimension is fitted back into the block positioner brackets on the bottom plate and centered. Push opposite pairs of blocks into position.

Tighten down 1/2 inch bolts. Hand tighten only! These plastic bolts are furnished to facilitate hand tightening and prevent the use of a wrench. Lightly tighten opposite pairs using both hands for an even pull-down. After initial tightening,

loosen all six bolts about one turn, check position of blocks again as above and retighten bolts. This double tightening procedure assures correct alignment.

The machine is delivered with a pump-bellows drive amplitude of about 1 mm. It is now necessary to set the machine for the desired valve closing pressure. First, however, the pressure transducers must be calibrated.

Pressure Calibration (See Figure 3)

The following calibration instructions assume the use of the Dynatek XSC pressure transducer electronic control unit and appropriate pressure transducers such as the Endevco 8510B-5. (If desired, calibration may be performed outside the M6 with direct connection to a manometer.) After the system is filled, debubbled, and systemic pressure is set to 0, the pressure transducers may be installed. Each transducer is provided with a gasket; light finger tightening is sufficient for a good seal. Remove the transducer port plug in the bottom plate and install the A transducer. A drop or two of fluid may come out of this port. There will be no other leakage because the system is completely sealed. Place the B transducer in the upper port.

Plug the transducers into the XSC inputs under "Voltage Adjust" and connect the outputs to a dual-channel oscilloscope. Turn XSC on.

Place the syringe barrel with rubber stopper in the stopcock. Fill the syringe barrel about half full of fluid. Insert the tube stopper. (See Figure 3.) Connect a sphygmomanometer to the stopper tube as illustrated in Figure 3.

Ground oscilloscope inputs and set the zero for each channel with the position controls. Switch oscilloscope to DC. Adjust each channel to zero with balance controls on XSC.

Apply 100mm Hg pressure to the system with the sphygmomanometer. Adjust "Voltage Adjust" pots on front of XSC to give a convenient deflection, such as 2 cm.

NOTE: the buffered outputs of the XSC are amplified from approximately 2X at a potentiometer setting of 0 to approximately 10X at a setting of 10. Adjusting both outputs should give a differential signal of 0mV at a pressure of 100mm Hg. We recommend a potentiometer setting as close to 0 as possible to result in 0mV differential signals.

Open manometer to atmosphere and recheck zero. Apply 100mm Hg again and check for scope deflection. The system is now calibrated to give 50mm/ 1cm deflection on the oscilloscope. Keep in mind that this process is just one example of the procedures that might be used. Actual output magnitude is at the discretion of the user.

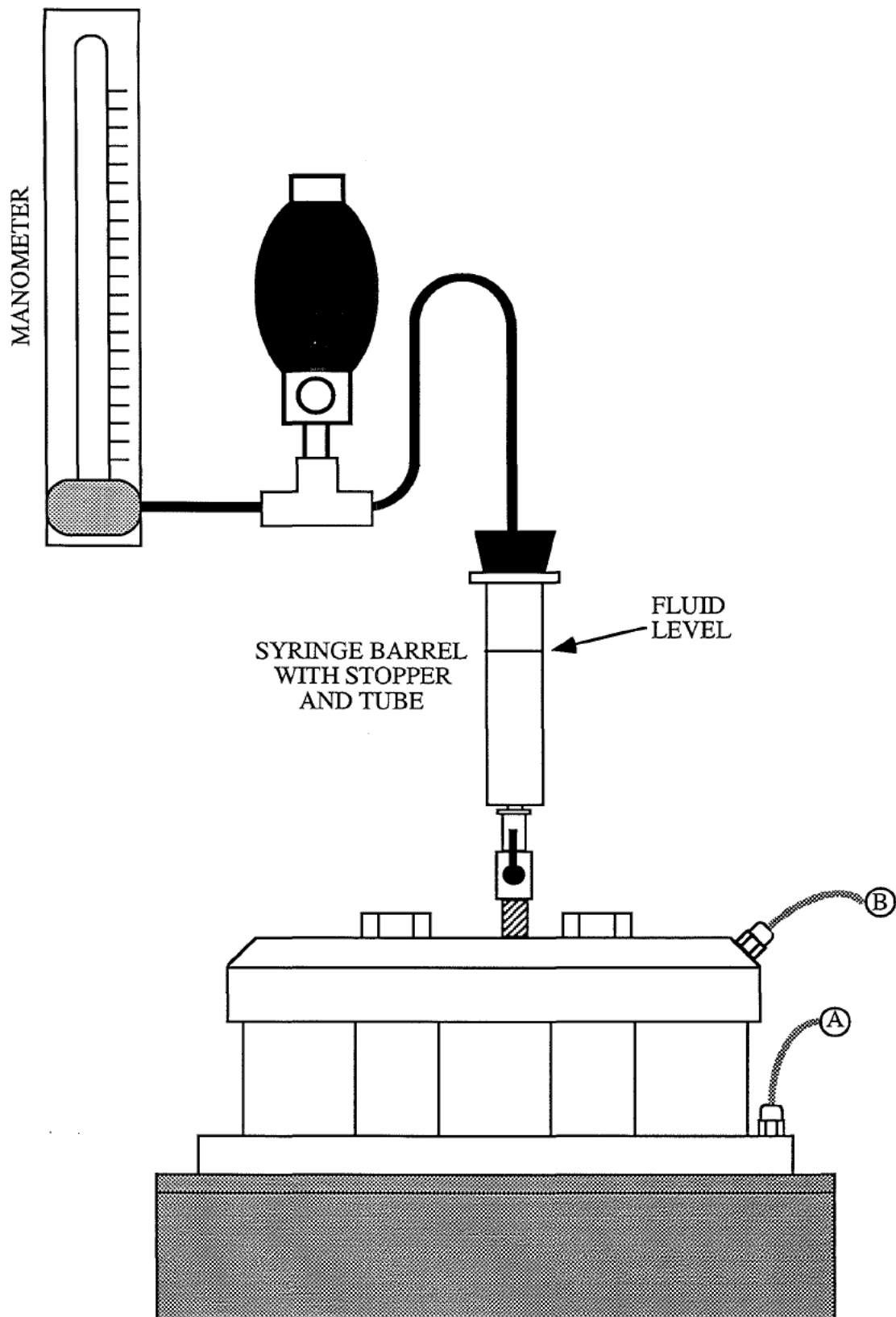


Figure 3
 Set Up For Transducer Calibration.
 A and B Are Transducer Locations
 To Give Differential Pressures ($p_A - p_B$).

