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Notice

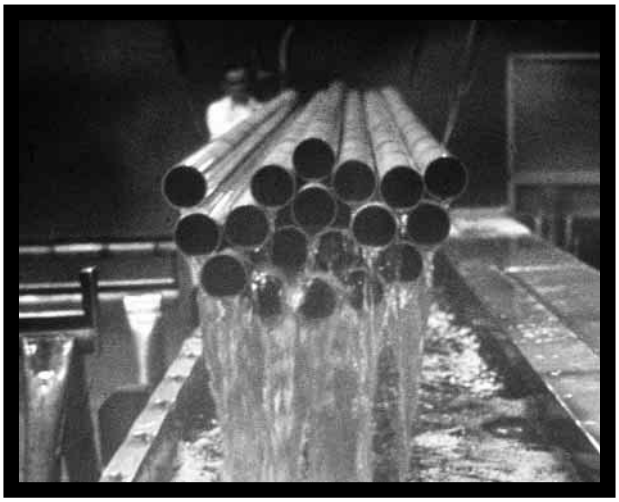
How To Use This Reference

Alloys are arranged by **metallurgical type**. This classification makes it easier to generalize the corrosion resistance and mechanical strength of the alloys and to aid in the selection of the alloys. If there is a question concerning the metallurgical type, check the index to locate the alloy, then turn to the appropriate section. In the alloy description you will find the **UNS Number**. A separate index lists the alloys by UNS Number. This number is unique for each alloy and provides a positive identification for alloy grade regardless of Trade Name applied to the alloy. Also listed are the **ASTM and ASME specification numbers** for the applicable **welded tubular products**. This is followed by a **generalized description**. Note in this description that warnings are given as the limitations of the alloy where applicable. The **basic composition** lists the major elements only, not the trace elements, impurities or steel making additives. For a complete listing of these we refer you to the applicable ASTM Standard. The **physical properties** are given in both English and Metric units. Note the units for **Thermal Conductivity**: these are the units typically used for heat transfer calculations and may differ from other handbook values by a factor of 12. **Corrosion and High Temperature Resistance** are generalized performance ratings and are for a "feel" rather than hard data. Because of the variation in corrosion rates, and the types of corrosion mechanisms that may be present, these generalized comments are appropriate. A new category is added in this Third Edition:
The **"P" Number and Group number**. These are from Section IX of the ASME Boiler and Pressure Vessel Code.

Generalized corrosion resistance may be determined from several charts.

- **GALVANIC, CREVICE AND PITTING CORROSION:** Refer first to the chart on page 49. This gives the critical crevice temperature above which corrosion will occur, but not below. These data were determined in ferric chloride, so the conditions may be more severe than in the real world. The galvanic series chart on page 52 also provides a hint as to the possibility of galvanic, pitting or crevice corrosion (all three are related). When reading this chart, the more negative the number (or the nearer the top) for the metal, the more it will corrode, especially when connected to a metal at the bottom. The pair will create a battery in which the voltage is the algebraic difference: $v = v_1 - v_2$. Keep in mind that metals like stainless steel, that form passive films, have two voltages: one positive value and one that is more negative. When this passive film is damaged a galvanic cell is set up between the passive and active sites, and a large voltage difference is generated.
- **GENERAL OR UNIFORM CORROSION:** Resistance to this form of corrosion may be estimated from the "Y" of Corrosion Chart and the Stainless Alloy Selection Guide on page 53. In both charts the stronger corrodants are at the top of the chart as are the more corrosion resistant materials. In the "Y" chart, the oxidizing resistant materials are on the left and the reducing resistant materials are on the right, with the neutral materials in the center.

- **STRESS CORROSION CRACKING:** The probability of chloride stress corrosion cracking is given on page 54. This chart is a compilation of two charts and represents the overall probability. Actually the chart should be in three dimensions and include temperature since many of the materials will not crack at the lower temperatures, but this chart illustrates the integrated effect. This chart also shows where the metallurgical changes occur because of nickel content. The chart on page 52 lists the environments that cause stress corrosion cracking in the different alloy systems.
- **INTERGRANULAR CORROSION:** This is usually caused by chromium carbide precipitation and may be estimated from the carbon/carbide precipitation chart on page 54. This chart also can be used to select materials for high temperature heat exchangers. If the temperature is in the 1100° F (600° C) range, this chart indicates that even the "L" grades will experience carbide precipitation and intergranular corrosion will take place below 212° F (100° C). In this case use a stabilized grade or a special high temperature alloy.
- **MICROBIOLOGICAL CORROSION:** The popular name for this phenomenon is MIC. Generally the corrosion mechanisms are uniform corrosion, pitting or crevice corrosion. The chart on page 49 indicates the bacteria and the corrosion products they produce.



Pickling/Passivation should be considered when optimum corrosion resistance is required.

Therefore alloy selection must be made to prevent such corrosion.

Mechanical properties may be determined from a number of charts.

- **COLLAPSING PRESSURE** may be calculated from the formulae on page 49 and the collapse pressure for pipe is given in the table on page 50.
- **BURST PRESSURE** may be calculated from Barlow's Formula given on page 51. The values for Pipe are given on page 50 and Tube on page 51. To calculate approximate Safe Allowable Working Pressure, divide the Burst Pressure by four.
- **EFFECT OF COLD WORK ON MECHANICAL PROPERTIES** is illustrated in a chart for Type 316L on page 55. The strengthening effect of cold work is much more pronounced in the austenitic stainless steels than the ferritic stainless steels.
- **EFFECT OF TEMPERATURE ON THERMAL EXPANSION** is illustrated in a graph on page 55. This effect holds true for most metals, except the slope of the curve is less for the ferritic stainless steels and alloys like Invar® 36.
- **CREEP RESISTANCE** is illustrated in a graph on page 54 for several alloys. The resistance to creep will decrease with temperature and may be different for the different alloy systems. This chart illustrates the amount of change with temperature and the relative order of magnitude at elevated temperatures.
- **PIPE DIMENSIONS AND WEIGHTS** are given in a table on page 56. Keep in mind that actual pipe wall thicknesses are usually 10% less than the nominal thickness.

Pages 46, 47 and 48 include a summary of the various specifications for the ASTM, ASME, Military and AMS Specifying Bodies.

Trent Tube – the world's largest producer of stainless steel and high alloy tubular products.

Facilities

Headquartered in East Troy, Wisconsin, Trent has two manu-facturing plants in Wisconsin, a plant in Carrollton, Georgia and a stainless steel processing plant in Chicago, Illinois.

Trent's Cold Worked Annealed plant (CWA), located in East Troy, uses an exclusive patented process to produce tubing for the electrical power industry. The CWA plant has the most modern and fully automated facilities available, including U-bending and stress relieving operations.

East Troy's other manu-facturing plant, Trentweld, is a modern facility designed for the production of stainless steel and high alloy products in welded and drawn products.

State-of-the-art polishing equipment allows Trent to produce superior finishes on both mechanical and electropolished tubing, including Trent 10 max® electropolished tubing that's interior polished to a 10Ra microinch or smoother surface finish.

Trent's Carrollton, Georgia facility produces welded stainless steel and high alloy pipe and tubing up to 48 inches (1220 mm) in diameter.

Trent's Stainless Processing facility, located in Chicago, Illinois, provides precision slitting and edging, to stringent industry standards, with oscillating ribbon winding capabilities to satisfy standard or special strip requirements.

Customer Service

Trent provides integrated solutions in stainless steel for the dairy, food processing, pharma-ceutical, chemical, petrochemical, pulp and paper, brewery, aerospace, nuclear and other high technology markets. Our goal is to be the manufacturer of choice by providing unmatched quality, product expertise and service.

People... Trent's staff of highly qualified employees, metallurgists, engineers, and specialists confirms that Trent is committed to providing its customers the support and service they deserve when working with the leader in the industry.

Products... Trent's reputation is built on its quality products and its proactive response to new market trends. Our research and development department can attest to the constant attention given to product quality and innovations in the industry.

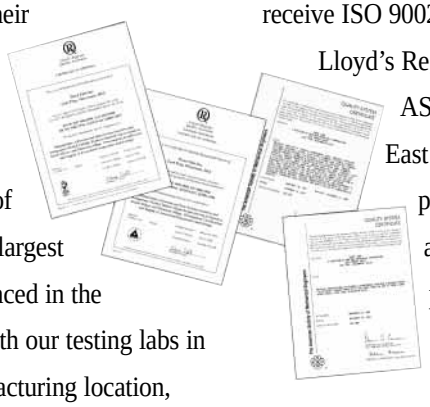
Service... Success through service is an achievement Trent works toward every day. Our goal is to

provide you with the products you want, when you want them, at competitive prices, with quick responses on inquiries and support whenever it is needed. Our educational programs have maintained an exceptional reputation within the industry for nearly 30 years. Seminars are structured for those companies who specify or use stainless steel and alloy tubular products.

We offer over 100 grades of stainless steel, electronic, cryogenic and nickel alloys as well as SEA-CURE® Stainless (Trent's own alloy for seawater and brackish environments). Some of our special processes are pickling, drawing, bright annealing, mechanical polishing and electropolishing. In addition we can precision cut, flare, bevel, and U-bend just to name a few

Technological Resources

Customer Service... This is the cornerstone upon which Trent Tube was built. The Engineering and Technical staff provide research, product testing, and quality control support, in addition to assisting customers in their choice of the proper alloy for their application or particular problem. An exceptional staff of metallurgists, the largest and most experienced in the industry, along with our testing labs in each Trent manufacturing location, provide unequalled service.



Testing... At the heart of maintaining the quality of the product during fabrication are Trent Tube's testing procedures. Trent uses both non-destructive and destructive techniques to monitor the quality.

Quality Certifications

Trent's quality programs are recognized worldwide. Our East Troy location was the first U.S. manufacturer of stainless steel and high alloy welded tubular products to receive ISO 9002 certification from Lloyd's Registry. Our two ASME certificates in East Troy allow us to provide seamless and autogenously welded products. This includes certification as a "nuclear" material supplier where we can assemble packages including complementary parts such as fittings and flanges.

Our Carrollton plant has two ASME Nuclear Certifications, MS and MO. These certifications permit us to manufacture tubular component parts for the nuclear industry. And as a result of Trent's continued commitment to quality, the Carrollton plant has been awarded their ISO 9002 certification through ASME.

Trent Tube headquarters, East Troy, Wisconsin.

Austenitic Stainless Steels

Trent Tube

Material	UNS/ Specification Number	Description/Applications	Basic Composition	Density LB/IN³ (G/CC)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 70˚ F (20˚C)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 1500˚F (815˚C)	High Temp. Resistance Above 1000˚F (540˚C): Oxidation	Corrosion Resistance: Carburization	Strength & Stability	Sulfuric Acid	Hydrochloric Acid	Hydrofluoric Acid	Phosphoric Acid	Nitric Acid	Organic Acids	Alkalies	Salts	Seawater	Chloride Cracking	Condition	Mechanical Properties at Room Temperature: Tensile Strength 1000psi (mPa)	Yield Strength 1000psi 0.2% offset (mPa)	Elongation %	Modulus of Elasticity 10⁶psi (GPa)	Hardness Rockwell B	Casting Alloy Equivalent	Welding Consumables	"P" Number*	Group Number
Type 304	UNS S30400 ASTM A249 A269 A270 A312 A358 A409 A814 ASME SA249 SA312 SA358 SA409	• An austenitic chromium-nickel stainless steel. • Non hardenable except by cold working. • Non-magnetic except when cold worked. • General purpose corrosion resistance. • May be susceptible to chloride stress-corrosion cracking. • Used in Food and beverage industries, chemical processing and petrochemical for hydraulic lines, heat exchangers, feedwater heaters, U-bent and straight condenser tubes.	18.0-20.0 Cr 8.0-11.0 Ni max 0.08 C Balance Fe	0.287 (7.94)	9.4 (16.3)	12.4 (21.5)	4	4	4	7	5	5	4	3	4	4	7	5	5	annealed	75 (515)	30 (205)	35	29.0 (200)	80	CG-8	ER308	8	1

SCROLL FOR MORE DATA

Material	UNS/ Specification Number	Description/Applications	Basic Composition	Density LB/IN³ (G/CC)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 70˚ F (20˚C)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 1500˚F (815˚C)	High Temp. Resistance Above 1000˚F (540˚C): Oxidation	Corrosion Resistance: Carburization	Strength & Stability	Sulfuric Acid	Hydrochloric Acid	Hydrofluoric Acid	Phosphoric Acid	Nitric Acid	Organic Acids	Alkalies	Salts	Seawater	Chloride Cracking	Condition	Mechanical Properties at Room Temperature: Tensile Strength 1000psi (mPa)	Yield Strength 1000psi 0.2% offset (mPa)	Elongation %	Modulus of Elasticity 10⁶psi (GPa)	Hardness Rockwell B	Casting Alloy Equivalent	Welding Consumables	"P" Number*	Group Number
Type 304L	UNS S30403 ASTM A249 A269 A270 A312 A358 A409 A814 ASME SA249 SA312 SA358 SA409	• An austenitic chromium-nickel, stainless steel adaptable for brazing or welding, where short-time exposure to high temperatures is encountered. • Non hardenable except by cold working. • May be susceptible to chloride stress-corrosion cracking. • General purpose corrosion resistance. • Use where field welding is employed. • Applications include sanitary, dairy, food processing, evaporators, heat exchangers, feedwater heaters.	18.0-20.0 Cr 8.0-13.0 Ni max 0.035 C Balance Fe	0.287 (7.94)	9.4 (16.3)	12.4 (21.5)	4	4	4	7	5	5	4	3	4	4	7	5	5	annealed	70 (485)	25 (170)	35	29.0 (200)	75	CF-3	ER308ELC ER308L	8	1

SCROLL FOR MORE DATA

Material	UNS/ Specification Number	Description/Applications	Basic Composition	Density LB/IN³ (G/CC)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 70˚ F (20˚C)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 1500˚F (815˚C)	High Temp. Resistance Above 1000˚F (540˚C): Oxidation	Corrosion Resistance: Carburization	Strength & Stability	Sulfuric Acid	Hydrochloric Acid	Hydrofluoric Acid	Phosphoric Acid	Nitric Acid	Organic Acids	Alkalies	Salts	Seawater	Chloride Cracking	Condition	Mechanical Properties at Room Temperature: Tensile Strength 1000psi (mPa)	Yield Strength 1000psi 0.2% offset (mPa)	Elongation %	Modulus of Elasticity 10⁶psi (GPa)	Hardness Rockwell B	Casting Alloy Equivalent	Welding Consumables	"P" Number*	Group Number
Type 304H	UNS S30409 ASTM A249 A312 A358 A814 ASME SA249 SA312 SA358	• Higher carbon Type 304 for better high temperature creep properties and to meet requirements of ASME Section II D, Table 1 A, Footnote G 19. • May be susceptible to chloride stress-corrosion cracking. • Corrosion resistance same as Type 304 except after exposure to elevated temperatures where intergranular precipitation may be more severe. • Used in high temperature (over 1000°F [540°C]) heat exchangers.	18.0-20.0 Cr 8.0-11.0 Ni 0.04-0.10 C Balance Fe	0.287 (7.94)	9.4 (16.3)	12.4 (21.5)	4	4	4	7	5	5	4	3	4	4	7	5	5	annealed	75 (515)	30 (205)	35	29.0 (200)	90	CF-8	ER308H ER308HC	8	1

SCROLL FOR MORE DATA

Material	UNS/ Specification Number	Description/Applications	Basic Composition	Density LB/IN³ (G/CC)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 70˚ F (20˚C)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 1500˚F (815˚C)	High Temp. Resistance Above 1000˚F (540˚C): Oxidation	Corrosion Resistance: Carburization	Strength & Stability	Sulfuric Acid	Hydrochloric Acid	Hydrofluoric Acid	Phosphoric Acid	Nitric Acid	Organic Acids	Alkalies	Salts	Seawater	Chloride Cracking	Condition	Mechanical Properties at Room Temperature: Tensile Strength 1000psi (mPa)	Yield Strength 1000psi 0.2% offset (mPa)	Elongation %	Modulus of Elasticity 10⁶psi (GPa)	Hardness Rockwell B	Casting Alloy Equivalent	Welding Consumables	"P" Number*	Group Number
Type 304N	UNS S30451 ASTM A249 A358 A814 ASME SA249	• High nitrogen Type 304. • Higher strength and ASME Section II D allowables than Type 304. • May be somewhat more susceptible to chloride stress-corrosion cracking than Types 304 or 304L. • Used in feedwater heater tubing and other applications where minimum wall and pressure requirements are critical.	18.0-20.0 Cr 8.0-11.0 Ni max 0.08 C 0.10-0.16 N Balance Fe	0.287 (7.94)	9.4 (16.3)	12.4 (21.5)	4	4	4	7	5	5	4	3	4	4	7	5	5	annealed	80 (550)	35 (240)	35	29.0 (200)	90	CF-8	ER308	8	1

1=Excellent • 2=Good to Excellent • 3=Good • 4=Acceptable • 5=Not Acceptable • 6=No Data Available • 7=Contact Trent Tube for Specific Details
***Boiler & Pressure Vessel Code Section IX • NA=Not Applicable • UA=Unassigned**

Austenitic Stainless Steels (continued)

