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- ▶ [About](#)
- ▶ [Products](#)
- ▶ [Applications](#)
- ▶ [Technical Tools](#)
- ▶ [Resources](#)
- ▶ [Courses](#)
- ▶ [Contact Us](#)

Austenitic Steels: Mechanical Properties at Cryogenic Temperatures

Note: To print this bulletin on austenitic steels and cryogenic temperatures, please [click here](#).

Since we discussed the maximum service temperatures of common austenitic steels in [Engineering Bulletin #106](#), we'll now look at how mechanical properties of austenitic steels are influenced by cryogenic temperatures and what types of stainless steel alloys are best suited for low temperature applications.

During World War II, experience with the brittle fracture of steel ships caused engineers to look closely at what happens to metals in cold weather. They found that though many metals have good "room-temperature" characteristics, they do not necessarily maintain those characteristics at low temperatures.

For example, Ferritic (405, 409, 430), Martensitic (403, 410, 414, 416) and Duplex stainless steels (329, 2205) tend to become brittle as the temperature is reduced. Fracture can occur, sometimes with catastrophic results. While stretching or bulging may serve as an indicator of impending plastic failure, such signs are absent in the case of these metals. Therefore alloys for low-temperature service are those that retain suitable properties such as yield, tensile strength and ductility.

The austenitic stainless steels such as 304 and 316 retain these engineering properties at cryogenic temperatures and can be classified as 'cryogenic steels.' They are commonly used in arctic locations and in the handling and storage of liquid gases such as liquid nitrogen and liquid helium. Liquid helium is the coldest material known with a boiling point of -452°F (-269 °C).

The table below shows mechanical properties of stainless steels at low temperatures. Elongation is an indication of their good ductility. There is an increase in tensile and yield strengths as the temperature decreases as well.

Mechanical Properties of 304, 321 and 316 Stainless Steels at Cryogenic Temperatures.

Alloy	Temperature		Yield Strength		Tensile Strength		Elongation in 2"
	°F	°C	ksi	MPa	ksi	MPa	
304	-40	-40	34	234	155	1069	47
	-80	-62	34	234	170	1172	39
	-320	-196	39	269	221	1524	40
	-423	-252	50	344	243	1675	40
316	-40	-40	41	283	104	717	59
	-80	-62	44	303	118	814	57
	-320	-196	75	517	185	1276	59
	-423	-252	84	579	210	1448	52
321	-40	-40	45	310	120	828	55

	-80	-62	50	345	138	952	52
	-320	-196	60	414	211	1455	23
	-423	-252	68	469	248	1710	34

Note: In designing a metal hose assembly for cryogenic service, care must be taken to ensure that the fittings and any accessory (guard/liner) materials are suitable for the intended operating temperatures as well.

If you have any questions or comments, please contact us.

Disclaimer: The info presented here has been compiled from sources believed to be reliable, including the American Society of Materials Specialty Handbook on Stainless Steels. No guarantee is implied or expressly stated here and the data given is intended as a guide only.

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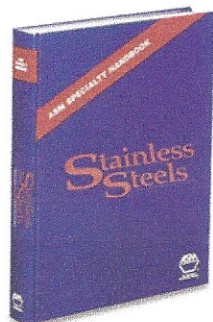
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 View Table of Contents

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