Setting the Pressure and Flow Rate

The valve closure loading pressure (closing pressure) is a function of the speed, the magnitude of the bellows compression, and the setting of the center throttle valve in the valve head. The machine is capable of speeds to 2000 cpm. Tissue valve flutter has been found to be an adverse operating condition so that cycle rates of 1000-2000 cpm are considered to be maximal. (See below.) If investigation of a particular failure mode is desired independent of longevity, higher rates and pressures may be used.

Pressure transducer taps are located at regions of equal area to give an accurate indication of pressure. The most important pressure measurement during the cycle is at valve closure when the flow is zero. The problems associated with dynamic pressure measurement are minimal at this instant so that closure loading pressure measurements are accurate. A sample differential pressure trace is shown in Figure 4. The closing spike is superimposed on a sinusoidal pressure oscillation. The minor oscillations are impulses from the closing of the other valves or bellows compression.

Fluid property variations are of little consequence at accelerated cycle rates. The Reynolds and Strouhal numbers are sufficiently supercritical that viscosity variations from 1 cp to 20 cp will have no effect on the flow and valve motion dynamics. Density is also not a factor since its main effect is in the determination of the pressure which is set directly.

Buffered saline is recommended for tissue valves. An alternate fluid is a 48% glycerol/ 52% saline mixture that has a viscosity about equal to that of blood at 37° C. This mixture also provides somewhat better lubricity for valve operation. In all cases, an agent to inhibit microorganisms (e.g. Kathon CG from Rohm and Haas) should be used.

There are several criteria that one must meet before proper instrument adjustment is completed. For all valve types these include:

- 1) Complete valve opening during each cycle (use a stroboscope).
- 2) Complete valve closing during each cycle (use a stroboscope).
- 3) Presence of a reproducible (this depends on your criteria) closing spike.
- 4) After 12 hours running at elevated temperature (e.g. 37° C), no bubbles present.

Some special considerations include:

For leaflet valves, absolutely no leaflet end flutter.

For mechanical valves, absolutely no cavitation. This can be seen as a transient flash of light as a gas bubble sweeps across the surface.

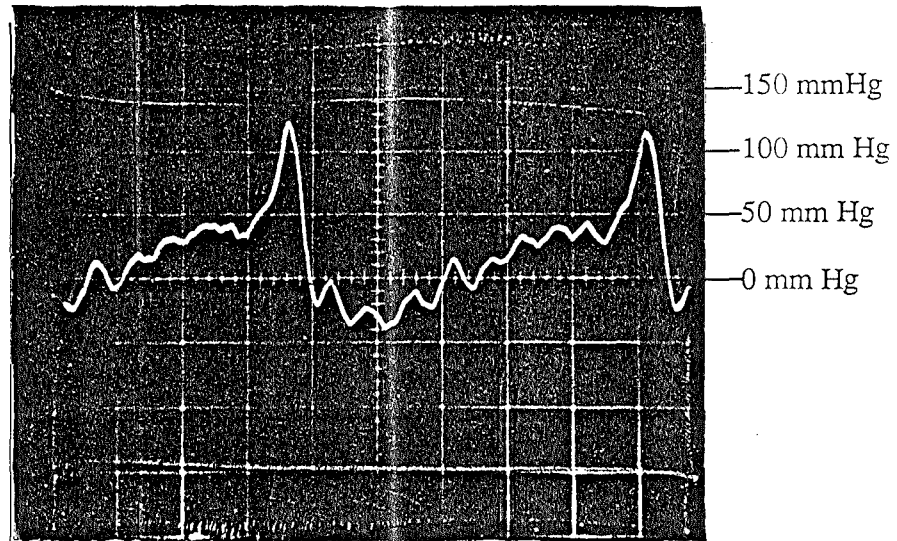


Figure 4. Differential Pressure Trace

Valve: 27mm Tissue
Speed: 1070 cpm
Volts/Div: 0.2/cm
Time/Div: 10ms/cm

Lack of sensitivity to these considerations simply renders your testing invalid and might destroy your valves prematurely. So don't do it.

Tissue Valves:

The following adjusting procedure is suggested for the setup of tissue valves.

Set the drive amplitude at the edge of the swashplate to 1 to 2 mm, nominally 1 mm for smaller valves and 2 mm for larger valves. Set the throttle valve at its center position as described in the DESCRIPTION section.

Insert and calibrate pressure transducers as described in the section on PRESSURE CALIBRATION. Watch the pressure trace on the oscilloscope while slowly increasing the speed. If the differential pressure exceeds its desired value, open the throttle valve a little. (See throttle valve procedure under DESCRIPTION.) If the pressure is not high enough, close the throttle valve a little. If the combination of speed and throttle valve settings does not produce a high enough pressure, increase the swashplate offset about 1/2mm and repeat above procedure. If the pressure is too high, open the throttle valve, etc.

When the desired pressure and motion have been obtained, the valve test may be started.

Remember: Full opening, full closing and no leaflet flutter.

Mechanical Valves:

A nominal testing cycle rate range for mechanical valves has been determined as 1200-1600 cpm. It is difficult to prevent cavitation at higher speeds in any accelerated rate machine.

The maximal speed for mechanical valves has been found to be limited by cavitation which occurs around the periphery of the occluder during maximal occluder motion (and therefore velocity) and at the instant of closure. Cavitation is reduced or inhibited by the following operating conditions: (1) minimal fluid temperature, (2) minimal flow rate, (3) minimal cycle rate, and (4) maximal system pressure. Cavitation is observed at the periphery of the occluder with a stroboscope at the instant of valve closure. It will appear as a fraction-of-a-millisecond flash at the location of maximal occluder motion. The maximal recommended system operating pressure is 5 psi. Laboratory or room temperature is suggested for testing of mechanical valves. Their material is insensitive to temperature variations from 10° C to 60° C.