Trent Tube

Material	UNS/ Specification Number	Description/Applications	Basic Composition	Density LB/IN³ (G/CC)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 70˚ F (20˚C)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 1500˚F (815˚C)	High Temp. Resistance Above 1000˚F (540˚C): Oxidation	Carburization	Strength & Stability	Corrosion Resistance: Sulfuric Acid	Hydrochloric Acid	Hydrofluoric Acid	Phosphoric Acid	Nitric Acid	Organic Acids	Alkalies	Salts	Seawater	Chloride Cracking	Condition	Mechanical Properties at Room Temperature: Tensile Strength 1000psi (mPa)	Yield Strength 1000psi 0.2% offset (mPa)	Elongation %	Modulus of Elasticity 10³psi (GPa)	Hardness Rockwell B	Casting Alloy Equivalent	Welding Consumables	"P" Number	Group Number
Type 304LN	UNS S30453 ASTM A249 A358 A814 ASME SA249	• Low carbon, high nitrogen Type 304. • Good weldability in field. • Has the same high temperature strength and ASME allowables as Type 304, but the weldability of Type 304L. • May be susceptible to chloride stress-corrosion cracking. • Corrosion resistance same as Type 304L. • Used in feedwater heater tubing and other applications where minimum wall, pressure requirements and weldability are critical.	18.0-20.0 Cr 8.0-13.0 Ni max 0.035 C 0.10-0.16 N Balance Fe	0.287 (7.94)	9.4 (16.3)	12.4 (21.5)	4	4	4	7	5	5	4	3	4	4	7	5	5	annealed	75 (515)	30 (205)	35	29.0 (200)	90	CF-3	ER308L	8	1
Type 316	UNS S31600 ASTM A249 A269 A270 A312 A358 A409 A814 ASME SA249 SA312 SA358 SA409	• An austenitic chromium-nickel steel with improved corrosion and heat resistance. • May be susceptible to chloride stress-corrosion cracking. • Non hardenable, non magnetic in the annealed condition and slightly magnetic when cold worked. • Improved corrosion resistance to chlorides. • Application in chemical process, rubber, plastics, pulp and paper, pharmaceutical and textile industries, heat exchangers, condensers, evaporators.	16.0-18.0 Cr 10.0-14.0 Ni 2.0-3.0 Mo max 0.08 C Balance Fe	0.286 (7.91)	9.3 (16.1)	12.4 (21.5)	4	4	4	7	5	5	4	3	4	4	7	5	5	annealed	75 (515)	30 (205)	—	28.0 (193)	80	CF-8M	ER316	8	1
Type 316L	UNS S31603 ASTM A249 A269 A270 A312 A358 A409 A814 ASME SA249 SA312 SA358 SA409	• An austenitic chromium-nickel steel with improved corrosion and heat resistance. • Adaptable for welding, brazing and other short time, high temperature conditions. • Non hardenable, non magnetic in the annealed condition and slightly magnetic when cold worked. • Improved corrosion resistance to chlorides. • May be susceptible to chloride stress-corrosion cracking. • Application in nuclear, chemical, rubber, plastics, pulp and paper, pharmaceutical and textile industries, heat exchangers, condensers, evaporators.	16.0-18.0 Cr 10.0-15.0 Ni 2.0-3.0 Mo max 0.035 C Balance Fe	0.286 (7.91)	9.3 (16.1)	12.4 (21.5)	4	4	4	7	5	5	4	3	4	4	7	5	5	annealed	70 (485)	25 (170)	35	28.0 (193)	80	CF-3M	ER316L	8	1
Type 316H	UNS S31609 ASTM A249 A312 A358 A814 ASME SA249 SA312 SA358	• Higher carbon Type 316 for better higher temperature creep properties and to meet requirements of ASME Section II D, Table 1 A, Footnote G 19. • May be susceptible to chloride stress-corrosion cracking. • Corrosion resistance same as Type 316 except after exposure to elevated temperatures where intergranular precipitation may be more severe. • Used in high temperature (over 1000°F) heat exchangers.	16.0-18.0 Cr 10.0-14.0 Ni 2.0-3.0 Mo 0.04-0.10 C Balance Fe	0.286 (7.91)	9.3 (16.1)	12.4 (21.5)	4	4	4	7	5	5	4	3	4	4	7	5	5	annealed	75 (515)	30 (205)	35	28.0 (193)	90	CF-8M	ER316H	8	1

1=Excellent • 2=Good to Excellent • 3=Good • 4=Acceptable • 5=Not Acceptable • 6=No Data Available • 7=Contact Trent Tube for Specific Details

Austenitic Stainless Steels (continued)

Trent Tube

Material	UNS/ Specification Number	Description/Applications	Basic Composition	Density LB/IN³ (G/CC)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 70˚ F (20˚C)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 1500˚F (815˚C)	High Temp. Resistance Above 1000˚F (540˚C): Oxidation	Corrosion Resistance: Carburization	Strength & Stability	Sulfuric Acid	Hydrochloric Acid	Hydrofluoric Acid	Phosphoric Acid	Nitric Acid	Organic Acids	Alkalies	Salts	Seawater	Chloride Cracking	Condition	Mechanical Properties at Room Temperature: Tensile Strength 1000psi (mPa)	Yield Strength 1000psi 0.2% offset (mPa)	Elongation %	Modulus of Elasticity 10⁶psi (GPa)	Hardness Rockwell B	Casting Alloy Equivalent	Welding Consumables	"P" Number	Group Number
Type 316N	UNS S31653 ASTM A249 A358 A814 ASME SA249 SA358	• High nitrogen Type 316. • Higher strength and ASME Section VIII allowables than Type 316. • May be somewhat more susceptible to chloride stress-corrosion cracking than Type 316 or 316L. • Corrosion resistance same as Type 316. • Used in tubing and applications where minimum wall pressure requirements are critical.	16.0-18.0 Cr 10.0-14.0 Ni 2.0-3.0 Mo max 0.08 C 0.10-0.16 N Balance Fe	0.286 (7.91)	9.3 (16.1)	12.4 (21.5)	4	4	4	7	5	5	4	3	4	4	7	5	5	annealed	80 (550)	35 (240)	35	28.0 (193)	90	CF-8M	ER316	8	1
Type 316LN	UNS S31653 ASTM A249 A358 A814 ASME SA249 SA358	• Low carbon, high nitrogen Type 316. • Good weldability in field. • Has same high temperature strength and ASME allowables as Type 316, but the weldabilty of Type 316L. • May be somewhat more susceptible to chloride stress-corrosion cracking than Type 316 or 316L. • Corrosion resistance same as Type 316. • Used in tubing and applications where minimum wall pressure requirements are critical.	16.0-18.0 Cr 10.0-15.0 Ni 2.0-3.0 Mo max 0.035 C 0.10-0.16 N Balance Fe	0.286 (7.91)	9.3 (16.1)	12.4 (21.5)	4	4	4	7	5	5	4	3	4	4	7	5	5	annealed	75 (515)	30 (205)	–	28.0 (193)	90	CF-3M	ER316L	8	1
Type 317	UNS S31700 ASTM A249 A269 A312 A409 A814 ASME SA249 SA312 SA409	• An austenitic chromium-nickel molybdenum steel with improved chloride pitting resistance over Type 316. • May be susceptible to chloride stress-corrosion cracking, but at higher temperatures than Type 304 or 316. • Non hardenable, non magnetic in annealed condition, slightly magnetic when cold worked. • Used in chemical, petroleum, pulp and paper industries, heat exchangers, evaporators, condenser tubes.	18.0-20.0 Cr 11.0-14.0 Ni 3.0-4.0 Mo max 0.08 C Balance Fe	0.286 (7.91)	9.3 (16.1)	12.4 (21.5)	4	4	4	7	5	5	3	3	4	4	7	7	5	annealed	75 (515)	30 (205)	35	28.0 (193)		CG8M	ER317 ERNiCrMo3	8	1
Type 317L	UNS S31703 ASTM A249 A312 A814 ASME SA249 SA312	• An austenitic chromium-nickel molybdenum steel with improved chloride pitting resistance over Type 316L. • May be susceptible to chloride stress-corrosion cracking, but at higher temperatures. • Used for welding, brazing and other short time exposure to high temperatures.	18.0-20.0 Cr 11.0-15.0 Ni 3.0-4.0 Mo 0.035 C Balance Fe	0.286 (7.91)	9.3 (16.1)	12.4 (21.5)	4	4	4	7	5	5	3	3	4	4	7	7	5	annealed	75 (515)	30 (205)	35	28.0 (193)	85	C98M	ER317L ERNiCrMo3	8	1
Type 317LM	UNS S31725 ASTM A249 A269 A312 A358 A409 ASME SA249 SA312 SA409	• Low carbon, high molybdenum Type 317. • Better corrosion resistance than Types 317L, 316L or 304L. • Weldable in the field. • May be susceptible to chloride stress-corrosion cracking, but at higher temperatures than Type 317. • Used for flue gas application and other heat exchanger tubing subject to higher acid chlorides.	18.0-20.0 Cr 13.5-17.5 Ni 4.0-5.0 Mo max 0.1 N max 0.03 C Balance Fe	0.286 (7.91)	9.3 (16.1)	12.4 (21.5)	4	4	4	4	5	5	3	3	4	4	7	4	5	annealed	75 (515)	30 (205)	35	28.0 (193)	90	Wisc-Alloy625	ERNiCrMo3	8	4

SCROLL FOR MORE DATA

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Austenitic Stainless Steels (continued)

Trent Tube

Material	UNS/ Specification Number	Description/Applications	Basic Composition	Density LB/IN³ (G/CC)	Thermal Conductivity Btu/ft-hr-°F (W/M-°C) 70° F (20°C)	Thermal Conductivity Btu/ft-hr-°F (W/M-°C) 1500°F (815°C)	High Temp. Resistance Above 1000°F (540°C): Oxidation	Corrosion Resistance: Carburization	Strength & Stability	Sulfuric Acid	Hydrochloric Acid	Hydrofluoric Acid	Phosphoric Acid	Nitric Acid	Organic Acids	Alkalies	Salts	Seawater	Chloride Cracking	Condition	Mechanical Properties at Room Temperature: Tensile Strength 1000psi (mPa)	Yield Strength 1000psi 0.2% offset (mPa)	Elongation %	Modulus of Elasticity 10⁶psi (GPa)	Hardness Rockwell B	Casting Alloy Equivalent	Welding Consumables	"P" Number	Group Number
Type 317LMN	UNS S31726 ASTM A249 A269 A312 A358 A409 ASME SA249 SA312 SA409	• Low carbon, high molybdenum, high nitrogen Type 317. • Same strength as Type 317. • Weldable in the field. • Best Chloride corrosion resistance of the 300 series stainless steels. • May be susceptible to chloride stress-corrosion cracking. • Used in corrosive conditions where weldability and strength are important.	17.0-20.0 Cr 13.5-17.5 Ni 4.0-5.0 Mo 0.1-0.2 N max 0.03 C Balance Fe	0.286 (7.91)	9.3 (16.1)	12.4 (21.5)	4	4	4	4	5	5	3	3	4	4	7	4	5	annealed	75 (515)	30 (205)	35	28.0 (193)	90	WISC-ALLOY625	ERNiCrMo3	8	4
Type 321	UNS S32100 ASTM A249 A269 A312 A318 A409 A814 ASME SA249 SA312 SA358 SA409	• Titanium stabilized 18-8 stainless steel. • Improved intergranular corrosion resistance. • Excellent for high temperature service in carbide precipitation range. • Excellent weldability in field. • May be susceptible to chloride stress-corrosion cracking. • Used for exhaust manifolds, expansion joints, high temperature chemical process heat exchanger tubes, recuperator tubes.	17.0-20.0 Cr 9.0-13.0 Ni max 0.08 C min 5xC Ti max .60 Ti Balance Fe	0.284 (7.86)	9.3 (16.1)	12.8 (22.2)	2	2	2	7	5	5	4	4	4	4	7	5	5	annealed	75 (515)	30 (205)	35	29.0 (200)	85	CF-8C	ER347	8	1
Type 321H	UNS S32109 ASTM A249 A312 A814 ASME SA249 SA312	• High carbon Type 321 for better temperature creep properties and to meet requirements of ASME Section II D, Table 1 A, Footnote G 19. • Corrosion resistance same as Type 321. • May be susceptible to chloride stress-corrosion cracking. • Good weldability in field. • Used in applications where temperatures exceed 1000°F.	17.0-20.0 Cr 9.0-13.0 Ni 0.04-0.10 C min 4xC Ti max .60 Ti Balance Fe	0.284 (7.86)	9.3 (16.1)	12.8 (22.2)	4	4	4	7	5	5	4	3	4	4	7	5	5	annealed	75 (515)	30 (205)	35	29.0 (200)	90	CF-8C	ER347	8	1
Type 347	UNS S34700 ASTM A249 A269 A312 A814 ASME SA249	• Columbium (Niobium) stabilized 18-8 stainless steel. • Improved intergranular corrosion resistance. • Excellent weldability in field. • Excellent for high temperature service in the carbide precipitation range. • May be susceptible to chloride stress-corrosion cracking. • Used for exhaust manifolds, expansion joints, high temperature heat exchanger tubes, recuperation tubes.	17.0-20.0 Cr 9.0-13.0 Ni max 0.08 C min 10xC = Cb+Ta max 1.0 = Cb+Ta Balance Fe	0.285 (7.89)	9.3 (16.1)	12.8 (22.2)	2	2	2	7	5	5	4	4	4	4	7	7	5	annealed	75 (515)	30 (205)	35	29.0 (200)	85	CF-8C	ER347	8	1
Type 347H	UNS S34709 ASTM A249 A312 A814 ASME SA249 SA312	• High carbon Type 347 for better high temperature creep properties and to meet requirements of ASME Section II D, Table 1 A, footnote G 19. • Corrosion resistance same as Type 347. • May be susceptible to chloride stress-corrosion cracking. • Excellent weldability in field. • Used in applications where temperatures exceed 1000°F.	17.0-20.0 Cr 9.0-13.0 Ni 0.04-0.010 C 8xC = Cb+Ta max1.0 = Cb+Ta Balance Fe	0.285 (7.89)	9.3 (16.1)	12.8 (22.2)	4	4	4	7	5	5	4	3	4	4	7	5	5	annealed	75 (515)	30 (205)	35	29.0 (200)	90	CF-8C	ER347	8	1

1=Excellent • 2=Good to Excellent • 3=Good • 4=Acceptable • 5=Not Acceptable • 6=No Data Available • 7=Contact Trent Tube for Specific Details

Austenitic Stainless Steels (continued)

Trent Tube

Material	UNS/ Specification Number	Description/Applications	Basic Composition	Density LB/IN³ (G/CC)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 70˚ F (20˚C)	Thermal Conductivity 1500˚F (815˚C)	High Temp. Resistance Above 1000˚F (540˚C): Oxidation	Carburization	Strength & Stability	Corrosion Resistance: Sulfuric Acid	Hydrochloric Acid	Hydrofluoric Acid	Phosphoric Acid	Nitric Acid	Organic Acids	Alkalies	Salts	Seawater	Chloride Cracking	Condition	Mechanical Properties at Room Temperature: Tensile Strength 1000psi (mPa)	Yield Strength 1000psi 0.2% offset (mPa)	Elongation %	Modulus of Elasticity 10³psi (GPa)	Hardness Rockwell B	Casting Alloy Equivalent	Welding Consumables	"P" Number	Group Number
Type 348	UNS S34800 ASTM A249 A269 A312 A358 A409 A814 ASME SA249 SA312 SA358 SA409	• Same as Type 347 except restricted tantalum content. • May be susceptible to chloride stress-corrosion cracking. • Used in nuclear applications where tantalum is undesirable because of high neutron cross section.	17.0-20.0 Cr 9.0-13.0 Ni max 0.08 C min 10xC = Cb+Ta max 1.0 = Cb+Ta max 0.10 Ta Balance Fe	0.285 (7.84)	9.3 (16.1)	12.8 (22.2)	4	4	4	7	5	5	4	3	4	4	7	5	5	annealed	75 (515)	30 (205)	35	29.0 (200)	90	CF-8C	ER347	8	1
Type 348H	UNS S34809 ASTM A249 A312 A814 ASME SA249 SA312	• High carbon Type 348 for better high temperature creep properties and to meet requirements of ASME Section II D, Table 1 A, Footnote G 19. • May be susceptible to chloride stress-corrosion cracking. • Use at temperatures over 1000°F in nuclear environments where tantalum is undesirable because of high neutron cross section.	17.0-20.0 Cr 9.0-13.0 Ni 0.04-0.10 C min 8xC = Cb+Ta max 0.10 = Cb+Ta max 0.10 Ta Balance Fe	0.285 (7.84)	9.3 (16.1)	12.8 (22.2)	4	4	4	7	5	5	4	3	4	4	7	5	5	annealed	75 (515)	30 (205)	35	29.0 (200)	85	CF-8C	ER347	8	1
Type 904L	UNS N08904 ASTM B-674 B673 ASME SB674 SB673	• Resistant to corrosion in a wide range of both oxidizing and reducing environments. • May be susceptible to chloride stress-corrosion cracking at high temperatures. • Resistant to pitting and crevice corrosion, as well as general corrosion in reducing acids. • Piping systems, pollution control equipment, heat exchangers, bleaching systems.	23.0-28.0 Ni 19.0-23.0 Cr 4.0-5.0 Mo 1.0-2.0 Cu max 0.02 C Balance Fe	0.290 (8.01)	7.5 (13)	10.5 (18)	7	7	7	3	4	4	2	4	2	2	2	7	3	annealed	75 (515)	32 (220)	35	28.5 (196)	–	Wisc Alloy 625	ERNiCrMo-3	45	N/A
Alloy 21-6-9 (XM-11)	UNS S21904 AMS 5561 5562 ASTM A312 ASME SA312	• High manganese nitrogen strengthened austenitic stainless steel. • High strength in the annealed condition, excellent oxidation resistance. • Good corrosion resistance. • May be susceptible to chloride stress-corrosion cracking. • Highly austenitic. • Used as aircraft hydraulic lines, heat exchanger tubes, pollution control equipment, particle accelerator tubes.	19.0-21.5 Cr 5.5-7.5 Ni 8.0-10.0 Mn 0.15-0.4 N max 0.04 C Balance Fe	0.283 (7.83)	8.0 (14.0)	15.5 (27.0)	2	2	2	7	5	5	4	4	4	4	7	5	5	annealed	110 (758)	65 (448)	42	28.5 (196)	95	CG6MMN	ER219	8	3
Alloy 22-13-5 (XM-19)	UNS S20910 ASTM A249 ASME SA249	• Nitrogen strengthened austenitic stainless steel. • Very good corrosion resistance (better than Type 316). • May be susceptible to chloride stress-corrosion cracking. • Good toughness at cryogenic temperature. • Used for petrochemical equipment, heat exchanger tubes, photographic process equipment.	20.5-23.5 Cr 11.5-13.5 Ni 1.50-3.0 Mo 4.0-6.0 Mn 0.2-0.4 N max 0.06 C 0.1-0.3 Cb+Ta 0.1-0.3 V	0.285 (7.88)	9.0 (15.6)	14.6 (25.2)	2	2	2	7	5	5	4	4	4	4	7	5	5	annealed	100 (690)	55 (380)	35	28.0 (193)	C25	CG6MMN	ER209	8	3

1=Excellent • 2=Good to Excellent • 3=Good • 4=Acceptable • 5=Not Acceptable • 6=No Data Available • 7=Contact Trent Tube for Specific Details

Austenitic Stainless Steels (continued)

Trent Tube

Material	UNS/ Specification Number	Description/Applications	Basic Composition	Density LB/IN³ (G/CC)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 70˚ F (20˚C)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 1500˚F (815˚C)	High Temp. Resistance Above 1000˚F (540˚C): Oxidation	Corrosion Resistance: Carburization	Strength & Stability	Sulfuric Acid	Hydrochloric Acid	Hydrofluoric Acid	Phosphoric Acid	Nitric Acid	Organic Acids	Alkalies	Salts	Seawater	Chloride Cracking	Condition	Mechanical Properties at Room Temperature: Tensile Strength 1000psi (mPa)	Yield Strength 1000psi 0.2% offset (mPa)	Elongation %	Modulus of Elasticity 10⁶psi (GPa)	Hardness Rockwell B	Casting Alloy Equivalent	Welding Consumables	"P" Number	Group Number
Alloy AL-6XN®	UNS N08367 ASTM B675 B676 ASME SB675 SB676 Code Case N-438-1	• Excellent resistance to oxidizing chlorides and reducing solutions. • High strength in solution annealed condition. • Good resistance to chloride stress-corrosion cracking at atmospheric pressure. • Highly resistant to seawater corrosion. • Good weldability even in heavy section. • Presence of nitrogen retards sigma phase formation during hot forming and welding.	20.0-22.0 Cr 23.5-25.5 Ni 6.0-7.0 Mo 0.18-0.25 N max 0.03 C Balance Fe	0.291 (8.06)	7.9 (13.7)	—	6	6	6	3	4	4	3	3	2	2	2	2	3	annealed	112 (770)	53 (365)	50	27.0 (186)	90	CN3MN	ERNiCrMo-3	45	NA
Nitronic 33® (XM-29)	UNS S24000 ASTM A240 ASME SA240	• High yield strength, high manganese alloy. • Good cryogenic properties. • Better wear and galling properties than standard austenitic stainless steels. • Better corrosion and stress-corrosion cracking resistance than Type 304. • Easily welded.	17.0-19.0 Cr 2.25-3.75 Ni 11.5-14.5 Mn 0.2-0.4 N max 0.75 Si max 0.08 C	0.280 (7.755)	9.0 (15.7)	14.8 (25.6)	4	4	4	7	5	5	4	3	3	4	7	5	5	annealed	100 (690)	55 (380)	40	29.0 (200)	100	CG6MMN	ER308L	8	3

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AL-6XN® is a registered trademark of Allegheny Ludlum Corp.
Nitronic 33® (XM-29) is a registered trademark of Armco Advanced Materials Corp.

1=Excellent • 2=Good to Excellent • 3=Good • 4=Acceptable • 5=Not Acceptable • 6=No Data Available • 7=Contact Trent Tube for Specific Details

Duplex Stainless Steels

Trent Tube

Material	UNS/ Specification Number	Description/Applications	Basic Composition	Density LB/IN³ (G/CC)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 70˚ F (20˚C)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 1500˚F (815˚C)	High Temp. Resistance Above 1000˚F (540˚C): Oxidation	Carburization	Strength & Stability	Corrosion Resistance: Sulfuric Acid	Hydrochloric Acid	Hydrofluoric Acid	Phosphoric Acid	Nitric Acid	Organic Acids	Alkalies	Salts	Seawater	Chloride Cracking	Condition	Mechanical Properties at Room Temperature: Tensile Strength 1000psi (mPa)	Yield Strength 1000psi 0.2% offset (mPa)	Elongation %	Modulus of Elasticity 10⁶psi (GPa)	Hardness Rockwell B	Casting Alloy Equivalent	Welding Consumables	"P" Number	Group Number
Alloy 7Mo PLUS®	UNS S32950 ASTM A789 A790 ASME SA789 SA790	• Good resistance to pitting corrosion and crevice corrosion in many severe environments. • Excellent resistance to hot nitric acid. • Excellent resistance to chloride stress-corrosion cracking. • Good corrosion resistance of weldments, and improved impact strength over 7-Mo®. • Potential applications include heat exchangers in petroleum refining, petrochemical, chemical, pulp and paper, nitric acid cooler condensers, digester liquor heaters, and allied processing industries. • Subject to 885°F (475°C) embrittlement starting at 600°F (315°C). • May lose ductility at sub-zero temperatures.	26.0-29.0 Cr 3.5-5.2 Ni 1.0-2.5 Mo 0.15-0.35 N max 0.03 C Balance Fe	0.280 (7.74)	8.8 (15.2)	12.5 (21.6)	2	2	☆	4	5	5	4	1	1	1	7	4	1	annealed	90 (620)	70 (480)	20	29.0 (200)	30.5 R_C	CD4MCU	RA2682	10H	1
Alloy 2205	UNS S31803 ASTM A789 A790 ASME SA789 SA790	• Good strength, toughness and corrosion resistance. • Resists oxidizing mineral acids and most organic acids in addition to reducing acids and chloride environments. • Potential applications include production/collection tubing/piping for oil/gas production; condensers and reboilers for oil refining/petrochemical industries; feedwater heaters and heat exchangers for power and chemical industries. • Subject to 885°F (475°C) embrittlement starting at 600°F (315°C). • May lose ductility at sub-zero temperatures.	21.0-23.0 Cr 4.5-6.5 Ni 2.5-3.5 Mo max 0.03 C 0.08-0.20 N Balance Fe	0.283 (7.83)	10.0 (17.3)	—	3	4	☆	4	5	5	4	3	3	3	7	4	2	annealed	90 (620)	65 (448)	25	29.0 (200)	30.5 R_C	CD7MCUN	2209	10H	1
Alloy 255	UNS S32550	• Excellent strength. • Excellent corrosion resistance. • Resistant to chloride stress-corrosion cracking. • Useful in marine environments because of resistance to chloride pitting and crevice corrosion. • Useful replacement for austenitic stainless steels in corrosive environments. • Subject to 885°F (475°C) embrittlement starting at 600°F (315°C). • May lose ductility at sub-zero temperatures.	24.0-27.0 Cr 4.5-6.5 Ni 2.0-4.0 Mo 1.5-2.5 Cu 0.1-0.25 N max 0.04 C Balance Fe	0.282 (7.81)	7.7 (13.3)	13.5 (23.3)	2	2	☆	3	5	5	4	1	1	1	7	3	1	annealed	110 (758)	80 (551)	15	30.5 (210)	32 R_C	CD7MCUN	Alloy 255	10H	1

7Mo PLUS® is a registered trademark of Carpenter Technology Corp.

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☆=Generally not used above 500°F (260°C) because of 885°F (475°C) embrittlement for sigma formation.

Electronic, Cryogenic and Other Alloys

Trent Tube

Material	UNS/ Specification Number	Description/Applications	Basic Composition	Density LB/IN³ (G/CC)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 70˚ F (20˚C)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 1500˚F (815˚C)	High Temp. Resistance Above 1000˚F (540˚C): Oxidation	Corrosion Resistance: Carburization	Strength & Stability	Sulfuric Acid	Hydrochloric Acid	Hydrofluoric Acid	Phosphoric Acid	Nitric Acid	Organic Acids	Alkalies	Salts	Seawater	Chloride Cracking	Condition	Mechanical Properties at Room Temperature: Tensile Strength 1000psi (mPa)	Yield Strength 1000psi 0.2% offset (mPa)	Elongation %	Modulus of Elasticity 10⁶psi (GPa)	Hardness Rockwell B	Casting Alloy Equivalent	Welding Consumables	"P" Number	Group Number
INVAR 36®	UNS K93601 ASTM A333 A334	• A 36% Ni Iron alloy with thermal expansion 1/10 that of carbon steel up to 400°F (200°C). • Used for applications where temperature variations must be minimized such as cryogenic piping, instrumentation and electronic devices, or in conjunction with high expansion alloys for temperature regulators or bimetallic devices.	35.0-37.0 Ni max 0.45 Si max 0.5 Mn max 0.10 C Balance Fe	0.291 (8.055)	6.05 (10.5)	—	5	5	5	5	5	5	5	5	5	5	5	5	annealed ❶	65 (448)	40 (276)	35	20.5 (137)	70	—	Modified INVAR 36®	UA	–
Modified INVAR 36®	UNS K93603 ASTM A333 A334	• Originally developed as a weld filler alloy for Invar 36®. • Provides somewhat better welding characteristics than Invar 36®. • Used for applications where temperature variations must be minimized such as cryogenic piping, instrumentation and electronic devices, or in conjunction with high expansion alloys for temperature regulators or bimetallic devices.	35.5-36.5 Ni max 0.1 Si max 3.0 Mn max 0.12 C max 0.5 Mo max 1.0 Ti 0.025 S+P Balance Fe	0.291 (8.055)	6.05 (10.5)	—	5	5	5	5	5	5	5	5	5	5	5	5	annealed ❶	65 (448)	40 (276)	35	20.5 (137)	70	—	Modified INVAR 36®	UA	–

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KOVAR®	UNS K94610 Usually Customer Specifications	• Vacuum melted low expansion alloy used for making hermetic seals with Pyrex glass and ceramic material. • Used for tubular components in power tubes, microwave tubes, transistors, diodes and integrated circuits.	17.0 Co 29.0 Ni 0.2 Si 0.3 Mn max 0.2 C Al+Mg+Zr+Ti max 0.2 Balance Fe	0.302 (8.359)	10.0 (17.3)	—	5	5	5	5	5	5	5	5	5	5	5	3	annealed ❶	75 (517)	50 (345)	30	20 (134)	68	—		UA	–

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HY-Mu80®	Usually• Customer Specifications	Unoriented 80% nickel-iron-molybdenum alloy with extremely high initial permeability and maximum permeability with minimum hysteresis loss. • Used for magnetic shields, transformer cores, etc.	80.0 Ni 4.2 Mo 0.35 Si 0.5 Mn 0.02 C Balance Fe	0.316 (8.747)	20.0 (34.6)	—	5	5	5	5	5	5	5	5	5	5	5	3	annealed (2050˚F) ❶ annealed (1600˚F)	79 (545) 90 (620)	22 (152) 33 (228)	64 57	33.3 (223) 31.4 (210)	62 85	—		UA	–

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High-PERM 49®	UNS K94800 Usually Customer Specifications	• 48% nickel alloy with a saturation flux density of 15,000 gauss after hydrogen annealing. • Hysteresis loss very low in either AC or DC circuits at frequencies <400Hz. • Used as electronic devices requiring tubular	48.0 Ni 0.35 Si 0.50 Mn 0.02 C Balance Fe	0.295 (8.249)	7.5 (13.0)	—	5	5	5	5	5	5	5	5	5	5	5	3	annealed ❶	75 (517)	23 (154)	43	24 (161)	75	—		UA	–

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Elgiloy®	UNS R30003 ASTM F1058 AMS 5833 5834 5875 5876	• Excellent fatigue life. • High strength, ductility, mechanical properties. • Non-magnetic. • Corrosion resistance in many environments. • Stable from -300°F to 850°F (-184C to 450°C). • used for springs, seals, torsion bars, pivots, medical devices.	19.0-21.0 Cr 14.0-16.0 Ni 39.0-41.0 Co 6.0-8.0 Mo 1.5-2.5 Mn max 0.15 C max 0.10 Be Balance Fe	0.300 (8.30)	—	—	2	2	2	5	5	5	5	5	5	5	5	5	4	annealed heat	120 (803) 325	70 (469) 310	38 10	30 (207) 30	90 28	—		UA	–

❶ Note: Carpenter Technology Corp. data

1=Excellent • 2=Good to Excellent • 3=Good • 4=Acceptable • 5=Not Acceptable • 6=No Data Available • 7=Contact Trent Tube for Specific Details

Ferritic Stainless Steels

Trent Tube

Material	UNS/ Specification Number	Description/Applications	Basic Composition	Density LB/IN³ (G/CC)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 70˚ F (20˚C)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 1500˚F (815˚C)	High Temp. Resistance Above 1000˚F (540˚C): Oxidation	Carburization	Strength & Stability	Corrosion Resistance: Sulfuric Acid	Hydrochloric Acid	Hydrofluoric Acid	Phosphoric Acid	Nitric Acid	Organic Acids	Alkalies	Salts	Seawater	Chloride Cracking	Condition	Mechanical Properties at Room Temperature: Tensile Strength 1000psi (mPa)	Yield Strength 1000psi 0.2% offset (mPa)	Elongation %	Modulus of Elasticity 10⁶psi (GPa)	Hardness Rockwell B	Casting Alloy Equivalent	Welding Consumables	"P" Number	Group Number
Type 405	UNS S40500 ASTM A268 ASME SA268	• Non Hardenable 12% Cr stainless steel. • Designed for use in the as-welded condition, however heat treatment improves corrosion resistance. • Has resistance to sulfide stress cracking at RC22. • Resistance to mild corrosives, however low chromium limits its resistance. • Resistance to chloride stress-corrosion cracking. • Low chromium favors less sensitivity to 885°F (475°C) embrittlement and sigma phase formation. • Subject to 885°F (475°C) embrittlement beginning at 600°F (315°C) although this is a very slow mechanism, and loss of ductility at sub-zero temperatures. • Used for heat exchanger tubes in the refining industry and other areas where exposure may result in the 885°F (475°C) or sigma temperature range.	11.5-13.5 Cr max 0.50 Ni max 0.08 C 0.10-0.30 Al Balance Fe	0.279 (7.72)	15.6 (27.0)	17.9 (31.0)	4	4	4	5	5	5	5	4	4	4	7	5	2	annealed	60 (415)	30 (205)	20	29.0 (200)	85	CA15	ER409	7	1
Type 409	UNS S40900 ASTM A268 A803 ASME SA268 SA803	• Titanium stabilized low chromium stainless steel. • Barely *"stainless"*. • Subject to 885°F (475°C) embrittlement beginning at 600°F (315°C) and loss of ductility at near freezing temperatures. • Can be welded in field, however heat treatment improves corrosion resistance. • Resistant to chloride stress-corrosion cracking. • Subject to hydrogen embrittlement in presence of nascent hydrogen. • Primarily used in automotive industry for mufflers, catalytic converters, tail pipes.	10.5-11.75 Cr max 0.5 Ni max 0.08 C min 6xC Ti max 0.75 Ti Balance Fe	0.28 (7.75)	14.4 (25.0)	16.6 (28.8)	4	4	4	5	5	5	5	4	4	4	7	5	2	annealed	55 (380)	30 (205)	20	29.0 (200)	85	CA15	ER409	7	1
Type 430	UNS S43000 ASTM A268 ASME SA268	• Corrosion resistant/heat resistant ferritic stainless steel. • Resistant to chloride stress-corrosion cracking. • Excellent resistance to elevated temperature sulfide attack. • Magnetic, non-hardenable by heat treatment. • Subject to 885°F (475°C) embrittlement beginning at 600°F (315°C) and loss of ductility at sub-zero temperatures. • Subject to hydrogen embrittlement in presence of nascent hydrogen. • Heat exchanger applications in petroleum and chemical processing industries, reboilers for desulfurized naptha, heat exchangers in sour water strippers, hydrogen plant and effluent coolers.	16.0-18.0 Cr max 0.12 C Balance Fe	0.278 (7.70)	15.1 (26.1)	15.2 (26.3)	4	4	4	5	5	5	5	3	5	4	7	5	1	annealed	60 (415)	30 (205)	20	29.0 (200)	90	CB30	ER430	7	2

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Ferritic Stainless Steels (continued)

Trent Tube

Material	UNS/ Specification Number	Description/Applications	Basic Composition	Density LB/IN³ (G/CC)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 70˚ F (20˚C)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 1500˚F (815˚C)	High Temp. Resistance Above 1000˚F (540˚C): Oxidation	Carburization	Strength & Stability	Corrosion Resistance: Sulfuric Acid	Hydrochloric Acid	Hydrofluoric Acid	Phosphoric Acid	Nitric Acid	Organic Acids	Alkalies	Salts	Seawater	Chloride Cracking	Condition	Mechanical Properties at Room Temperature: Tensile Strength 1000psi (mPa)	Yield Strength 1000psi 0.2% offset (mPa)	Elongation %	Modulus of Elasticity 10³psi (GPa)	Hardness Rockwell B	Casting Alloy Equivalent	Welding Consumables	"P" Number	Group Number
Alloy 439 (sometimes referred to as Alloy 439L)	UNS S43035 ASTM A268 A803 ASME SA268 SA803	• Resistant to chloride stress corrosion. • Magnetic and non-hardenable through heat treatment. • Subject to 885°F (475°C) embrittlement beginning at 600°F (315°C) and loss of ductility at near freezing temperatures. • Resists intergranular attack and formation of martensite in the as-welded, heat affected zone. • Heat exchangers, condensers, feedwater heaters, lube oil coolers, moisture separator reheaters. • Subject to hydrogen embrittlement in presence of nascent hydrogen.	17.0-19.0 Cr max 0.07 C max 0.04 N min 0.20+4 (C+N) Ti max 0.80 Ti Balance Fe	0.280 (7.75)	15.1 (26.1)	15.2 (26.3)	4	4	☆	5	5	5	5	3	4	4	7	5	1	annealed	60 (415)	30 (205)	20	29.0 (200)	90	CB30	Matching	7	2

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Alloy 444 (18-2)	UNS S44400 ASTM A268 A803 ASME SA268 SA803	• Low carbon plus molybdenum for better chloride pitting resistance than 430 or 439L, similar to Type 316. • Generally considered equal to Type 304 in corrosion resistance. • Virtually immune to chloride stress-corrosion cracking. • Subject to 885°F (475°C) embrittlement beginning at 600°F (315°C) and loss of ductility at near freezing temperatures. • Subject to hydrogen embrittlement in presence of nascent hydrogen. • Used for heat exchangers in chemical, petroleum and food processing industries.	17.5-19.5 Cr 1.75-2.50 Mo max 0.025 C min 0.20+4 (C+N) Ti max 0.80 Ti Balance Fe	0.280 (7.75)	15.5 (26.8)	—	4	4	☆	5	5	5	5	3	3	4	7	5	1	annealed	60 (415)	40 (275)	20	29.0 (200)	95	CG-8M	ER316L ER308L ERNiCr-3	7	2

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SEA-CURE® Stainless	UNS S44660 ASTM A268 A803 ASME SA268 SA803	• Excellent resistance to chloride, including pitting crevice corrosion, and stress-corrosion cracking. • Better resistance than austenitic stainless steels to general corrosion in diverse conditions. • High strength, good ductility. • Subject to 885°F (475°C) embrittlement beginning at 600°F (315°C) and loss of ductility at sub-zero temperatures. • Subject to hydrogen embrittlement in presence of nascent hydrogen. • Used in electric power plant condensers and feedwater heaters, heat exchangers in chemical,	25.0-28.0 Cr 3.0-4.0 Mo 1.0-3.5 Ni max 1.0 Ti+Cb Balance Fe	0.278 (7.70)	9.9 (17.1)	—	5	5	5	3	4	4	3	3	2	2	2	2	1	annealed	90 (620)	75 (517)	25	31.5 (217)	95	CG-8M	ERNiCrMo-3 ERNiFeCr-1	10K	1

1=Excellent • 2=Good to Excellent • 3=Good • 4=Acceptable • 5=Not Acceptable • 6=No Data Available • 7=Contact Trent Tube for Specific Details
☆=Generally not used above 500°F (260°C) because of 885°F (475°C) embrittlement for sigma formation.