Mechanical valves are much more difficult to get to close for two reasons: They have a higher dynamic closing backflow, and their occluder-fluid dynamic flow conditions in both the mitral and aortic positions during closing are counter to

those for a natural or tissue valve. The test section geometry for mechanical valves is therefore different from that for tissue or original equipment valves.

Example: The dynamic closing regurgitory backflow for mechanical valves is on the order of 5-7%, or 4-5 cc. The volume flow/pulse at accelerated rates is much less than at normal rates, nominally 5-6 cc. The available pumping volume to produce closure is therefore severely limited. It may take more time to "tune" the system to obtain the desired combination of speed and closing pressure for mechanical valves.

The differential loading pressure for mechanical valves is set with the same procedure as described under Tissue Valves.

Remember: Full opening, full closing and no cavitation.

Valve Removal

One or more valves may be removed for inspection or replacement. It is only necessary to drain the top module. Bleed the fluid pressure off the system with the stopcock syringe. Air may be pulled into the top plate since this part of the system is to be drained.

Unscrew the heater fitting nut and remove the heater with the nut. Insert a tube to the bottom of the center chamber and siphon off the fluid to the bottom of this chamber. This volume will be less than one liter.

Loosen the hold-down bolts enough to free the valve block to be removed and pull the block out. Be careful not to drop or pinch the O-rings. The top plate may be removed if desired.

SERVICE AND MAINTENANCE

Valve Head and Throttle Valve

The top plate and valve blocks are removed as described under Valve Removal. The center throttle valve cylinder is removed by first backing off its jack screws and then lifting it with a rotary oscillating motion.

Pumping Unit

First remove the eight allen-head cap screws around the outside of the aluminum clamping ring that clamp the bottom plate to the top cylinder sectors. Leave two opposite screws in until the remaining six are out. Then unscrew these two alternately about one turn at a time (or both at the same time). The bellows are pre-compression loaded 0.1 in. They last longer in compression than in tension, and a positive sealing pressure is maintained on the O-rings. This bottom plate and ring should be pulled down evenly when reassembling. (Do not remove the

inner ring of eight stainless steel cap screws. Removal of the ring from the plate is never necessary except in case of breakage.)

Loosen the three tilt coupling clamp screws and lift off the pumping unit. It may be necessary to pry up on the coupling between it and the shaft collar with a large screwdriver to get it started. It is necessary to lift from under the bottom of the tilt coupling since it will cock and bind if the unit is lifted by the swashplate. The coupling is keyed to the motor shaft.

Aligning the coupling, key and motor shaft is a little tedious, but not difficult, when reassembling. CAUTION: The coupling clamp screws should always be tightened securely before operating the machine!

Note that three of the cylinder sectors have been left attached to the motor plate.

Proximity Sensor

The proximity sensor should only have to be removed in the unlikely event that the motor or motor bearing needs to be replaced. It is easier to remove the sensor and its mounting bracket as one unit by removing the two socket head cap screws holding the mounting bracket. To reassemble, use the socket head cap screws to lightly install the mounting bracket (with the sensor in place). Use a feeler gauge to adjust the position of the bracket so that the sensor is 0.008" from the surface of the reflecting tape attached to the motor shaft collar. Tighten the socket head cap screws.

Motor Drive

The motor is easily removed by first removing the four 3/8 inch allen-head screws. The motor will drop to the table when the clamping thrust collar is loosened. A 1/2 inch or 1 inch thick pad may be placed under the motor. Lift the cylinder assembly up off the motor. Note the shims that provide for a square alignment of the motor C-face with the motor plate. Also note the thrust washer under the clamping ring. This bearing may be removed by removing this ring.

Inside the Control Console

Although not usual, it may be necessary to perform some work on the inside of the M6 control box. This work may be for one or more of the following: To replace fuses for individual components such as the counter, speed indicator, etc, or to adjust the pressure switch settings.

Opening Top Cover

First turn main power switch OFF and unplug the M6 from its power source. Remove the button screws from the sides of the cabinet, and lift the cover. The unit is now ready for service. The M6 may be run for short periods with the cover open, but should be closed for proper cooling during long operations.

Fuse Replacement

In addition to the main power fuse (15 amp) on the rear of the controller, there are seven (7) others located in three areas within the control box. Two inline fuse blocks are located on the motor speed controller board. This board is positioned on the left side of the cabinet just below the digital speed readout. The right fuse is a line fuse (ABC10), and the left fuse is the armature (MDL 2). Four (4) fuses are located on the rear wall of the cabinet and are listed below from top to bottom:

Heater	3 amp
Counter	1/4 amp
Relay	1/4 amp
Fan/Set Up Lamp	1/4 amp

Pressure Switch Adjustment

Remove cover plate from pressure switch located behind the temperature controller. Remove all tools and cover plate from M6 and reconnect power to supply source, turn main power ON, and put SET UP/RUN switch in RUN position. Connect pressure tube and manometer and pump up to halfway between desired high/low setpoints. Make sure the temperature is within the deviation range of the setpoint. Next press the green start button (D) and observe temperature controller display. If display does not stay lit, you may already be above or below the present setpoints. In this case (facing the front of the controller) turn the left dial counterclockwise (ccw) and the right dial clockwise (cw). Again press the green start button (D), controller display should stay lit. If not, repeat above procedure.

Once motor is running at a pressure that is halfway between desired high/low setpoints, slowly raise pressure until switch is tripped and display goes dark. If this pressure is too high, turn right dial (ccw) and repeat till desired high point is set. Then with a pressure slightly less than the high set point, slowly reduce pressure until switch is tripped and display goes dark. Adjust the left dial (cw) to increase or (ccw) to decrease and repeat above procedure until desired low set point is set.

Replace pressure switch cover and tighten screws.

Turn M6 off and disconnect from power source, replace cover and mounting screws.