High Temperature Alloys

Trent Tube

Material	UNS/ Specification Number	Description/Applications	Basic Composition	Density LB/IN³ (G/CC)	Thermal Conductivity Btu/ft-hr-°F (W/M-°C) 70° F (20°C)	Thermal Conductivity Btu/ft-hr-°F (W/M-°C) 1500°F (815°C)	High Temp. Resistance Above 1000°F (540°C): Oxidation	Carburization	Strength & Stability	Corrosion Resistance: Sulfuric Acid	Hydrochloric Acid	Hydrofluoric Acid	Phosphoric Acid	Nitric Acid	Organic Acids	Alkalies	Salts	Seawater	Chloride Cracking	Condition	Mechanical Properties at Room Temperature: Tensile Strength 1000psi (mPa)	Yield Strength 1000psi 0.2% offset (mPa)	Elongation %	Modulus of Elasticity 10⁶psi (GPa)	Hardness Rockwell B	Casting Alloy Equivalent	Welding Consumables	"P" Number	Group Number
Alloy X	UNS N06002 ASTM B619 B626 ASME SB619 SB626 AMS 5588	• Non-magnetic, heat and corrosion resistant nickel based alloy. • Exceptional mechanical properties to 2200°F (1200°C) through solid solution strengthening. • Used in gas turbine components, high temperature heat exchangers, after burner components, furnace hardware, chemical processing components.	20.5-23.0 Cr 8.0-10.0 Mo 17.0-20.0 Fe 0.2-1.0 W 0.05-0.15 C 0.5-2.5 Co Balance Ni	0.297 (8.221)	5.2 (9.1)	11.2 (19.6)	2	2	2	2	3	3	2	1	1	1	1	1	1	annealed	100 (690)	40 (276)	35	29.0 (208)	92.5	Wisc-AlloyX	ERNiFeCr-2	43	N/A
Alloy 102	UNS N06102 Usually Customer Specifications	• Non-magnetic nickel-chromium based alloy strengthened with refractory metals. • Excellent corrosion properties, strength, ductility, toughness. • Outstanding structural stability. • Used as pipe and tubing for steam turbines, gas turbines, rocket engines, heat shields, furnace parts, chemical plant components and seawater environments.	14.0-16.0 Cr 2.75-3.25 Cb 2.75-3.25 Mo 2.75-3.25 W 5.0-9.0 Fe 0.3-0.6 Al 0.4-0.7 Ti 0.003-0.008 B max 0.08 C Balance Ni	0.309 (8.55)	6.5 (11.2)	11.3 (19.6)	2	2	2	3	4	4	1	1	1	1	1	1	1	annealed	120 (827)	60 (414)	35	29.7 (205)	98	—	Matching	UA	–
Alloy 230™	UNS N06230	• Excellent high temperature strength, outstanding resistance to oxidizing environments up to 2100°F (1150°C) . • Excellent long term thermal stability. • Low thermal expansion. • Resistant to grain coarsening at high temperatures. • Easily fabricated. • Resistance to nitriding.	22.0 Cr 14.0 W 2.0 Mo max 3.0 Fe max 5.0 Co 0.30 Al 0.10 C 0.02 La 0.005 B Balance Ni	0.319 (8.83)	5.2 (8.9)	11.1 (18.4)	2	2	2	2	4	3	1	2	1	1	1	1	1	annealed ❶	128 (885)	62 (425)	45	30.6 (210)	93	—	Matching	47	N/A
Alloy 556™	UNS R30556 ASTM B626 B619 ASME SB626 SB619	• Good resistance to sulfidizing, carburizing and chlorine bearing environments at high temperatures. • Good oxidation resistance fabricability and excellent high temperature strength. • Resists corrosion to molten chloride salts, other salts and molten zinc. • Used for tubing in waste heat recuperators, municipal and chemical waste incinerators, combustion cans, transition ducts in turbines and internals for fluidized beds.	19.0-22.5 Ni 21.0-23.0 Cr 2.5-4.0 Mo 2.0-3.5 W 0.05-0.15 C 0.2-0.8 Si 16.0-21.0 Co 0.5-2.00 Mn 0.1-0.5 Al 0.3-1.25 Ta 0.001-0.1 Zr 0.005 La 0.1-0.3 N Balance Fe	0.297 (8.23)	6.4 (11.1)	12.3 (20.8)	2	2	2	3	1	3	1	3	1	1	1	1	1	annealed	100 (690)	45 (310)	40	29.7 (205)	95	556	Matching	45	N/A

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Alloy 230™ is a trademark of Haynes International, Inc.

❶ Note: Haynes International Inc. data

Alloy 230™ and Alloy 556™ are trademarks of Haynes International, Inc.

1=Excellent • 2=Good to Excellent • 3=Good • 4=Acceptable • 5=Not Acceptable • 6=No Data Available • 7=Contact Trent Tube for Specific Details

High Temperature Alloys (continued)

Trent Tube

Material	UNS/ Specification Number	Description/Applications	Basic Composition	Density LB/IN³ (G/CC)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 70˚ F (20˚C)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 1500˚F (815˚C)	High Temp. Resistance Above 1000˚F (540˚C): Oxidation	Carburization	Strength & Stability	Corrosion Resistance: Sulfuric Acid	Hydrochloric Acid	Hydrofluoric Acid	Phosphoric Acid	Nitric Acid	Organic Acids	Alkalies	Salts	Seawater	Chloride Cracking	Condition	Mechanical Properties at Room Temperature: Tensile Strength 1000psi (mPa)	Yield Strength .1000psi 0.2% offset (mPa)	Elongation %	Modulus of Elasticity 10⁶psi (GPa)	Hardness Rockwell B	Casting Alloy Equivalent	Welding Consumables	"P" Number	Group Number
Alloy 253MA	UNS S30815 ASTM A213 A249 A312 A358 A409 ASME SA213 SA249 SA312 SA358 SA409	• Austenitic heat resisting alloy with high strength and oxidation resistance. • Creep rupture strength comparable to nickel base alloys. • Oxidation resistance to 2100°F (1150°C), obtained through micro alloy additions. • Used for heat exchangers, radiant heating tubes, furnace parts.	20.0-22.0 Cr 10.0-12.0 Ni 0.05-0.10 C 1.40-2.00 Si 0.14-0.20 N 0.03-0.08 Ce Balance Fe	0.282 (7.80)	8.38 (14.5)	12.0 (21.0)	2	2	2	5	5	5	5	4	4	4	5	5	5	annealed	87 (600)	45 (310)	35	29.0 (200)	95	HF	Matching	8	2
SCROLL FOR MORE DATA																													
Type 309S	UNS S30908 ASTM A249 A312 A358 A409 A554 ASME SA249 SA312 SA358 SA409	• Superior heat resisting austenitic stainless steel. • Good for continuous exposure to 2000°F (1090°C) and intermittent service to 1800°F (1000°C). • Slightly better corrosion resistance than Type 304 stainless steel. • May be susceptible to chloride stress-corrosion cracking. • Better temperature creep strength than the 18-8 austenitic stainless steels. • Resistant to corrosive action of high sulfur flue gases providing they are oxidizing, but poor in reducing gases like H_2S. • Used for heat exchanger tubes in refineries, petrochemical, heat recuperators, pulp and paper mills, gas carburizing and bright annealing/hardening service.	22.0-24.0 Cr 12.0-15.0 Ni max 0.08 C Balance Fe	0.287 (7.95)	8.0 (13.9)	10.8 (18.7)	2	2	2	4	5	5	4	3	3	3	4	4	5	annealed	75 (515)	30 (205)	35	29.0 (200)	90	CH20 Low carbon HH High carbon controlled	ER309 ER309L ER309Cb ER309Mo	8	2
SCROLL FOR MORE DATA																													
Type 310S	UNS S31008 ASTM A249 A312 A358 A409 A554 ASME SA249 SA312 SA358 SA409 AMS 5577	• Austenitic stainless steel with excellent high temperature oxidation resistance. • Good for continuous exposure to 2100°F (1150°C) intermittent service to 1900°F (1040°C). • Better elevated temperature creep strength than the 18-8 grades. • Good resistance to both carburizing and reducing environments. • General corrosion resistance better than Types 304 and 309. • May be susceptible to chloride stress-corrosion cracking. • Used for heat exchanger and heat recuperator tubing, molten salt applications, sulfur bearing gas atmospheres.	24.0-26.0 Cr 19.0-22.0 Ni max 0.08 C Balance Fe	0.289 (8.00)	8.0 (13.9)	10.8 (18.7)	2	2	2	3	5	5	4	3	3	3	4	4	5	annealed	75 (515)	30 (205)	35	29.0 (200)	90	CH20 Low carbon HH High carbon controlled	ER310 ER310Cb ER310Mo	8	2

1=Excellent • 2=Good to Excellent • 3=Good • 4=Acceptable • 5=Not Acceptable • 6=No Data Available • 7=Contact Trent Tube for Specific Details

High Temperature Alloys (continued)

Trent Tube

Material	UNS/ Specification Number	Description/Applications	Basic Composition	Density LB/IN³ (G/CC)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 70˚ F (20˚C)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 1500˚F (815˚C)	High Temp. Resistance Above 1000˚F (540˚C): Oxidation	Carburization	Strength & Stability	Corrosion Resistance: Sulfuric Acid	Hydrochloric Acid	Hydrofluoric Acid	Phosphoric Acid	Nitric Acid	Organic Acids	Alkalies	Salts	Seawater	Chloride Cracking	Condition	Mechanical Properties at Room Temperature: Tensile Strength 1000psi (mPa)	Yield Strength 1000psi 0.2% offset (mPa)	Elongation %	Modulus of Elasticity 10³psi (GPa)	Hardness Rockwell B	Casting Alloy Equivalent	Welding Consumables	"P" Number	Group Number
Alloy 330	UNS N08330 ASTM B535 B546 B710 ASME SB535	• Austenitic heat and corrosion resistant alloy. • Excellent combination of high strength and resistance to carburization. • Carburization and oxidation resistance up to 2200°F (1200°C). • Good for continuous exposure up to 2100°F (1150°C) intermittent service up to 1900°F (1010°C). • Good resistance to thermal cycling. • Used in high temperature heat exchangers, radiant tubes and furnace rollers.	17.0-20.0 Cr 34.0-37.0 Ni 0.75-1.1 Si max 0.08 C Balance Fe	0.289 (8.00)	8.0 (13.9)	10.8 (18.7)	2	2	2	3	5	5	4	3	3	3	4	4	5	annealed	70 (483)	30 (205)	30	28.5 (196)	85	WISC-ALLOY 20-32Nb HT (High Carbon)	ER330	44	N/A
Alloy 333	UNS N06333 ASTM B726 B723 ASHE SB726 SB723	• Austenitic, non-hardenable, heat and corrosion resistant alloy. • Excellent high temperature strength, oxidation, carburization resistance to 2200°F(1200°C). • One of lowest coefficients of expansion of chromium-nickel high temperature alloys. • Used in heat exchanger tubes, radiant heating tubes, muffler tubes and furnace parts.	25.0 Cr 45.0 Ni 3.0 Co 3.0 Mo 3.0 W 18.0 Fe 1.25 Si 1.5 Mn 0.05 C Balance Fe	0.298 (8.249)	6.4 (11.2)	11.3 (19.8)	2	2	2	3	3	4	1	1	1	1	3	1	1	annealed	100 (690)	50 (344)	50 ❶	28.0 (193)	85	–	ER333 RA333®	UA	–
Alloy 617	UNS N06617 AMS 5889	• Solid solution strengthened alloy. • Excellent high temperature strength and oxidation resistance. • Easily formed and welded. • Excellent resistance to wide range of corrosive environments, both reducing and oxidizing media. • Oxidation resistance at temperatures over 1800°F (1000°C) makes this alloy useful for high temperature ductility and combustion parts.	20.0-24.0 Cr 10.0-15.0 Co max 3.0 Fe 8.0-10.0 Mo 0.05-0.15 C 0.8-1.5 Al max 0.006 B max 1.0 Si max 0.5 Cu max 0.6 Ti Balance Ni	0.302 (8.36)	7.8 (13.4)	15.0 (26.0)	2	2	2	3	2	2	2	2	1	1	1	1	1	solution annealed (typical)	110 (758)	55 (380)	56	30.6 (211)	90	–	INCO-FM617	UA	–
Alloy 690	UNS N06690 ASTM B163 B167 ASME B163 B167	• Solid solution strengthened alloy with excellent resistance to many corrosive media and to high temperature atmosphere. • High strength, good metallurgical stability and fabricability. • Used for coal gasification parts, coils to heat pickle acids, steam generators, ducts recuperators. • Excellent resistance to chloride stress corrosion cracking.	27.0-31.0 Cr 7.0-11.0 Fe min 58.0 Ni max 0.05 C	0.296 (8.19)	7.5 (13.0)	15.6 (26.6)	2	2	2	3	4	3	4	3	1	1	3	4	1	solution annealed	85 (586)	35 (241)	30	30.6 (211)	92	Inconel®	ERNiCrFe5 MIL-RN62 MIL-EN62 Inco-FM62	43	N/A
Alloy MP-35N	UNS R30035 AMS 5844 AMS 5845	• Ultra high strength, toughness, ductility and outstanding corrosion resistance. • Hardened by work hardening and aging. • Resistant to H2S, salt water, chloride solutions, mineral acids, crevice and stress corrosion cracking in seawater. • Used for tubing where strength and exceptional corrosion resistance are required.	19.0-21.0 Cr 33.0-37.0 Ni 9.0-10.5 Mo max 0.025 C Balance Co	0.304 (8.43)	7.3 (12.7)	12.3 (21.3)	2	2	2	2	2	3	2	2	2	2	2	1	1 1 1	annealed Cold Worked Cold Worked	140 (970) 240 (1660) 280 (1940)	60 (415) 220 (1520) 250 (1730)	50 5 5	33.8 (233) – –	95 45 R_C 48 R_C	–	Matching	UA	–

❶ Rolled Alloys Data

1=Excellent • 2=Good to Excellent • 3=Good • 4=Acceptable • 5=Not Acceptable • 6=No Data Available • 7=Contact Trent Tube for Specific Details

High Temperature Alloys (continued)

Trent Tube

Material	UNS/ Specification Number	Description/Applications	Basic Composition	Density LB/IN³ (G/CC)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 70˚ F (20˚C)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 1500˚F (815˚C)	High Temp. Resistance Above 1000˚F (540˚C): Oxidation	Carburization	Strength & Stability	Corrosion Resistance: Sulfuric Acid	Hydrochloric Acid	Hydrofluoric Acid	Phosphoric Acid	Nitric Acid	Organic Acids	Alkalies	Salts	Seawater	Chloride Cracking	Condition	Mechanical Properties at Room Temperature: Tensile Strength 1000psi (mPa)	Yield Strength 1000psi 0.2% offset (mPa)	Elongation %	Modulus of Elasticity 10⁶psi (GPa)	Hardness Rockwell B	Casting Alloy Equivalent	Welding Consumables	"P" Number	Group Number
Alloy 601	UNS N06001 ASME Code Case 1500	• Excellent high temperature properties. • Resistant to oxidizing and carburizing atmospheres. • Heat exchangers, thermocouple tubes, aircraft engine components.	60.5 Ni 23.0 Cr 14.0 Fe 1.4 Al	0.293 (8.11)	6.5 (11.2)	14.2 (24.7)	2	2	2	4	5	4	4	4	2	2	2	4	2	annealed	80 (550)	30 (210)	30	30 (207)	95	Inconel®	ERNiCr-3 MIL-RN82 MIL-EN82	UA	–
Alloy L605	UNS R30605	• Non-magnetic cobalt-chromium-nickel alloy with good oxidation and corrosion resistance and high strength at elevated temperatures. • High strength obtained by cold working. Remains non-magnetic in cold worked conditions. • Used in gas turbine components, human body implants, instrumentation components.	19.0-21.0 Cr 9.0-11.0 Ni 14.0-16.0 W max 3.0 Fe 0.05-0.15 C 1.00-2.00 Mn Balance Co	0.333 (9.225)	7.3 (12.7)	12.1 (21.0)	2	2	2	2	2	3	2	2	2	2	2	1	1	annealed ❶ 30% cold worked	133 (917) 195 (1345)	69 (476) 145 (1000)	41 76	35.3 (243)	–	–	Matching	UA	–
Alloy X750	UNS N07750 AMS 5582 Customer Specifications	• Age hardenable alloy with good corrosion and oxidation resistance up to 1300°F (700°C). • Excellent properties down to cryogenic temperatures. • Excellent relations resistance. • Used for high temperature applications where strength and corrosion resistance are important.	14.0-17.0 Cr 5.0-9.0 Fe 0.4-1.0 Al 0.7-1.2 Cb 2.25-2.75 Ti max 0.08 C Balance Ni	0.299 (8.28)	6.9 (12.0)	13.2 (22.9)	2	2	2	4	4	5	4	5	1	1	3	4	4	aged annealed	165 (1140) 130 (900)	105 (725) 60 (415)	20 40	31.0 (213) –	32 R_C	WISC-ALLOY X	ERNiFeCr-2 Inco-FM718	UA	–
Alloy 800H	UNS N08810 ASTM B515 B514 ASME SB515 SB514	• Better strength at high temperatures than Alloy 800. • Improved creep and stress-to-rupture properties in 1100°F to 1800°F (595°C to 980°C). • Chemical and power plant super heater and reheater tubing, heaters and furnace tubing, process piping.	30.0-35.0 Ni 19.0-23.0 Cr 0.05-0.10 C 0.15-0.60 Ti 0.15-0.60 Al Balance Fe	0.287 (7.94)	6.7 (11.5)	14.5 (25.1)	2	2	2	4	5	7	4	2	2	4	4	4	3	annealed	65 (450)	25 (170)	30	28.5 (196)	85	HT HP	ERNiCr-3 MIL-RN82 MIL-EN82 Inco-FM82	45	N/A
Alloy A286	UNS S66286 AMS 5731 5732 5734 5737 5895	• Austenitic alloy with high strength and corrosion resistance at temperatures up to 1300°F (700°C). • High ductility in notched specimens. • Notched rupture strength superior to many other high temperature alloys. • Can be precipitation hardened. • Used in gas turbine components and applications requiring high strength and corrosion resistance.	13.5-16.0 Cr 24.0-27.0 Ni 1.0-2.0 Mo 1.9-2.35 Ti 0.1-0.5 V 0.001-0.01 B max 0.08 C Balance Fe	0.286 (7.916)	8.7 (15.0)	13.8 (23.8)	2	2	2	4	5	5	4	3	3	3	4	4	4	heat treated	130 (895)	85 (585)	15	28.8 (198)	25 R_C	–	Matching ERNiFeCr-2	UA	–

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Note: Exposures over 1300˚F (700˚C) results in over-aging with loss of strength.