Reassembly

Set the motor on end with the shims in place and drop the cylinder, motor plate, and thrust bearing assembly over the motor shaft. It may be necessary to put a block under the motor to get the shaft far enough through the thrust bearing bore. Rotate the cylinder assembly until the motor face holes line up and insert the

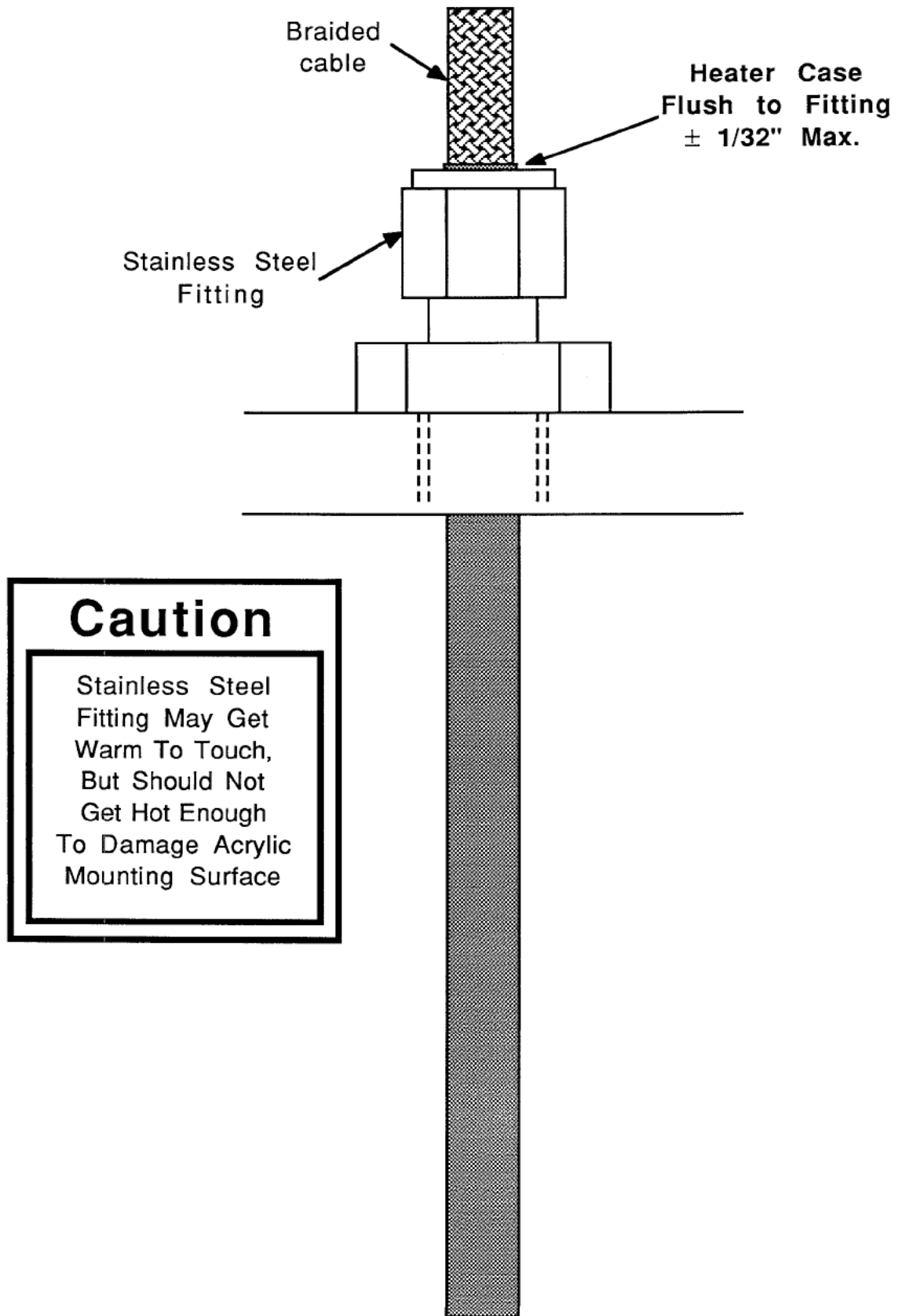
screws a few turns. Do not put any tightening pressure on these screws yet. Install the thrust washer and thrust collar and tightly tighten it. Carefully turn this sub-assembly upside down. Loosen the thrust collar, hold it against the washer and bearing and tighten it tightly. This procedure allows the thrust to be taken by this thrust bearing and the motor plate, rather than by the motor bearings, and provides a more positive motor shaft positioning. Tighten the four allen-head screws, lightly the first time, then tightly in a crosswise pattern.

Cleaning and Sterilization

Clean all parts of the machine with Alconox or a similar laboratory cleaner and rinse thoroughly. Machine sterility should be maintained throughout testing by incorporating an appropriate anti-microbial such as Kathon CG (Rohm and Hass). Sterilization after cleansing should be accomplished with a non-oxidizing agent such as isopropyl alcohol or a glutaraldehyde containing rinse. Under no circumstances should bleach be used since this and other oxidizing sterilizers will compromise bellows life. DO NOT USE BLEACH.

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APPENDIX



80DLU-8100 PROGRAMMING MENU

Function Code	Sub Function	Subfunction Options	Selection Number
1 Totalizer		No Options	NOT USED
2 Preset Control	2.1	Main Count continues counting at Preset Level 1	1 *
		Main Count resets to zero at Preset Level 1	2
		Main Count resets to Preset Level 1 at zero	3
	2.2	Main Count continues counting at Preset Level 2	1 *
		Main Count resets to zero at Preset Level	2
	2.4	Output 1 dwell time Enter 1 to 999,999 for dwell time in milliseconds or 0 to latch output 1 ON	0 *
	2.5	Output 2 dwell time Enter 1 to 999,999 for dwell time in milliseconds or 0 to latch Output 2 ON	0 *
	2.6	Not used	
	2.7	Outputs normally OFF	1 *
		Outputs normally ON	2
	2.8	Non-alternating (non-logging) outputs	1 *
		Alternate (toggle) outputs	2
3 Ratemeter	3.1	Ratemeter Enter 1 to 9,999 for timebase in milliseconds	1000 *
	3.2	Ratemeter scale factor Enter .0001 to 99.9999 or 0 or 1.0000 for a scale factor of 1	6.000 *
	3.3	Channel A drives the Ratemeter	1 *
		Channel B drives the Ratemeter	2
		Channel A and Channel B drive the Ratemeter	3
	3.4	Location of decimal point in displayed rate. Enter 1 through 6. 6 = X.XXXXX, 5 = XX.XXXX, ... 1 = XXXXXX, etc.	1 *
	3.5	Lower rate setpoint Enter 1 to 999,999	0 *
	3.6	Upper rate setpoint Enter 1 to 999,999	0 *
	3.7	Ratemeter Setpoints OFF	1 *
		Ratemeter Setpoints ON	2
	3.8(*)	Ratemeter timebase scale factor 1X (Subfunction 3.1 value in milliseconds x 1)	1
		10X (Subfunction 3.1 value in milliseconds x 10)	2 *

* = Program selections chosen by DYNATEK prior to shipping

80DLU-8100 PROGRAMMING MENU

Function Code	Sub Function	Subfunction Options	Selection Number
NOT USED 4 Communication	4.1	Serial communication setup	
		110 baud	1
		300 baud	2
		600 baud	3
		1200 baud	4
		2400 baud	5
		4800 baud	6
		9600 baud	7
	4.2	Network address set to 00 for current loop communication set to 01 to 99 for RS-232C or RS-423 communication	
5 Input/Output	5.1	Count up Channel A, count down Channel B	1
		Count up Channel A with Channel B ON, count down Channel A with Channel B OFF; or Quadrature X1	2
		Count up Channel A with Channel B ON	3
		Count up Channel A and Channel B	4
		Count up Channel A scaled, count up Channel B not scaled	5 *
		Count up separately (two independent counters)	6
		Not used	7
		Quadrature X2	8
		Quadrature X4	9
		Count down separately (two independent counters)	10 (*)
	5.2	Count on Trailing edge of input signal	1 *
		Count on Leading edge of input signal	2
	5.3	Enable Internal Debounce	1
		Disable Internal Debounce	2 *
	5.4	Reset like RA-key on Trailing edge of external reset signal	1 *
		Reset like RA-key on Leading edge of external reset signal	2
	5.5	Preset 2 clears Output 1	1
		Preset 1 clears Output 2	2
		Both of the above	3
		No Output interlocking	4 *
	5.6	External Output Control Signal turns all outputs ON	1
		External Output Control Signal turns all outputs OFF	2
		External Output Control Signal simulates a count reaching Preset 1 (Crop cut like Preset 1)	3
		Not used	4 *

80DLU-8100 PROGRAMMING MENU

Function Code	Sub Function	Subfunction Options	Selection Number
5 Input/Output	5.6	External Output Control Signal bypasses Preset 2	5
		External output control Signal enables/disables Hertz timer	6
		External Output Control Signal simulates a count reaching Preset 2 (Crop Cut like Preset 2)	7
		External Output Control Signal forces serial communication	8
		External Output Control Signal resets the Auxiliary Count when Subfunction 5.1 = 6	9
	5.7	Location of decimal point in Main Count. Enter 1 through 6 6 = X.XXXXX, 5 = XX.XXXX, ... 1 = XXXXXX.	4 *
	5.8	Main Count scale factor Enter .0001 to 99.9999 or 0 or 1.0000 for scale factor of 1	0.0010 *
	5.9	Location of decimal point in Auxiliary Count. Enter 1 through 6. 6 = X.XXXXX, 5 = XX.XXXX, ... 1 = XXXXXX.	1 *
	5.10	Auxiliary count scale factor Enter .0001 to 99.9999 or 0 or 1.0000 for a scale factor of 1	1.0000 *
	5.11	Display Truncate result of scaled operation	1 *
		Display Round off result of scaled operation	2
	5.12	Background Ratemeter OFF	1
		Background Ratemeter ON	2 *
	5.13(*)	Totalize without direction	1 *
		Totalize with direction	2
6 Locking	6.1	Lock the keypad	1 *
		Unlock the keypad	2
	6.2	Lock all menu modes except Function Code 6	1
		Lock preset levels only	2
		Lock all except preset levels	3
		Lock Preset Level 1 only	4
		Lock Preset Level 2 only	5
		Lock all except Preset Level 1	6 *
		Lock all except Preset Level 2	7
	6.3	Lockcode if locking enter 0000 to 9999 if unlocking, four digits must match the code used to lock	1234
7 Preset Level	7.1	Preset Level1 Enter 1 to 999,999	0 *
	7.2	Preset Level 2 Enter 1 to 999,999	0*
	7.3	Not used	
	7.4	Not used	
		Not used	

80DLU-8100 PROGRAMMING MENU

Function Code	Sub Function	Subfunction Options	Selection Number
8 Diagnostic		No Options	
9 Run/Edit	9.1	Totalizer	1
		Preset Control	2
		Ratemeter	3
		Serial Communication setup	4
		Input Setup	5
		Locking	6
		Preset Levels	7
		Diagnostics	8
		Run	9

* = Program selections chosen by DYNATEK prior to shipping

Programming Menu for 80 DLU Counter

LOADING OR RESETTING COUNTER TO A NUMBER OTHER THAN ZERO

Example below is to load 125,000,000 cycles and set preset to 150,000,000:

STEP	DEPRESS	DISPLAY WILL SHOW
1	CE then PGM	F.C 2
2	6 then ENT	6.1 1
3	2 then ENT	0000
4	1 then 2 then 3 then 4 then ENT*	9.1 0
5	2 then ENT	2.1 1
6	3 then ENT	2.2 1
7	ENT	0
8	ENT	0
9	ENT	2.7 1
10	ENT	2.8 1
11	ENT	9.1 0
12	7 then ENT	Present Preset Level
13	1 then 2 then 5 then 0 then 0 then 0 ENT	0
14	ENT	9.1 0
15	9 then ENT	Present Count
16	RA	125.000 or value loaded in step 13
17	CE then PGM	F.C 2
18	ENT	2.1 3
19	1 then ENT	2.2 1
20	ENT	0
21	ENT	0
22	ENT	2.7 1
23	ENT	2.8 1
24	ENT	9.1 0
25	7 then ENT	~~125000~~ 150000
26	1 then 5 then 0 then 0 then 0 then 0 then ENT	0
27	ENT	9.1 0
28	6 then ENT	6.1 2
29	1 then ENT	6.2 6
30	ENT	0000
31	1 then 2 then 3 then 4 then ENT	125.000

* 1234 is the lock code chosen by Dynatek. Any combination of four digits can be used. If code is changed when locking, the same code must be used to unlock. If code is forgotten, see page 24 of Photoswitch manual, paragraph entitled "Lost Code Protection".