❶ Carpenter Technology Corp. Data

1=Excellent • 2=Good to Excellent • 3=Good • 4=Acceptable • 5=Not Acceptable • 6=No Data Available • 7=Contact Trent Tube for Specific Details

Nickel Alloys

Trent Tube

Material	UNS/ Specification Number	Description/Applications	Basic Composition	Density LB/IN³ (G/CC)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 70˚ F (20˚C)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 1500˚F (815˚C)	High Temp. Resistance Above 1000˚F (540˚C): Oxidation	Carburization	Strength & Stability	Corrosion Resistance: Sulfuric Acid	Hydrochloric Acid	Hydrofluoric Acid	Phosphoric Acid	Nitric Acid	Organic Acids	Alkalies	Salts	Seawater	Chloride Cracking	Condition	Mechanical Properties at Room Temperature: Tensile Strength 1000psi (mPa)	Yield Strength 1000psi 0.2% offset (mPa)	Elongation %	Modulus of Elasticity 10⁶psi (GPa)	Hardness Rockwell B	Casting Alloy Equivalent	Welding Consumables	"P" Number	Group Number
Alloy 200	UNS N02200 ASTM B725 B730	• Commercially pure wrought nickel. • Good mechanical properties. • Excellent resistance to many corrosives. • Used in food processing, caustic handling, aerospace components.	99.0-100.0 Ni max 0.15 C	0.321 (8.89)	40.6 (70.2)	36.7 (63.5)	5	5	5	4	4	3	4	5	3	3	3	3	1	annealed	55	15 (380)	40 (105)	28.0	70 (193)	Nickel CZ100	ERNi-1 MIL-RN61 MIL-ER61	41	N/A
Alloy 201	UNS N02201 ASTM B725 B730	• Commercially pure wrought nickel with low carbon to prevent embrittlement at temperatures over 600°F (315°C). • Softer than Alloy 200, suitable for cold forming. • Excellent resistance to many corrosives. • Used in food processing, caustic handling, aerospace components.	99.0-100.0 Ni max 0.020 C	0.321 (8.89)	45.8 (79.3)	37.8 (65.4)	5	5	5	4	4	3	4	5	3	3	3	3	1	annealed	50 (345)	12 (80)	40	28.0 (193)	62	Nickel CZ100	ERNi-1 MIL-RN61 MIL-ER61 Inco-FM61	41	N/A

SCROLL FOR MORE DATA

Material	UNS/ Specification Number	Description/Applications	Basic Composition	Density LB/IN³ (G/CC)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 70˚ F (20˚C)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 1500˚F (815˚C)	High Temp. Resistance Above 1000˚F (540˚C): Oxidation	Carburization	Strength & Stability	Corrosion Resistance: Sulfuric Acid	Hydrochloric Acid	Hydrofluoric Acid	Phosphoric Acid	Nitric Acid	Organic Acids	Alkalies	Salts	Seawater	Chloride Cracking	Condition	Mechanical Properties at Room Temperature: Tensile Strength 1000psi (mPa)	Yield Strength 1000psi 0.2% offset (mPa)	Elongation %	Modulus of Elasticity 10⁶psi (GPa)	Hardness Rockwell B	Casting Alloy Equivalent	Welding Consumables	"P" Number	Group Number
Alloy 400	UNS N04400 ASTM B725 B730	• High strength and toughness over wide temperature range. • Excellent resistance to reducing corrosive environments. • Good weldability. • Used in heat exchangers, food processing, petroleum refinery and chemical processing industry applications.	63.0-70.0 Ni 30.0-37.0 Cu	0.318 (8.80)	12.6 (21.8)	26.9 (46.6)	5	5	5	2	4	3	2	5	2	3	3	2	1	annealed	85 (585)	28 (195)	32	26.0 (179)	75	Monel A	ERNiCu-7 MIL-RN60 MIL-EN60 Inco-FM60	42	N/A

SCROLL FOR MORE DATA

Material	UNS/ Specification Number	Description/Applications	Basic Composition	Density LB/IN³ (G/CC)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 70˚ F (20˚C)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 1500˚F (815˚C)	High Temp. Resistance Above 1000˚F (540˚C): Oxidation	Carburization	Strength & Stability	Corrosion Resistance: Sulfuric Acid	Hydrochloric Acid	Hydrofluoric Acid	Phosphoric Acid	Nitric Acid	Organic Acids	Alkalies	Salts	Seawater	Chloride Cracking	Condition	Mechanical Properties at Room Temperature: Tensile Strength 1000psi (mPa)	Yield Strength 1000psi 0.2% offset (mPa)	Elongation %	Modulus of Elasticity 10⁶psi (GPa)	Hardness Rockwell B	Casting Alloy Equivalent	Welding Consumables	"P" Number	Group Number
Alloy 600	UNS N06600 ASTM B516 B517 ASME SB516 SB517	• Resistant to oxidizing and reducing environments. • For severe corrosion environments at elevated temperatures. • Steam generators, food processing, chemical processing, electronic components.	min 72.0 Ni 14.0-17.0 Cr 6.0-10.0 Fe max 0.15 C	0.306 (8.47)	8.58 (14.9)	16.1 (27.8)	2	2	2	4	5	4	4	4	2	2	2	4	1	annealed	80 (550)	35 (240)	30	30.0 (207)	85	Inconel A	ERNiCr-3 MIL-RN62 MIL-EN62 Inco-FM62	43	N/A

SCROLL FOR MORE DATA

Material	UNS/ Specification Number	Description/Applications	Basic Composition	Density LB/IN³ (G/CC)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 70˚ F (20˚C)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 1500˚F (815˚C)	High Temp. Resistance Above 1000˚F (540˚C): Oxidation	Carburization	Strength & Stability	Corrosion Resistance: Sulfuric Acid	Hydrochloric Acid	Hydrofluoric Acid	Phosphoric Acid	Nitric Acid	Organic Acids	Alkalies	Salts	Seawater	Chloride Cracking	Condition	Mechanical Properties at Room Temperature: Tensile Strength 1000psi (mPa)	Yield Strength 1000psi 0.2% offset (mPa)	Elongation %	Modulus of Elasticity 10⁶psi (GPa)	Hardness Rockwell B	Casting Alloy Equivalent	Welding Consumables	"P" Number	Group Number
Alloy 625	UNS N06625 ASTM B704 B705	• High strength and toughness from cryogenic temperatures to 1800°F (1000°C). • Good oxidation resistance, exceptional fatigue strength. • Good resistance to many corrosives.	min 58.0 Ni 20.0-23.0 Cr 8.0-10.0 Mo 3.15-4.15 Cb+Ta	0.305 (8.44)	5.7 (9.8)	12.6 (21.8)	2	2	2	3	2	2	2	1	1	2	1	1		annealed	120 (827)	60 (414)	30	30.1 (207)	95 R_C	WISC ALLOY®	ERNiCrMo-3 MIL-RN625 MIL-EN625	43	N/A

SCROLL FOR MORE DATA

Material	UNS/ Specification Number	Description/Applications	Basic Composition	Density LB/IN³ (G/CC)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 70˚ F (20˚C)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 1500˚F (815˚C)	High Temp. Resistance Above 1000˚F (540˚C): Oxidation	Carburization	Strength & Stability	Corrosion Resistance: Sulfuric Acid	Hydrochloric Acid	Hydrofluoric Acid	Phosphoric Acid	Nitric Acid	Organic Acids	Alkalies	Salts	Seawater	Chloride Cracking	Condition	Mechanical Properties at Room Temperature: Tensile Strength 1000psi (mPa)	Yield Strength 1000psi 0.2% offset (mPa)	Elongation %	Modulus of Elasticity 10⁶psi (GPa)	Hardness Rockwell B	Casting Alloy Equivalent	Welding Consumables	"P" Number	Group Number
JS 700	UNS N08700 ASTM B599 B672 ASME SB599 SB672	• Excellent corrosion resistance. • Resistant to intergranular corrosion. • Minimal sigma formation in welds and heat affected zones. • Field weldable. • Better corrosion resistance than 317LM.	24.0-26.0 Ni 19.0-23.0 Cr 4.3-5.0 Mo min 8xC Cb max 0.4 Cb max 0.04 C max 1.00 Si max2.00 Mn max 0.50 Cu	0.290 (8.02)	8.5 (14.6)		–	–	–	4	5	5	1	1	1	1	4	1	1	annealed	80 (551)	35 (240)	30	28.0 (193)	95	CG8M	ERNiCrMo-3	45	N/A

SCROLL FOR MORE DATA

Material	UNS/ Specification Number	Description/Applications	Basic Composition	Density LB/IN³ (G/CC)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 70˚ F (20˚C)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 1500˚F (815˚C)	High Temp. Resistance Above 1000˚F (540˚C): Oxidation	Carburization	Strength & Stability	Corrosion Resistance: Sulfuric Acid	Hydrochloric Acid	Hydrofluoric Acid	Phosphoric Acid	Nitric Acid	Organic Acids	Alkalies	Salts	Seawater	Chloride Cracking	Condition	Mechanical Properties at Room Temperature: Tensile Strength 1000psi (mPa)	Yield Strength 1000psi 0.2% offset (mPa)	Elongation %	Modulus of Elasticity 10⁶psi (GPa)	Hardness Rockwell B	Casting Alloy Equivalent	Welding Consumables	"P" Number	Group Number
Alloy 800	UNS N08800 ASTM B514 B515 ASME SB514 SB515	• Strong and resistant to oxidation & carburization. • Resists sulfidation, internal oxidation, scaling and corrosion. • Used in heat exchangers, process piping, steam generators, heating element cladding.	30.0-35.0 Ni 19.0-23.0 Cr 0.15-0.6 Al max 0.10 C 0.15-0.6 Ti Balance Fe	0.287 (7.94)	6.7 (11.5)	14.5 (25.1)	2	2	2	4	5	7	4	3	2	4	4	4	3	annealed	75 (520)	30 (209)	30	28.5 (196)	85	HT HP	ERNiCr-3 MIL-RN82 MIL-EN82	45	N/A

1=Excellent • 2=Good to Excellent • 3=Good • 4=Acceptable • 5=Not Acceptable • 6=No Data Available • 7=Contact Trent Tube for Specific Details

Nickel Alloys (continued)

Trent Tube

Material	UNS/ Specification Number	Description/Applications	Basic Composition	Density LB/IN³ (G/CC)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 70˚ F (20˚C)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 1500˚F (815˚C)	High Temp. Resistance Above 1000˚F (540˚C): Oxidation	Carburization	Strength & Stability	Corrosion Resistance: Sulfuric Acid	Hydrochloric Acid	Hydrofluoric Acid	Phosphoric Acid	Nitric Acid	Organic Acids	Alkalies	Salts	Seawater	Chloride Cracking	Condition	Mechanical Properties at Room Temperature: Tensile Strength 1000psi (mPa)	Yield Strength 1000psi 0.2% offset (mPa)	Elongation %	Modulus of Elasticity 10⁶psi (GPa)	Hardness Rockwell B	Casting Alloy Equivalent	Welding Consumables	"P" Number	Group Number
Alloy 825	UNS N08825 ASTM B704 B705	• Resists pitting and intergranular corrosion. • Excellent corrosion resistance in a wide variety of environments and applications. • Applications include nuclear industry, chemical processing, hydroflouric acid production, pollution control systems.	38.0-46.0 Ni 19.5-23.5 Cr 2.5-3.5 Mo 1.5-3.0 Cu 0.6-1.2 Ti max 0.2 Al Balance Fe	0.294 (8.14)	6.4 (11.1)	13.7 (23.6)	2	2	4	3	3	3	3	3	1	2	2	2	2	annealed	85-105 (590 -720)	36-65 (240 -450)	50-30 (205)	29.8	80	CN7M	ERNiFeCr-1 MIL-RN65 Inco-FM65	45	N/A
Alloy C-276	UNS N10276 ASTM B626 B619 ASME SB626 SB619	• Outstanding corrosion resistance in reducing and oxidizing environments. • Excellent resistance to pitting and stress-corrosion cracking. • Maintains corrosion resistance in welded joints. • Applications in chemical processing, pollution control, pulp and paper and other severe environments/conditions.	15.0-17.0 Mo 14.5-16.5 Cr 4.0-7.0 Fe 3.0-4.5 W max 0.02 C Balance Ni	0.321 (8.89)	5.7 (9.8)	13.8 (23.7)	2	2	2	2	2	2	2	2	2	2	2	2	1	annealed	115 (750)	60 (415)	50	29.8 (205)	80	CW12M WISC-ALLOY-C	ERNiCrMo-4	44	N/A
Alloy C-22™	UNS N06022 ASTM B619 B626 ASME SB619 SB626	• Better corrosion resistance in some environments than C-276, C-4 and 625. • Outstanding resistance to pitting, crevice and stress-corrosion cracking. • Excellent corrosion resistance of as-welded components. • Applications include heat exchanger tubing, piping, spargers, reheat components, SO2 cooling lines, HF furnaces, incineration systems.	20.0-22.5 Cr 12.5-14.5 Mo 2.5-3.5 W 2.0-6.0 Fe Balance Ni	0.314 (8.69)	5.8 (10.1)	12.3 (21.3)	2	2	2	2	2	2	2	2	2	2	2	2	1	annealed	100 (690)	41 (283)	55	29.9 (206)	87	CW12M WISC-ALLOY-C	ERNiCrMo-4	44	N/A
Alloy C-4	UNS N06455 ASTM B626 B619 ASME SB626 SB619	• Outstanding high temperature stability. • Maintains high ductility and corrosion resistance even after long time aging at 1200-1900°F (650-1040°C). • Chemical processing applications, seawater environments. • Excellent corrosion resistance to dry chlorine, not contaminated mineral acids, seawater, brine, chlorine and chlorine contaminated media.	14.0-18.0 Cr 14.0-17.0 Mo max 0.7 Ti max 3.0 Fe Balance Ni	0.312 (8.64)	5.8 (10.1)	11.8 (20.5)	2	2	2	2	1	2	2	1	1	1	1	1	1	annealed	115 (790)	55 (375)	56	30.8 (212)	90	CW12M WISC-ALLOY-C	ERNiCrMo-7	44	N/A
Alloy G	UNS N06007 ASTM B626 B619 ASME SB626 SB619	• Excellent corrosion resistance in many media. • Resists pitting, crevice corrosion and intergranular corrosion. • Evaporators, heat exchangers, pollution control industry; manufacture of phosphoric and sulfuric acids.	21.0-23.5 Cr 5.5-7.5 Mo 18.0-21.0 Fe 1.5-2.5 Cu max 1.0 W 1.0-2.0 Mn 1.75-2.5 Cb Balance Ni	0.300 (8.30)	5.8 (10.1)	12.9 (22.3)	2	2	4	2	3	3	2	2	2	2	2	2	2	annealed	100 (703)	45 (319)	60	27.8 (191)	84	WISC-ALLOY-C	ERNiCrMo-1	45	N/A

C-22™ is a trademark of Haynes International, Inc.