TO CHANGE PRESET LEVEL ON PHOTOSWITCH 80 DLU COUNTER

Example below sets preset level to 125,000,000:

STEP	DEPRESS	DISPLAY WILL SHOW
1	CE then PGM then 7	Present preset level
2	1 then 2 then 5 then 0 then 0 then 0 then ENT	Present count

NOTE: The above procedure assumes that the counter is locked with subfunction 6.2 set to 6

To view Preset level:

Press the number 1, the small legend light above the display will show (PRE 1) and display will show present preset level.

To return to the main count display press CNT.

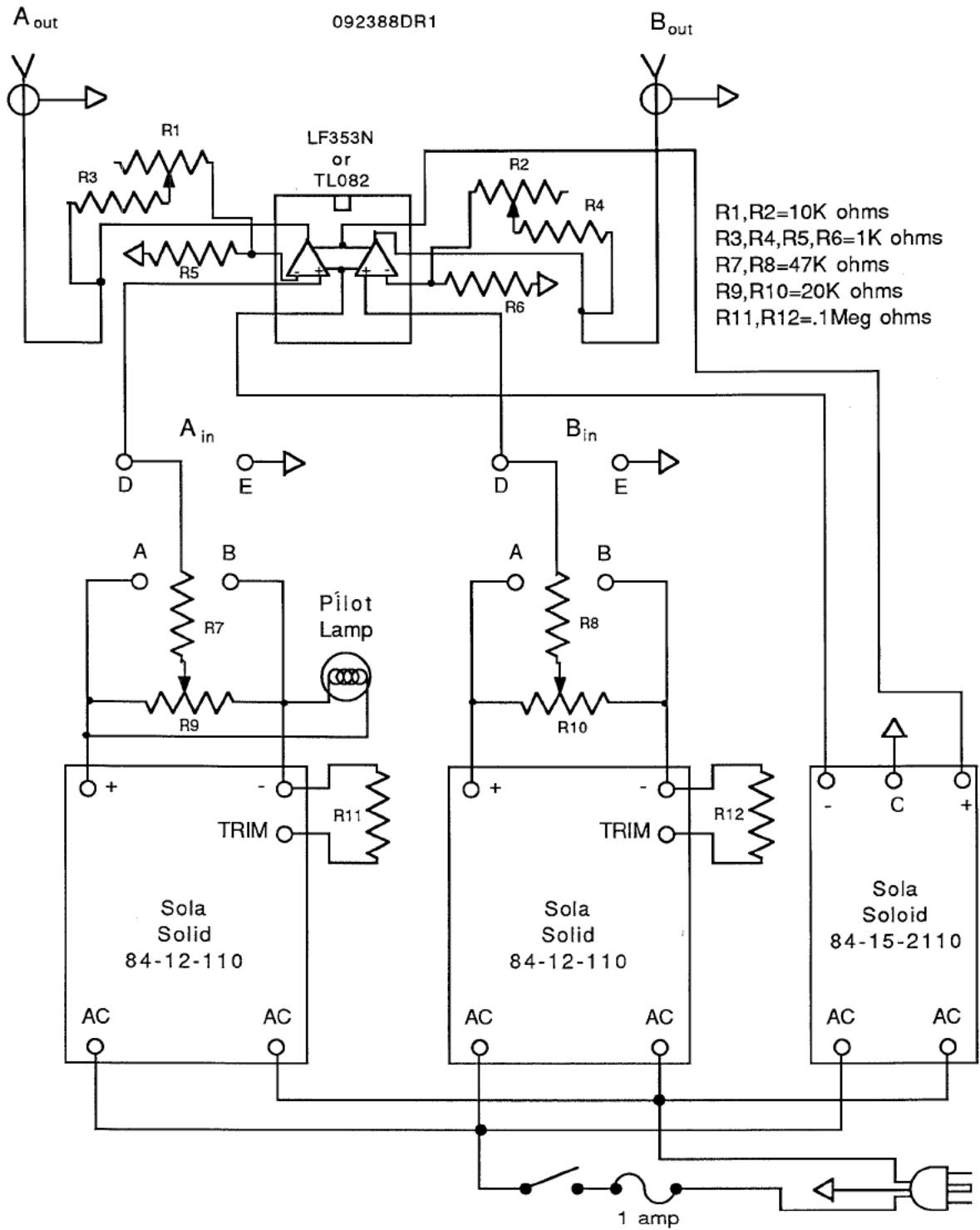
Below are the values chosen for the Watlow 985 prior to shipping.