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Nickel Alloys (continued)

Trent Tube

Material	UNS/ Specification Number	Description/Applications	Basic Composition	Density LB/IN³ (G/CC)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 70˚ F (20˚C)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 1500˚F (815˚C)	High Temp. Resistance Above 1000˚F (540˚C): Oxidation	Carburization	Strength & Stability	Corrosion Resistance: Sulfuric Acid	Hydrochloric Acid	Hydrofluoric Acid	Phosphoric Acid	Nitric Acid	Organic Acids	Alkalies	Salts	Seawater	Chloride Cracking	Condition	Mechanical Properties at Room Temperature: Tensile Strength 1000psi (mPa)	Yield Strength 1000psi 0.2% offset (mPa)	Elongation %	Modulus of Elasticity 10⁶psi (GPa)	Hardness Rockwell B	Casting Alloy Equivalent	Welding Consumables	"P" Number	Group Number
Alloy G-3	UNS N06985 ASTM B626 B619 ASME SB626 SB619	• Same excellent general corrosion resistance as Alloy G, but greater resistance to HAZ attack. • Excellent corrosion resistance in as-welded condition. • Excellent resistance to hot sulfuric and phosphoric acids, stress-corrosion cracking. • Good resistance to chloride pitting. • Applications include sulfuric and phosphoric acid equipment, flue gas desulfurization systems and gas scrubbers.	21.0-23.5 Cr 6.0-8.0 Mo max 1.5 W 13.0-21.0 Fe 1.0-2.5 Cu Balance Ni	0.300 (8.30)	5.75 (10.0)	12.5 (21.8)	2	2	4	2	3	3	2	2	2	2	2	2	2	annealed	100 (692)	45 (311)	58	28.9 (199)	85	WISC-ALLOY-C	ERNiCrMo-9	45	N/A
Alloy G-30®	UNS N06030 ASTM B626 B619 ASME SB626 SB616	• Superior corrosion resistance over most other nickel and iron base alloys in commercial phosphoric acids and environments containing nitric acid. • Excellent corrosion resistance in the as-welded condition. • Applications are pipe and tubing in phosphoric acid manufacture, sulfuric acid manufacture, FGDS systems, fertilizer and pesticide manufacture.	28.0-31.5 Cr 4.0-6.0 Mo 1.5-4.0 W 13.0-17.0 Fe 1.0-2.4 Cu 0.30-1.50 Cb Balance Ni	0.297 (8.22)	5.9 (10.2)	12.4 (21.4)	2	2	2	2	3	3	2	2	2	2	2	2	2	annealed	100 (690)	47 (325)	55	29.3 (202)	85	WISC-ALLOY-C	ERNiCrMo-11	45	N/A
Alloy B-2	UNS N10665 ASTM B626 B619 ASME SB626 SB169	• Improved resistance to knife-line and heat affected zone attack. • Resists formation of grain-boundary carbide precipitates in the weld affected zone. • Used in reducing environments (never oxidizing) or vacuum. • Used in chemical processing applications and other hydrochloric acid environments.	26.0-30.0 Mo max 1.0 Cr max 2.0 Fe Balance Ni	0.333 (9.22)	6.4 (11.1)	10.8 (18.7)	5	4	4	2	1	2	2	5	2	2	2	2	2	annealed	130 (894)	58 (400)	55	31.4 (216)	98	N12M	ERNiMo-7	44	N/A
Alloy 20Cb-3®	UNS N08020 ASTM B464 B468 B474 ASME SB464 SB468	• Superior resistance to stress-corrosion cracking in boiling 20 to 40% sulfuric acid. • Excellent general corrosion resistance to sulfuric acid. • Excellent mechanical properties & fabricability. • Minimal carbide precipitation during welding. • Used in chemical and allied industries, food and dye production, heat exchangers, SO_2 scrubbers and other severe environments. • Good resistance to chloride stress corrosion cracking.	32.5-35.0 Ni 19.0-21.0 Cr 2.0-3.0 Mo 3.0-4.0 Cu max 1.0 Cb max 0.06 C Balance Fe	0.292 (8.08)	7.0 (12.2)	10.5 (18.1)	2	2	5	2	4	4	2	2	2	2	2	7	2	annealed	93 (641)	46 (317)	38	28.0 (193)	90	CN7M	ER320 ER320LR	45	N/A

Alloy 20Cb-3® is a registered trademark of Carpenter Technology Corp.

1=Excellent • 2=Good to Excellent • 3=Good • 4=Acceptable • 5=Not Acceptable • 6=No Data Available • 7=Contact Trent Tube for Specific Details

Nickel Alloys (continued)

Trent Tube

Material	UNS/ Specification Number	Description/Applications	Basic Composition	Density LB/IN³ (G/CC)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 70˚ F (20˚C)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 1500˚F (815˚C)	High Temp. Resistance Above 1000˚F (540˚C): Oxidation	Corrosion Resistance: Carburization	Strength & Stability	Sulfuric Acid	Hydrochloric Acid	Hydrofluoric Acid	Phosphoric Acid	Nitric Acid	Organic Acids	Alkalies	Salts	Seawater	Chloride Cracking	Condition	Mechanical Properties at Room Temperature: Tensile Strength 1000psi (mPa)	Yield Strength 1000psi 0.2% offset (mPa)	Elongation %	Modulus of Elasticity 10⁶psi (GPa)	Hardness Rockwell B	Casting Alloy Equivalent	Welding Consumables	"P" Number	Group Number
Alloy 20 Mo-6®	UNS N08026 ASTM B464 B468 B474 ASME SB464 SB468	• Resistant to corrosion in hot chloride environments with low pH. • Good resistance to pitting, crevice corrosion and stress-corrosion cracking in chloride environments. • Good resistance to sulfuric acid. • Resistant to oxidizing media. • High strength in solution annealed condition. • Acid environments, chemical processing and related industries, other severe environments and conditions.	33.0-37.2 Ni 22.0-26.0 Cr 5.0-6.7 Mo 2.0-4.0 Cu max 0.03 C Balance Fe	0.294 (8.13)	6.9 (12.1)	10.6 (18.3)	2	2	4	2	4	4	2	2	2	2	2	2	2	annealed	88 (607)	40 (276)	48	27.0 (186)	85	WISC-ALLOY-C	ERNiCrMo-3	45	N/A

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1=Excellent • 2=Good to Excellent • 3=Good • 4=Acceptable • 5=Not Acceptable • 6=No Data Available • 7=Contact Trent Tube for Specific Details

Precipitation Hardening Stainless Steels

Trent Tube

Material	UNS/ Specification Number	Description/Applications	Basic Composition	Density LB/IN³ (G/CC)	Thermal Conductivity Btu/ft-hr-°F (W/M-°C) 70° F (20°C)	Thermal Conductivity Btu/ft-hr-°F (W/M-°C) 1500°F (815°C)	High Temp. Resistance Above 1000°F (540°C)		Corrosion Resistance												Mechanical Properties at Room Temperature										
							Oxidation	Carburization	Strength & Stability	Sulfuric Acid	Hydrochloric Acid	Hydrofluoric Acid	Phosphoric Acid	Nitric Acid	Organic Acids	Alkalies	Salts	Seawater	Chloride Cracking	Condition	Tensile Strength 1000psi (mPa)	Yield Strength 1000psi 0.2% offset (mPa)	Elongation %	Modulus of Elasticity 10⁶psi (GPa)	Hardness Rockwell B	Casting Alloy Equivalent	Welding Consumables	"P" Number	Group Number
Alloy 350	UNS S35000 AMS (Seamless only) Usually• Customer Specifications	• An austenitic/martensitic alloy with good formability and, when heat treated, high strength. • Normally contains 5-10% delta ferrite which aids weldability. Corrosion resistance similar to Type 304 stainless steel. • Optimum properties require a complex heat treatment including two sub-zero (-100°F [70°C]) exposures. • May be subject to intergranular attack unless cooled to sub-zero temperatures prior to aging. • Used where high strength and corrosion resistance at room temperatures are essential.	16.0-17.0 Cr 4.0-5.0 Ni 2.5-3.25 Mo 0.5-1.25 Mn 0.07-0.13 N 0.07-0.11 C Balance Fe	0.286 (7.92)	8.4 (14.5)	12.2 (21.1)	**Note:** Service over 1000°F (530°C) will cause overaging. Overaging may occur at lower temperatures depending on tempering temperature selected.	5	5	5	4	3	4	4	7	5	5 4	annealed aged	160 (1103) 200 (1380)	60 (414) 85 (585)	30 12	— 29.4 (202)	95 30 R_C	—	Autogenous only	UA	—
Alloy 355	UNS S35500 Usually• Customer Specifications	• Can be hardened by martensitic transformation and/or precipitation hardening. Depending on heat treatment the alloy may be austenitic with formability similar to other austenitic stainless steels. Other heat treatments yield a martensitic structure with high strength. • Better corrosion resistance than other quench hardenable martensitic stainless steels. • Overaged material is susceptible to intergranular corrosion (IGA). • Sub-zero treatment during heat treatment removes this susceptibility to IGA. • Used where high strength is required at intermediate temperatures.	14.0-16.0 Cr 4.0-5.0 Ni 2.5-3.25 Mo 0.07-0.13 N 0.05-1.25 Mn 0.10-0.15 C Balance Fe	0.286 (7.92)	8.75 (15.1)	12.0 (20.8)	**Note:** Service over 1000°F (530°C) will cause overaging. Overaging may occur at lower temperatures depending on tempering temperature selected.	5	5	5	5	4	5	4	7	5	5 4	annealed aged Sub-zero cooled and 850°F (450°C) age. (CT)	182 (1255) 200 (1517)	167 (1151) 185 (1276)	16 12	— 29.4 (202)	40 R_C 48 R_C	—	Autogenous only	UA	—
Custom 450®	UNS S45000 Usually Customer Specifications	• A martensitic, age-hardenable stainless steel with very good corrosion resistance and moderate strength. • High strength, good ductility and toughness and is easily fabricated. • Corrosion resistance similar to Type 304. • Unlike 17-4, Custom 450 can be used in solution annealed condition. • Applications where Type 304 is not strong enough or Type 410 is insufficiently corrosion resistant.	14.0-16.0 Cr 5.0-7.0 Ni 1.25-1.75 Cu 0.50-1.0 Mo max 0.06 C min 8xC Cb Balance Fe	0.280 (7.75)	—	—	**Note:** Service over 1150°F (620°C) will cause overaging. Overaging may occur at lower temperatures depending on tempering temperature selected.	4	5	5	4	3	4	4	7	5	4 4	annealed (CT) aged (H900) (CT)	142 (979) 196 (1351)	118 (814) 188 (1276)	13 14	28.0 (193) 29.0 (200)	28 R_C 42.5 R_C	—	Autogenous only	UA	—

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Precipitation Hardening Stainless Steels (continued)

Trent Tube

Material	UNS/ Specification Number	Description/Applications	Basic Composition	Density LB/IN³ (G/CC)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 70˚ F (20˚C)	Thermal Conductivity Btu/ft-hr-˚F (W/M-˚C) 1500˚F (815˚C)	High Temp. Resistance Above 1000˚F (540˚C): Oxidation	Carburization	Strength & Stability	Corrosion Resistance: Sulfuric Acid	Hydrochloric Acid	Hydrofluoric Acid	Phosphoric Acid	Nitric Acid	Organic Acids	Alkalies	Salts	Seawater	Chloride Cracking	Condition	Mechanical Properties at Room Temperature: Tensile Strength 1000psi (mPa)	Yield Strength 1000psi 0.2% offset (mPa)	Elongation %	Modulus of Elasticity 10⁶psi (GPa)	Hardness Rockwell B	Casting Alloy Equivalent	Welding Consumables	"P" Number	Group Number
Custom 455®	UNS S45500 AMS 5578	• A martensitic, age-hardenable stainless steel which is relatively soft and formable in the annealed condition. • Single-step aging treatment develops exceptionally high yield strength with good ductility and toughness. • High strength, with corrosion resistance better than Type 410, approaching Type 430. • May be susceptible to hydrogen embrittlement under some conditions. • Consider Custom 455® when ease of fabrication, high strength and corrosion resistance are all required.	11.0-12.5 Cr 7.5-9.5 Ni 1.5-2.5 Cu 0.8-1.4 Ti 0.1-0.5 Cb+Ta max 0.05 C Balance Fe	0.280 (7.76)	10.4 (18.0)	14.3 (24.8)	**Note:** Service over 1050°F (560°C) will cause overaging. Overaging may occur at lower temperatures depending on tempering temperature selected.	5	5	5	5	4	5	4	8	5	4 4	annealed aged (H950) (CT)	140 (965) 230 (1585)	115 (793) 220 (1516)	12 10	— 29.0 (200)	31 R_C 48 R_C	—	Autogenous only	UA	—
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Alloy 718	UNS N07718 AMS 5589 (Seamless Only) AMS 5590 (Seamless Only) Usually Customer Specifications	• High strength, corrosion resistant, used from -423°F to 1300°F(-250°C to 700°C). • Readily fabricated. Resistance to post weld cracking is excellent. • Good tensile fatigue, creep and rupture strength. • Age hardenable. • Excellent oxidation resistance up to 1800°F (1000°C).	17.0-21.0 Cr 50.0-55.0 Ni 4.75-5.50 Cb+Ta 2.8-3.3 Mo 0.65-1.15 Ti 0.20-0.80 Al max 0.08 C Balance Fe	0.296 (8.19)	6.6 (11.4)	13.9 (21.1)		2	2	2	4	5	5	5	5	4	4	7	5	3 3	annealed (PW) aged (PW)	140 (970) 180 (1250)	80 (550) 150 (1040)	30 15	— 29.0 (200)	20 R_C 36 R_C	—	ERNiFeCr-2 Inco FM718	UA	—
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Alloy 17-7 PH	UNS S17700 AMS 5568	• Semi-austenitic stainless steel. Austenitic (non-magnetic) in the annealed or solution annealed condition and martensitic (magnetic) in the aged or cold worked condition. • High strength. • Corrosion resistance similar to Type 304.	16.0-18.0 Cr 6.5-7.75 Ni 0.75-1.5 Al max 0.09 C Balance Fe	0.282 (7.81) 0.276 (7.65)	9.75 (16.9) (H950)	12.2 (21.1)	**Note:** Service over 1050°F (560°C) will cause overaging. Overaging may occur at lower temperatures depending on tempering temperature selected.	5	5	5	5	5	3	4	7	5	5 4	annealed (AS) aged (H950)	133 (917) 210 (1448)	42 (290) 190 (1310)	19 5	30.5 (210) 32.5 (224)	85 48 R_C	—	W17-7PH	UA	—
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Alloy 15-5 PH	UNS S15500	• Martensitic precipitation hardening stainless steel. • Excellent toughness. • Corrosion resistance not as good as Type 304. • Low temperature hardening and reactment minimizes scaling and warpage.	14.0-15.5 Cr 3.5-5.5 Ni 0.15-0.45Cb+Ta 2.5-4.5 Cu max 0.07 C Balance Fe	0.280 (7.78)	1.2 (2.1)	1.6 (2.8)	**Note:** Service over 1050°F (560°C) will cause overaging. Overaging may occur at lower temperatures depending on tempering temperature selected.	3	5	5	5	4	4	4	5	5	5 5	annealed aged (H950)	185max (1274) 190 (1310)	160max (1102) 170 (1171)	3min 8	— —	38 R_C 40 R_C	CB7CU2	ER630	UA	—
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17-4 PH Alloy	UNS S17400	• Martensitic precipitation hardening stainless steel. • Corrosion resistance similiar to Type 304. • Low temperature heat treatment at 900°-1150°F (480°-620°C) minimizes scaling and warpage.	15.5-17.5 Cr 3.0-5.0 Ni 3.0-5.0 Cu 0.15-0.45Cb+Ta max 0.07 C Balance Fe	0.280 (7.78)	10 (17.3)	13.3 (22.9)	**Note:** Service over 1050°F (560°C) will cause overaging. Overaging may occur at lower temperatures depending on tempering temperature selected.	3	5	5	5	4	4	4	5	5	5 5	annealed aged (H950)	 190 (1310)	 170 (1171)	 8	 28.5 (196)	38 R_C	CB7CU1	ER630	UA	—

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ASTM and ASME Specifications Summary

Agency & Specification Number		Title	Scope
ASTM A249	ASME SA249	Welded Austenitic Stainless Steel Boiler, Superheater, Heat-Exchanger and Condenser Tubes	Pressure tubes, made from austenitic stainless steels. (Types 304, 316, 316L, 317, 321 and other austenitic grades)
ASTM A268	ASME SA268	Seamless and Welded Ferritic Stainless Steel Tubing for General Service	Ferritic stainless steel tubing for general corrosion resistance (Types 409, 430, 439, SeaCure and other ferritic grades).
ASTM A269		Seamless and Welded Austenitic Stainless Steel Tubing for General Service 304L, 316, 316L, 321 and other austenitic grades)	Austenitic stainless steel tubing for general corrosion resisting and high temperature service. (Types 304,
ASTM A270		Seamless and Welded Austenitic Stainless Steel Sanitary Tubing	Austenitic stainless steel tubing intended for use in dairy and food industry in sizes up to and including 4" in outside diameter. (Types 304, 304L, 316, 316L)
ASTM A312	ASME SA312	Seamless and Welded Austenitic Stainless Steel Pipe	Austenitic stainless steel pipe intended for high temperature and general corrosive service. (Types 304, 304L, 316, 316L, 317, 321 and other austenitic grades)
ASTM A358	ASME SA358	Electric-Fusion-Welded Austenitic Chromium-Nickel Alloy Steel Pipe for High Temperature Service	For corrosion and high temperature service, normally not less than 8" nominal diameter. (Types 304, 304L, 316, 316L, 317, 321 and other austenitic grades)
ASTM A409	ASME SA409	Welded Large Outside Diameter Light-Wall Austenitic Chromium-Nickel Alloy Steel Pipe for Corrosive or High Temperature Service	Nominal diameter 14-30" in Schedules 5S and 10S. (Types 304, 304L, 316, 316L, 317, 321 and other austenitic grades)
ASTM A450	ASME SA450	General Requirements for Ferritic and Austenitic Alloy Steel Tubes	Common requirements for ASTM tubular specifications.
ASTM A530	ASME SA530	General Requirements for Carbon, Ferritic Alloy and Austenitic Alloy Steel Pipe	Common requirements for ASTM pipe specifications.
ASTM A554		Welded Stainless Steel Mechanical Tubing	Mechanical applications. Rounds, squares, rectangles, and special shapes are included. (Types 304, 304L, 316, 316L, 317, 321 and other austenitic grades)
ASTM A688		Welded Austenitic Stainless Steel Feedwater Heater Tubes	Feedwater heater tubes, including those bent, if specified, into the form of U-tubes. (Types 304, 304L, 304N, 304LN, 316, 316L, 316N and 316LN)
ASTM A789		Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service	Duplex grades intended for general corrosive service, with particular emphasis on resistance to stress corrosion cracking. (Types 7Mo-PLUS®, 2205 and other ferritic/austenitic grades)
ASTM A790		Seamless and Welded Ferritic/Austenitic Stainless Steel Pipe	Duplex grades intended for general corrosive service, with particular emphasis on resistance to stress corrosion cracking. (Types 7Mo-PLUS®, 2205 and other ferritic/austenitic grades)
*Also Vol. 2.04		Nonferrous Metals	Includes nickel base alloys.