Setup Parameters	Value	Range	Factory Default
LOC	3	0 - 3	0
In	rt.d	J, K, t, n, Pt2, rtd, rt.d, 0-5, 420 Dependent on model number.	J
rSP	OFF	OFF, 0-5, 420	OFF
DEC	N/A	0, 0.0, or 0.00 Dependent on input type.	0
C_F	C	C or F Will not appear if In = 0-5 or 420.	F
rL	15.0	rL to rH	Input selection dependent.
rH	40.0	rH to rL	Input selection dependent.
Ot1	Ht	Ht or CL	Ht
Ot2	AL	Ht, CL, AL or no	AL
ALt	dE	Pr or dE Dependent on Ot2 = AL.	Pr
LA t	nLA	LA t or nLA Dependent on Ot2 = AL.	nLA
SIL	OFF	OFF or On Appears if Ot2 = AL & ALt = dE.	OFF
rtd	din	JIS or din Appears if In = rtd or rt.d.	JIS

Operation Parameters	Value	Range	Factory Default
SP2	N/A	rL to rH	Same as primary set point.
Pb1	0.5	0 to 999°F/0 to 555°C or 0 to 99.9°F/0 to 55.5°C 0=ON/OFF control with 3°F or 1.7°C switching differential. 0.3°F or 0.17°C for 0.1° units.	25°F/13°C (3 or 4 digit)
Pb2	N/A	Same as Pb1. Only appears if Ht/CL or CL/Ht operation.	0°F/0°C (3 or 4 digit)
rE1	0.02	0.00 to 9.99 repeats/min. 0.00 = No Reset Action	0.00 repeats/min.
rE2	N/A	Same as rE1. Only appears if Ht/CL or CL/Ht operation. Will not appear if Pb2 = 0.	0.00 repeats/min.
rA1	0.48	0.00 to 9.99 min. 0.00 = No Rate Action	0.00 min.
rA2	N/A	Same as rA1. Only appears if Ht/CL or CL/Ht operation. Will not appear if Pb2 = 0.	0.00 min.
ALO - Deviation dE ~~Process Pr~~	-5.0	-99° to 0° (3 digit display) -999° to 0° (4 digit display) rL to AHl	-99° -999° rL
AHl - Deviation dE ~~Process Pr~~	3.0	0° to 99° (3 digit display) 0° to 999° (4 digit display) ALO to rH	99° 999° rH
Ct1	10	1 to 60 seconds	5 seconds
Ct2	N/A	1 to 60 seconds Appears if Ht/CL or CL/Ht. Will not appear if PB2 = 0.	5 seconds
db	N/A	±99°F/±55°C. Appears if Ht/CL or CL/Ht.	0
CAL	0.0	±99°F/±55°C	0
AUt	0	0-3 Appears if Ot1 = Ht.	0
L-r	N/A	L or r.	

XSC2AMP

092388DR1



For any questions concerning this machine, or if any problems arise with its operation, please feel free to call:

DYNATEK DALTA®
FOURTH AND MAIN
PO BOX 254
GALENA, MO 65656
(417) 357-6155
FAX 417-357-6327

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PRESSURE TRANSDUCER TEST REPORT

MODEL 8510B-5

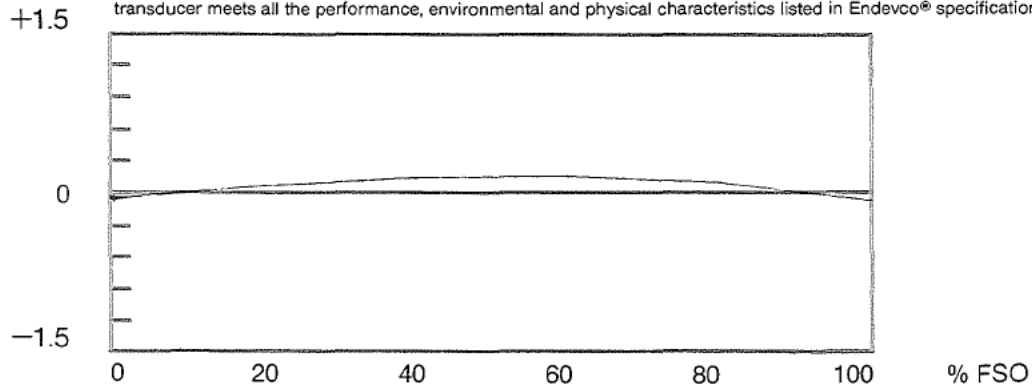
SERIAL # H66L

Range	5	psi
Sensitivity	59.13	mV/psi
Excitation	10.00	Vdc
Zero Pressure Output	5	mV
Full Scale Output	296	mV
Non-Linearity	.13	%FSO
Hysteresis	.03	%FSO
Non-Repeatability	0	%FSO
Combined Lin., Hyst., & Rep.*	.13	%FSO
Thermal Zero Shift	1.12	%FSO
Zero Shift After 3 X FSO	0	% 3 X FSO
Thermal Sensitivity Shift	1.46	%
Input Resistance	1907.4	Ω
Output Resistance	1604.7	Ω
Isolation Resistance	>100	M Ω

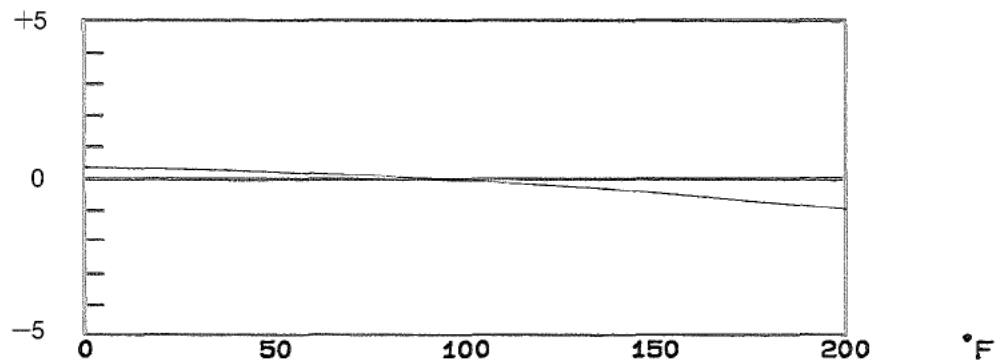
*RSS

All calibrations are traceable to the National Bureau of Standards and in accordance with MIL-STD-45662. This certifies that this transducer meets all the performance, environmental and physical characteristics listed in Endevco® specifications.