Department of Defense Specifications Summary

Agency & Specification Number	Title	Scope
MIL-T-5695	Tubing, Steel, Corrosion Resistant, (304), Cold Drawn (1/2 or 1/4 Hard)	Intended for use in the fabrication of aircraft structural parts requiring resistance to corrosion and high strength.
MIL-T-6737	Tubing, Steel, Corrosion and Heat Resistant (18-8 Stabilized) Welded	Types 321 and 347 tubing intended for use in the manufacturer of exhaust stacks, manifolds, blast tubes, ring collectors and similar applications where a weldable corrosion and heat resisting steel is required or for use at 800˚ to 1500˚F.
MIL-T-6845 (T304) (Replaced by AMS 5566)	Tubing, Steel, Corrosion Resistant (304) Aerospace Hydraulic System. (1/8 Hard Condition)	Intended for use in high pressure hydraulic and pneumatic systems in which corrosion resistant materials are required. The tubing is not suitable for use in applications assembled by welding or brazing or exposure to temperatures higher than 800°F, because of impaired resistance to corrosion.
MIL-T-8504 (T304) (Replaced by AMS 5567)	Tubing, Steel, Corrosion Resistant (18-8) Annealed, Aircraft Hydraulic System	Intended for use in high pressure hydraulic and pneumatic systems in which corrosion resistant materials are required. This tubing is not suitable for use in applications assembled by welding or brazing or exposed to temperatures higher than 800°F, because of impaired resistance to corrosion. This tubing is of lower strength and higher ductility than tubing to Specification MIL-T-6845. May be used to replace MIL-T-6845 tubing but heavier wall thickness must be used.
MIL-T-8506 (T304)	Tubing, Steel, Corrosion Resistant, (304) Annealed	Intended for use in the fabrication of aircraft parts requiring a high degree of resistance to corrosion. Not to be used in high pressure hydraulic control systems.
MIL-T-8606 (T304L) (T321) (T347)	Tubing, Steel, Corrosion Resistant, (18-8 Stabilized)	Intended for use in applications which require a high degree of resistance to corrosion or to temperatures in the range of 800° to 1500°F or in applications which involve welding. Suitable for use in tank-automotive equipment, hydraulic and mechanical applications.
MIL-T-8808 (T321) (T347)	Tubing, Steel, Corrosion Resistant, (18-8 Stabilized) Aircraft Hydraulic Quality	Intended for use in high pressure hydraulic and pneumatic systems where corrosion and heat resistance are required and in which welding or brazing may be involved during fabrication. Resists oxidation at temperatures to 1200°F, but is useful at that temperature only when stresses are low.
MIL-P-24691-3 304, 304L, 316, 316L and other austenitics	Pipe and Tube, Corrosion Resistant, Stainless Steel	Intended for elevated temperature and general corrosive service, including cryogenic applications. (Seamless or Welded)

AMS Specifications Summary

Agency & Specification Number	Title	Scope
AMS 5557	Steel Tubing, Corrosion and Heat Resistant 18Cr, 11Ni, Ti, SAE 30321, Hydraulic	Annealed Type 321 hydraulic line tubing.
AMS 5558	Steel Tubing, Welded, Corrosion and Heat Resistant. 18Cr, 11 Ni,Ti, SAE 30321 Thin Wall	High pressure ducting, wall thickness 2% of OD or less.
AMS 5559	Steel Tubing, Welded, Corrosion and Heat Resistant. 18Cr, 10Ni, Ti, SAE 30321, Thin Wall	High pressure ducting, wall thickness 2% of OD or less.
AMS 5565	Steel Tubing, Welded, Corrosion Resistant, SAE 30304	Annealed Type 304 aircraft hydraulic line tubing. (Not subject to high pressure)
AMS 5566	Steel Tubing, Seamless or Welded Corrosion Resistant, SAE 30304 High Pressure Hydraulic	Cold drawn Type 304, high pressure, aircraft hydraulic line tubing.
AMS 5567	Steel Tubing, Seamless or Welded Corrosion Resistant, SAE 30304, Hydraulic, Solution Treated	Fluid lines subject to medium high pressures requiring corrosion resistance.
ASM 5568	Steel Tubing, Welded, Corrosion Resistant, 17Cr, 7Ni, 1Al, Precipitation Hardening	Annealed 17-7PH for corrosion resistance and high strength to 600°F and where parts may require welding during fabrication.
AMS 5575	Steel Tubing, Welded, Corrosion and Heat Resistant 18Cr, 11Ni, (Cb+Ta), SAE 30321	Parts and assemblies requiring both corrosion and heat resistance especially when such parts are welded during fabrication. Requiring oxidation resistance up to approximately 1500°F, but useful at that temperature only when stresses are low.
AMS 5576	Steel Tubing, Welded, Corrosion and Heat Resistant 18Cr, 11Ni, Ti, SAE 30321	Parts and assemblies requiring both corrosion and heat resistance especially when such parts are welded during fabrication. Requiring oxidation resistance up to approximately 1500°F, but useful at that temperature only when stresses are low.
AMS 5577	Steel Tubing, Welded, Corrosion and Heat Resistant 25Cr, 20Ni, SAE 30310	Parts and assemblies requiring both corrosion and heat resistance especially when such parts are welded during fabrication. Requiring oxidation resistance up to approximately 2000°F, but useful at that temperature only when stresses are low.
AMS 5588	Alloy Tubing, Welded and Drawn, Corrosion and Heat Resistant. 47.5Ni, 22Cr, 1.5Co, 9.0Mo, 0.60W, 18.5Fe	Primarily for fluid lines operating in service under appreciable stresses at elevated temperatures. Alloy has good strength up to 1800°F (980°C) and oxidation resistance up to 2200°F (1205°C).

Collapsing Pressure Formula

Following are formulae for calculating the collapsing pressures of stainless tubes where the length of the tube exceeds six times the diameter and where temperature is not over 400°F (200°C).

(a) $P = 50{,}200{,}000 \left(\frac{t}{D}\right)^3$

Applicable where the ratio of wall thickness to outside diameter $\left(\frac{t}{D}\right)$ is less than .023.

(b) $P = 70{,}200 \left(\frac{t}{D}\right) - 1025$ Applicable for values $\left(\frac{t}{D}\right)$ greater than those for formula (a)

P = Collapsing pressure in pounds per square inch
T = Thickness of tube wall in inches
D = Outside diameter of tube in inches

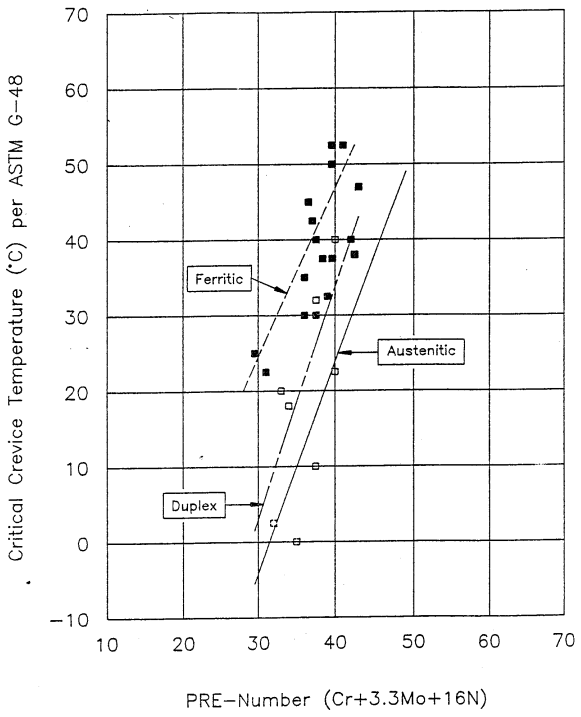
Pitting Resistance Equivalent

PRE = %Cr + 3.3 (%Mo) + 16 (%N2)
Tungsten is considered the same as molybdenum.
Apply to alloys within the same metallurgical structure

CPI > 32 for pitting corrosion resistance for Austenitic Alloys
CPI > 36 for crevice corrosion resistance

AUSTENITIC	PRE	DUPLEX	PRE
304	18.0	2205	30.5
304N	19.6	7-MoPLUS®	31.7
316	22.6		
316N	24.2	FERRITIC	PRE
317	27.9	SEA-CURE®	39.5
317LMN	31.8	430	16.0
AL-6XN®	42.7		
625	46.4		
C-276	73.9		
20Cb-3®	25.6		

AL-6XN® is a registered trademark of Allegheny Ludlum Corp.
7-MoPLUS® is a registered trademark of Carpenter Technology Corp.
SEA-CURE® is a registered trademark of Crucible Materials Corp.
20Cb-3® is a registered trademark of Carpenter Technology Corp.



Corrosive Microorganisms

Organism	Action	Problem
Desulfovibrio Clostridium Thiobacillus	Hydrogen sulfide producers (Sulfate reducers)	Corrosive to metals Reduces chromates Destroys chlorine Precipitates zinc
Thiobacillus Nitrobacter Nitrosomonas	Sulfuric acid producer Nitric acid producers	Corrosive to metals Corrosive to metals
Gallionella Crenothrix Spaerotilus	Converts soluble ferrous ions to insoluble ferric ions	Produces iron oxide deposits Increases corrosion

From "Identification & Control of Corrosive Microbiological Organisms Found in Recirculating Cooling Water Systems," by Paul R. Puckorius, Corrosion '78, paper Number 81.

Pipe – Theoretical Bursting and Collapsing Pressures

Nom Size Inches	Schedule Number	OD Inches	Wall Thickness Inches	ID Inches	Internal Cross Sect. Area, Sq. In.	Internal Pressure psi Bursting*	External Pressure psi Collspsing
1/8	40	0.405	0.068	0.269	.0.57	25,185	10,761
1/4	40	0.540	0.088	0.364	0.104	24,444	10,415
3/8	40	0.675	0.091	0.493	0.191	20,132	8,397
1/2	5	0.840	0.065	0.710	0.396	11,607	4,407
	10	.840	0.083	0.674	0.357	14,821	5,911
	40	0.840	0.109	0.622	0.304	19,464	8,084
	80	0.840	0.147	0.546	0.234	26,250	11,260
3/4	5	1.050	0.065	0.920	0.665	9,285	3,295
	10	1.050	0.083	0.884	0.614	11,857	4,624
	40	1.050	0.113	0.824	0.533	16,142	6,529
	80	1.050	0.154	0.742	0.432	22,000	9,271
1	5	1.315	0.065	1.185	1.102	7,414	2,445
	10	1.315	0.109	1.097	0.945	12,433	4,795
	40	1.315	0.133	1.049	0.864	15,171	6,075
	80	1.315	0.179	0.957	0.718	20,418	8,530
1-1/4	5	1.660	0.065	1.530	1.830	5,873	1,725
	10	1.660	0.109	1.442	1.633	9,849	3,585
	40	1.660	0.140	1.380	1.495	12,650	3,895
	80	1.660	0.191	1.278	1.282	17,259	7,052
1-1/2	5	1.900	0.065	1.770	2.460	5,131	1,376
	10	1.900	0.109	1.682	2.222	8,605	3,002
	40	1.900	0.145	1.610	2.036	11,447	4,332
	80	1.900	0.200	1.500	1.766	15,789	6,364
2	5	2.375	0.065	2.245	3.958	4,105	896
	10	2.375	0.109	2.157	3.654	6,884	2,196
	40	2.375	0.154	2.067	3.356	9,726	3,526
	80	2.375	0.218	1.939	2.953	13,768	5,418
2-1/2	5	2.875	0.083	2.709	5.761	4,330	1,001
	10	2.875	0.120	2.635	5.450	6,260	1,905
	40	2.875	0.203	2.469	4.785	10,591	3,931
3	5	3.500	0.083	3.334	8.726	3,557	639
	10	3.500	0.120	3.260	8.343	5,142	1,375
	40	3.500	0.216	3.068	7.389	9,257	3,307
3-1/2	5	4.000	0.083	3.834	11.54	3,112	431
	10	4.000	0.120	3.760	11.10	4,500	1,081
	40	4.000	0.226	3.548	9.887	8,475	2,941
4	5	4.500	0.083	4.334	14.75	2,766	315
	10	4.500	0.120	4.260	14.25	4,000	845
	40	4.500	0.237	4.026	12.72	7,900	2,672
5	5	5.563	0.109	5.345	22.43	2,949	377
	10	5.563	0.134	5.295	22.01	3,613	665
	40	5.563	0.258	5.047	20.00	6,957	2,231
6	5	6.625	0.109	6.407	32.22	2,467	225
	10	6.625	0.134	6.357	31.72	3,033	415
	40	6.625	0.280	6.065	28.89	6,340	1,942

*Bursting pressures shown are calculated on basis of minimum tensile strength of 75,000 psi. All dimensions shown are nominal. These are burst pressures and should not be considered as safe working pressure. The above values are provided as an example only for comparative purposes only and are based on ASTM properties and standard formulae. No warranty is made either expressed or implied concerning the accuracy of the calculations or the formula used to calculate the values.

Important Information

The information provided in this chart is a theoretical number to be used for comparison only. All values are based on Barlow's Formula. When selecting a size for an application, the user is responsible for deciding the appropriate safety factor based on the application and the testing of the product. The user should also consider additional sources of stress other than those caused by pressure in their design.

Tubing – Theoretical Internal Bursting Pressures

OD Inches	.020 25	.022 24	.025 23	.028 22	.032 21	.035 20	.042 19	.049 18	.058 17	.065 16	.072 15	.083 14	.095 13	.109 12	.120 11	.134 10	.148 9	.165 8
1/8	24,000	26,400	30,000	33,600	38,600	38,400	42,000	50,400	58,800									
1/4	12,000	13,200	15,000	16,800	19,200	21,000	25,200	29,400	34,800	39,000								
3/8	8,000	8,800	10,000	11,200	12,800	14,000	16,800	19,600	23,200	26,000								
1/2	6,000	6,600	7,500	8,400	9,600	10,500	12,600	14,700	17,400	19,500	21,600	24,900	28,500					
5/8	4,800	5,300	6,000	6,725	7,675	8,400	10,075	11,750	13,925	15,600	17,250	19,925	22,800					
3/4	4,000	4,400	5,000	5,600	6,400	7,000	8,400	9,800	11,600	13,000	14,400	16,600	19,000	21,800				
7/8	3,425	3,750	4,300	4,800	5,475	6,000	7,200	8,400	9,950	11,150	12,350	14,225	16,275	18,675				
1	3,000	3,300	3,750	4,200	4,800	5,250	6,300	7,350	8,700	9,750	10,800	12,450	14,250	16,350	18,000	20,100	22,200	
1-1/8			3,325	3,750	4,275	4,650	5,600	6,550	7,750	8,650	9,600	11,050	12,650	14,550	16,000	17,875	19,725	
1-1/4			3,000	3,350	3,850	4,200	5,050	5,875	6,950	7,800	8,650	9,950	11,400	13,075	14,400	16,075	17,750	
1-3/8			2,725	3,050	3,500	3,825	4,575	5,350	6,325	7,100	7,850	9,050	10,350	11,900	13,100	14,625	16,150	
1-1/2			2,500	2,800	3,200	3,500	4,200	4,900	5,800	6,500	7,200	8,300	9,500	10,900	12,000	13,400	14,800	
1-5/8			2,300	2,575	2,950	3,225	3,875	4,525	5,350	6,000	6,650	7,650	8,775	10,050	11,075	12,375	13,650	
1-3/4			2,150	2,400	2,750	3,000	3,600	4,200	4,975	5,575	6,175	7,125	8,150	9,350	10,275	11,475	12,675	
1-7/8						2,800	3,350	3,925	4,650	5,200	5,750	6,650	7,600	8,725	9,600	10,725	11,850	
2						2,625	3,150	3,675	4,350	4,875	5,400	6,225	7,125	8,175	9,000	10,050	11,100	
2-1/8						2,475	2,975	3,450	4,100	4,600	5,075	5,850	6,700	7,700	8,475	9,450	10,450	
2-1/4							2,800	3,275	3,875	4,350	4,800	5,550	6,350	7,275	8,000	8,975	9,875	
2-3/8							2,650	3,100	3,675	4,100	4,550	5,250	6,000	6,900	7,575	8,475	9,350	10,425
2-1/2							2,525	2,950	3,475	3,900	4,325	4,975	5,700	6,550	7,200	8,050	8,875	9,900
2-5/8							2,400	2,800	3,325	3,725	4,125	4,850	5,425	6,225	6,850	7,650	8,450	9,425
2-3/4								2,675	3,150	3,550	3,925	4,525	5,175	5,950	6,550	7,300	8,075	9,000
2-7/8								2,550	3,025	3,400	3,750	4,325	4,950	5,675	6,250	7,000	7,725	8,600
3								2,450	2,900	3,250	3,600	4,150	4,850	5,450	6,000	6,700	7,400	8,250
3-1/8								2,350	2,775	3,125	3,450	3,975	4,550	5,225	5,550	6,425	7,100	7,925
3-1/4								2,250	2,675	3,000	3,325	3,825	4,375	5,025	5,525	6,175	6,825	7,600
3-3/8								2,175	2,575	2,875	3,200	3,675	4,225	4,850	5,325	5,950	6,575	7,325
3-1/2								2,100	2,475	2,775	3,075	3,550	4,075	4,675	5,150	5,750	6,350	7,075
3-5/8								2,025	2,400	2,675	2,975	3,425	3,925	4,500	4,950	5,550	6,100	6,825

OD	.049	.058	.065	.072	.083	.095	.109	.120	.134	.148	.165	.180	.203	.220	.238	.259	.284	.300
3-3/4	1,950	2,325	2,600	2,875	3,325	3,800	4,350	4,800	5,350	5,900	6,600	7,200	8,125	8,800				
3-7/8	1,900	2,250	2,500	2,775	3,200	3,675	4,200	4,650	5,175	5,725	6,375	6,975	7,850	8,500				
4	1,825	2,175	2,425	2,700	3,100	4,075	4,090	4,500	5,025	5,550	6,175	6,750	7,600	8,250				
4-1/4	1,725	2,050	2,300	2,550	2,925	3,350	3,850	4,225	4,725	5,225	5,825	6,350	7,150	7,750				
4-1/2	1,625	1,925	2,150	2,400	2,750	3,150	3,625	4,000	4,450	4,925	5,500	6,000	6,750	7,325	7,925			
4-3/4	1,550	1,825	2,050	2,275	2,625	3,000	3,450	3,775	4,225	4,675	5,200	5,675	6,400	6,950	7,500			
5	1,475	1,750	1,950	2,150	2,500	2,850	3,275	3,600	4,025	4,450	4,950	5,400	6,100	6,600	7,150			
5-1/4	1,400	1,650	1,850	2,050	2,375	2,700	3,100	3,425	3,825	4,225	4,700	5,150	5,800	6,275	6,800			
5-1/2	1,325	1,575	1,775	1,950	2,250	2,600	2,975	3,275	3,650	4,025	4,500	4,900	5,550	6,000	6,500	7,050		
5-3/4	1,275	1,500	1,700	1,875	2,150	2,475	2,850	3,125	3,500	3,850	4,300	4,700	5,300	5,725	6,200	6,750		
6	1,220	1,450	1,625	1,800	2,075	2,375	2,725	3,000	3,350	3,700	4,125	4,500	5,075	5,500	5,950	6,475	7,100	
8	925	1,100	1,225	1,350	1,550	1,775	2,050	2,250	2,525	2,775	3,100	3,375	3,800	4,125	4,475	4,850	5,325	5,625
10	750	875	975	1,075	1,250	1,425	1,625	1,800	2,000	2,225	2,475	2,700	3,050	3,300	3,575	3,875	4,250	4,500
12	625	725	825	900	1,050	1,200	1,375	1,500	1,675	1,850	2,075	2,250	2,550	2,750	2,975	3,250	3,550	3,750
14	525	625	700	775	900	1,025	1,175	1,300	1,450	1,600	1,775	1,925	2,175	2,350	2,550	2,775	3,050	3,225
16	450	550	600	675	775	900	1,025	1,125	1,250	1,400	1,550	1,700	1,900	2,050	2,225	2,425	2,675	2,825
18	400	475	550	600	700	800	900	1,000	1,125	1,250	1,375	1,500	1,700	1,850	1,975	2,150	2,350	2,500
20	375	450	500	550	625	725	825	900	1,000	1,100	1,250	1,350	1,525	1,650	1,775	1,950	2,125	2,250
24	300	375	400	450	525	600	675	750	850	925	1,025	1,125	1,250	1,375	1,475	1,625	1,775	1,875
30	250	300	325	350	425	475	550	600	675	750	825	900	1,025	1,100	1,200	1,300	1,425	1,500

Theoretical Bursting pressure, in pounds for welded stainless tubes. Based on Barlow's Formula: $P = \frac{2ST}{D}$

P = Bursting pressure in psi
D = Outside diameter of tube in inches
S = Fiber stress of 75,000psi ultimate for bursting pressure
T = Wall thickness

*Bursting pressures shown are calculated on basis of minimum tensile strength of 75,000 psi. All dimensions shown are nominal. These are burst pressures and should not be considered as safe working pressure. The above values are provided as an example only for comparative purposes only and are standard formulae. No warranty is made either expressed or implied concerning the accuracy of the calculations or the formula used to calculate the values.