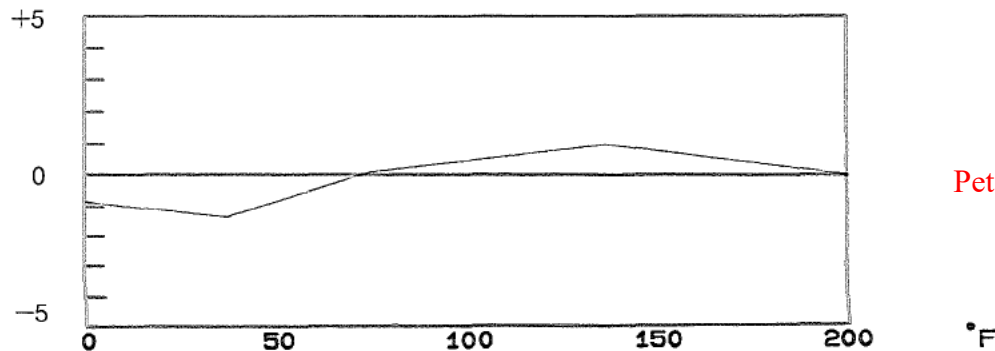
NON-LINEARITY
(% FSO)



THERMAL
ZERO
SHIFT
(% FSO)



THERMAL
SENSITIVITY
SHIFT
(%)



Petitioner's Exhibit 1031
VIVITRO v. BDC
IPR2024-00320

PRESSURE TRANSDUCER TEST REPORT

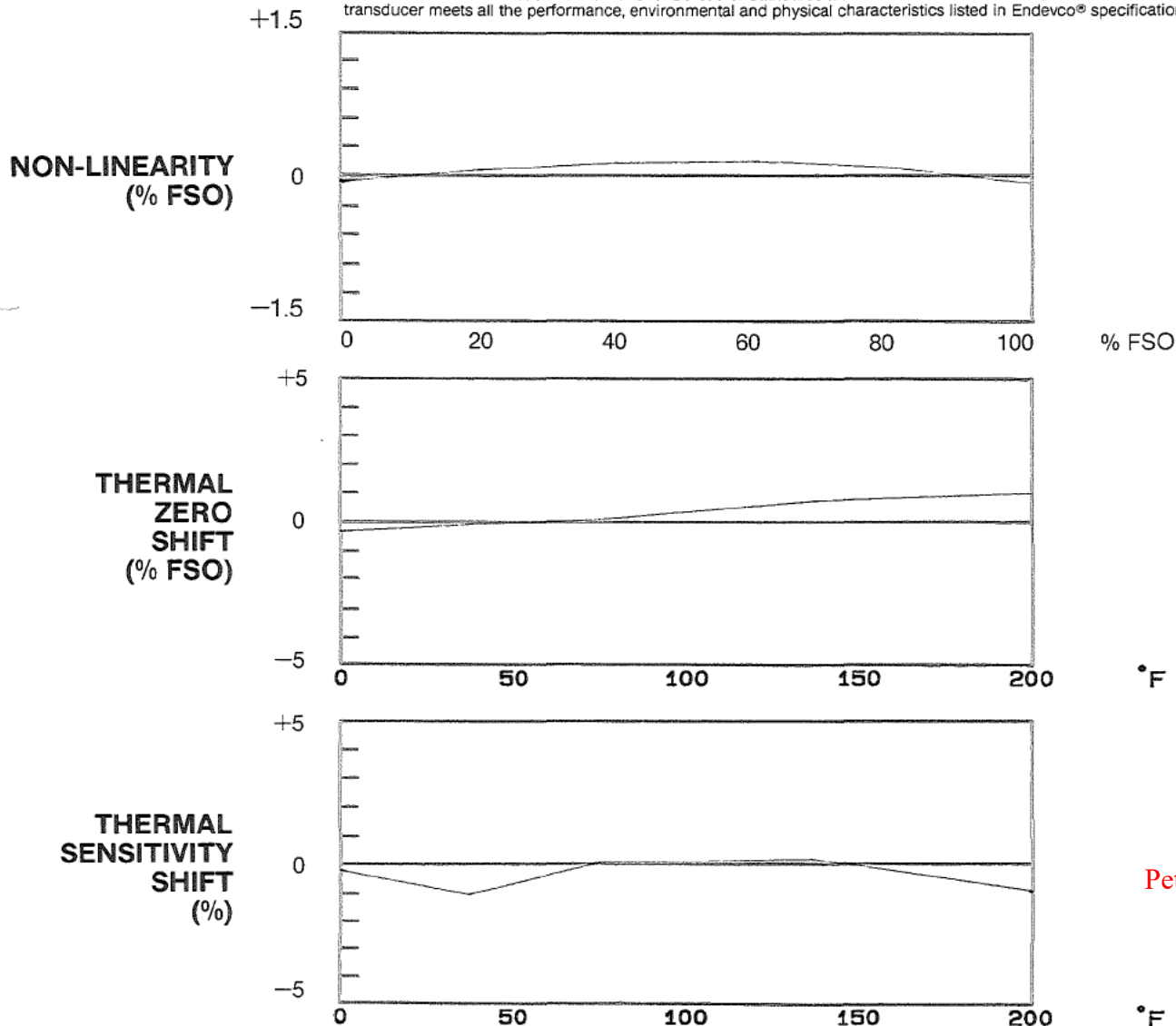
MODEL 8510B-5

SERIAL # H59L

Range	5	psi
Sensitivity	60.22	mV/psi
Excitation	10.00	Vdc
Zero Pressure Output	4	mV
Full Scale Output	301	mV
Non-Linearity	.13	%FSO
Hysteresis	.02	%FSO
Non-Repeatability	.02	%FSO
Combined Lin., Hyst., & Rep.*	.13	%FSO
Thermal Zero Shift	.91	%FSO
Zero Shift After 3 X FSO	0	% 3 X FSO
Thermal Sensitivity Shift	1.12	%
Input Resistance	1982.4	Ω
Output Resistance	1689.8	Ω
Isolation Resistance	>100	M Ω

*RSS

All calibrations are traceable to the National Bureau of Standards and in accordance with MIL-STD-45662. This certifies that this transducer meets all the performance, environmental and physical characteristics listed in Endevco® specifications.



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