Alloy Systems Subject to Stress-Corrosion Cracking

Alloy	Environment
Aluminum base	• Air • Seawater • Salt & chemical combinations
Magnesium base	• Nitric acid • Caustic • HP solutions • Salts • Coastal atmospheres
Copper base	• Primarily ammonia & ammonium hydroxide • Amines • Mercury
Carbon steel	• Caustic • Anhydrous ammonia • Nitrate solutions
Martensitic & Precipitation Hardening Stainless Steels	• Seawater • Chlorides • H_2S solutions
Austenitic stainless steels	• Chlorides-inorganic & organic • Caustic solutions • Sulfurous & polythionic acids
Nickel base	• Caustic above 600°F (315°C) • Fused caustic • Hydrofluoric acid
Titanium	• Seawater • Salt atmospheres • Fused salt

Simplified. See Logan, H.L., "The Stress Corrosion of Metals," John Wiley & Sons, for comprehensive list.

Galvanic Series of Metals and Alloys

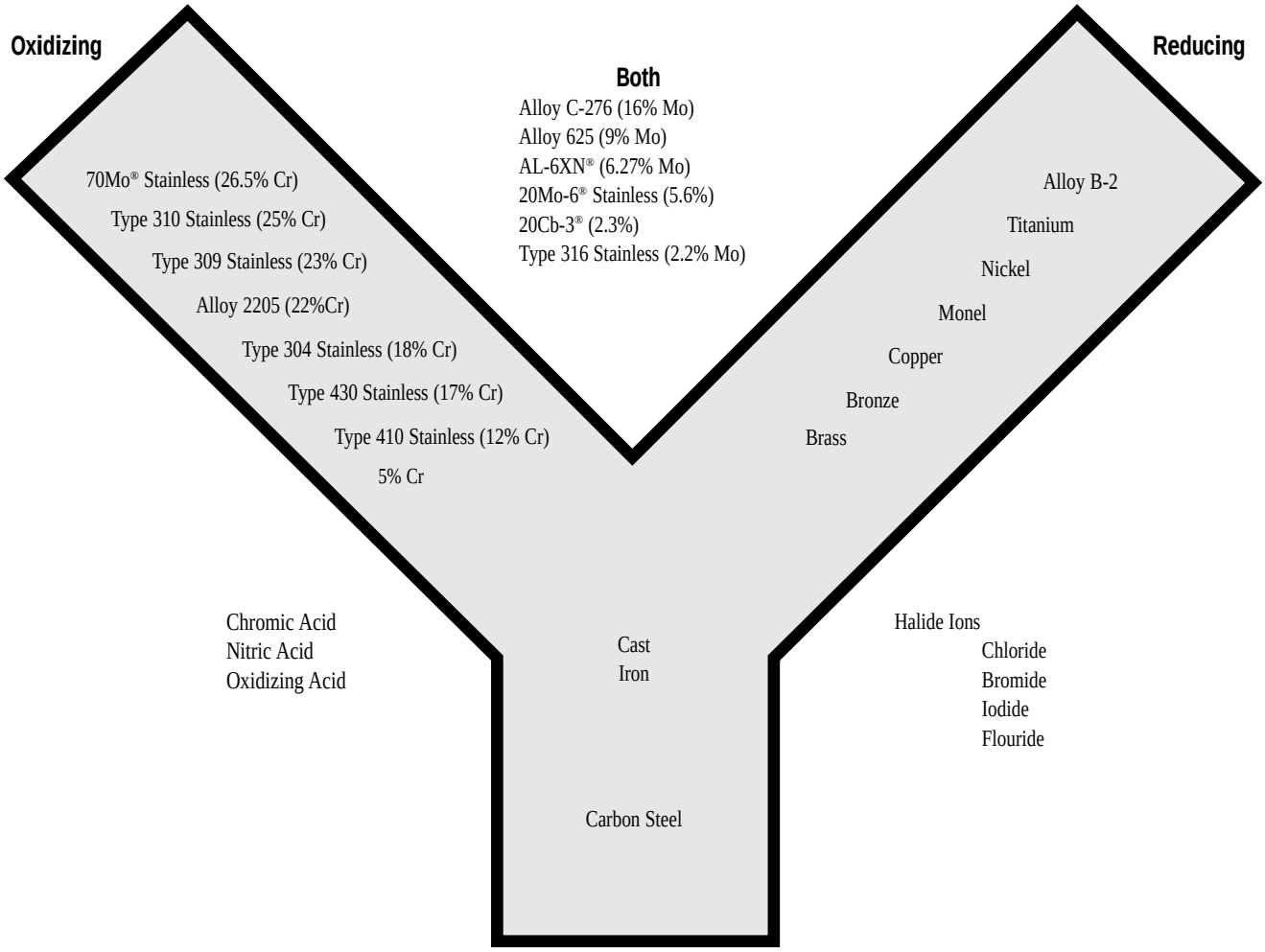
Electromotive Series		Practical Series:
Metal	Volts	Material or Alloy
Corroded end (anodic or least noble)		
Magnesium	-1.55	Magnesium
Aluminum	-1.33	Aluminum 2S
Zinc	-0.76	Zinc
Iron	-0.44	Steel or iron, Stainless steel (active), Alloy 20Cb-3 (active), Hastelloy C (active)
Nickel	-0.23	Nickel (active), Inconel (active), Hastelloy B
Hydrogen	0.00	
Copper	+0.34	Brasses, Copper, Monel, Nickel (passive), Inconel (passive), Stainless Steel (passive), Alloy 20Cb-3® (passive)
Silver	+0.80	Silver
Gold	+1.36	Gold, Platinum
Protected end (cathodic or most noble)		

Stainless Alloy Selection Guide

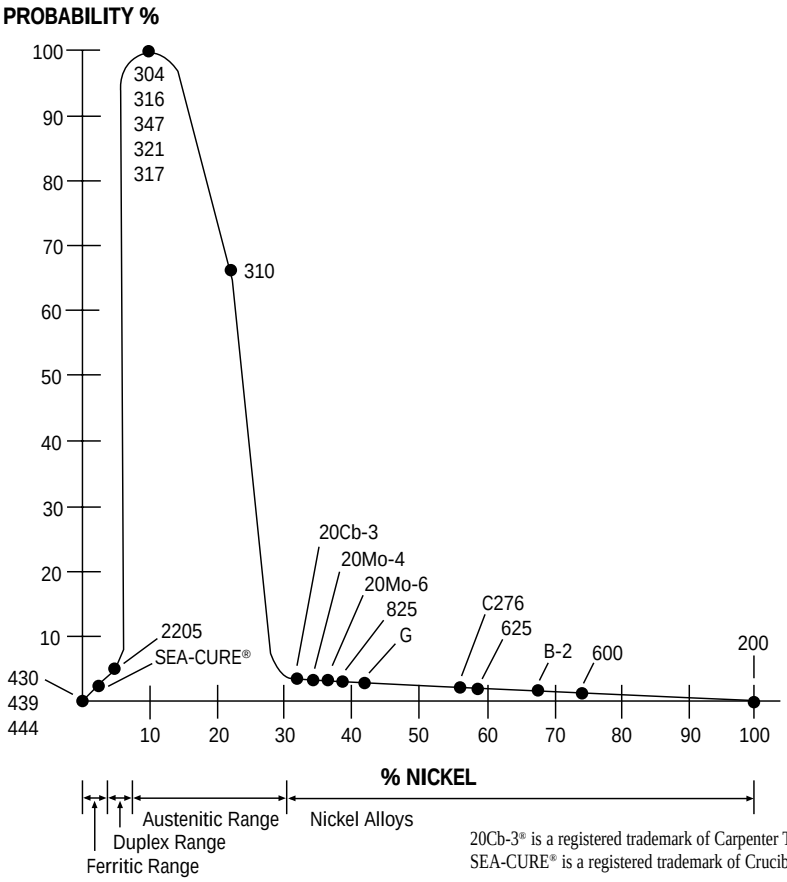
	General Corrosion			Localized Corrosion	
Corrodent Severity	Sulfuric Acid	Phosphoric Acid	Nitric Acid	Pitting or Crevice	Chloride SCC
Very severe to severe	20Cb3®	Alloy G 20Mo-6® 20Mo-4®	7MoPLUS® 20Mo-4® 20Mo-6® SEA-CURE®	SEA-CURE® 20Mo-6® AL-6XN®	2205 20Mo-6® 7MoPLUS® 20Cb-3® SEA-CURE®
Moderate to severe	20Mo-4® 20Mo-6®	20Cb-3®	20CB-3®	20Mo-4®	AL-6XN®
Moderate		SEA-CURE® 7MoPLUS®	Type 316 Type 304	7MoPLUS® 20Cb-3®	
Mild to moderate	SEA-CURE® 7MoPLUS®	Type 316		Type 316	
Mild	Type 316	Type 304		Type 304	

20Cb-3®, 20Mo-4®, 7MoPLUS®, 20Mo-6® are registered trademarks of Carpenter Technology Corp.
AL-6XN® is a registered trademark of Allengheny Ludlum Corp.
SEA-CURE® is a registered trademark of Crucible Materials Corp.

The "Y" of Corrosion for Several Metals and Alloys

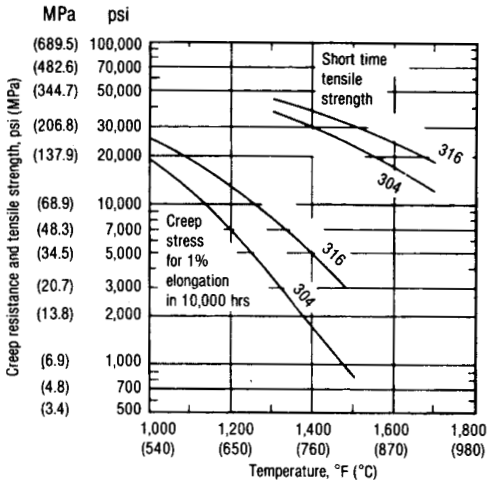


Probability of Chloride Stress Corrosion Cracking vs. Nickel Content

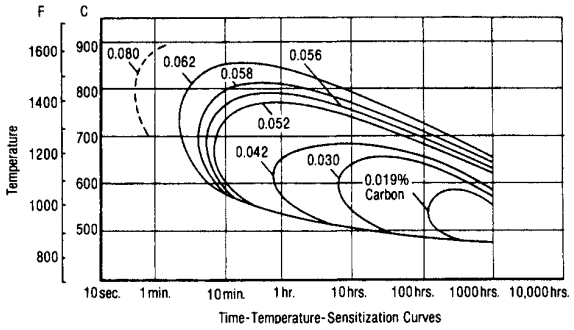


20Cb-3® is a registered trademark of Carpenter Technology Corp.
SEA-CURE® is a registered trademark of Crucible Materials Corp.

Creep Resistance and Tensile Strength at Elevated Temperatures



Effect of Carbon on Carbide Precipitation

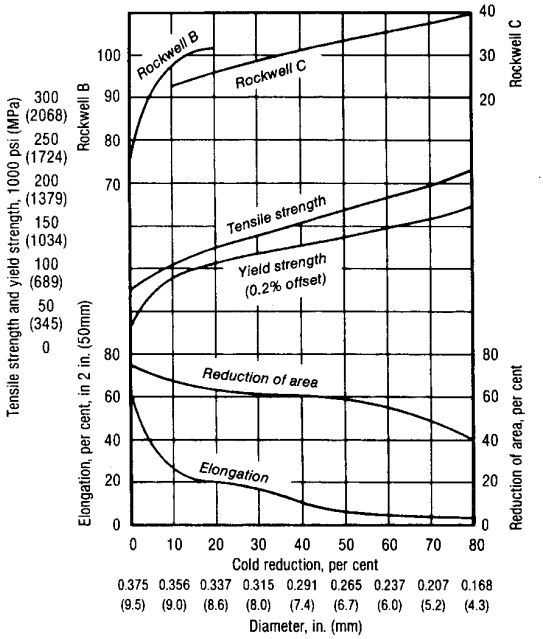


Time required for formation of harmful amounts of chromium carbide in stainless steels with various carbon contents. Carbide precipitation forms in the areas to the right of the various carbon content curves. Within time periods applicable to welding, chromium-nickel stainless steels with 0.05% carbon would be quite free from grain boundary precipitation.

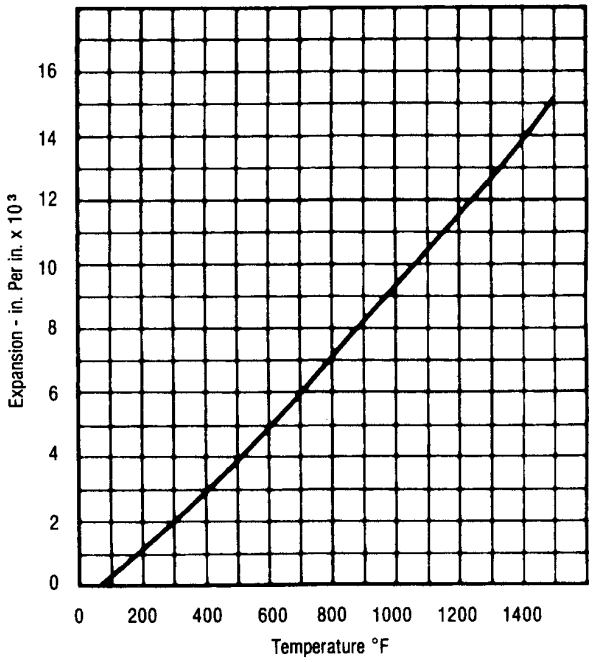
Important Information

Properties shown for the graphs above are typical values. Normal variations in chemistry, size and conditions of heat treatment may cause deviations from these values. For additional data or metallurgical engineering assistance, contact Trent Tube.

Representative Mechanical Properties as Cold Worked (Type 316L)



Thermal Expansion (Type 304)



Important Information

Properties shown for the graphs above are typical values. Normal variations in chemistry, size and conditions of heat treatment may cause deviations from these values. For additional data or metallurgical engineering assistance, contact Trent Tube.

Conversion Tables – SWG-BWG

	Birmingham Wire Gauge (B.W.G.)		Imperial Standard Wire Gauge (I.W.G./S.W.G.)		Brown & Sharpe Wire Gauge	
gauge	mm	inches	mm	inches	mm	inches
1	7.620	0.300	7.620	0.300	7.341	0.289
2	7.214	0.284	7.010	0.276	6.553	0.258
3	6.579	0.259	6.401	0.252	5.817	0.229
4	6.045	0.238	5.893	0.232	5.182	0.204
5	5.588	0.220	5.385	0.212	4.623	0.182
6	5.156	0.203	4.877	0.192	4.115	0.162
7	4.572	0.180	4.470	0.176	3.658	0.144
8	4.191	0.165	4.064	0.160	3.251	0.128
9	3.759	0.148	3.658	0.144	2.896	0.114
10	3.404	0.134	3.251	0.128	2.591	0.102
11	3.048	0.120	2.946	0.116	2.311	0.091
12	2.769	0.109	2.642	0.104	2.057	0.081
13	2.413	0.095	2.337	0.092	1.829	0.072
14	2.108	0.083	2.032	0.080	1.626	0.064
15	1.829	0.072	1.829	0.072	1.448	0.057
16	1.651	0.065	1.626	0.064	1.295	0.051
17	1.473	0.058	1.422	0.056	1.143	0.045
18	1.245	0.049	1.219	0.048	1.016	0.040
19	1.067	0.042	1.016	0.040	0.914	0.036
20	0.889	0.035	0.914	0.036	0.813	0.032
21	0.813	0.032	0.813	0.032	0.724	0.029
22	0.711	0.028	0.711	0.028	0.643	0.025
23	0.635	0.025	0.610	0.024	0.574	0.023
24	0.559	0.022	0.559	0.022	0.510	0.020
25	0.508	0.020	0.508	0.020	0.455	0.018
26	0.457	0.018	0.457	0.018	0.404	0.016
27	0.406	0.016	0.417	0.016	0.361	0.014
28	0.356	0.014	0.376	0.015	0.320	0.013
29	0.330	0.013	0.345	0.014	0.287	0.011

Pipe Dimensions and Weights Stainless, Carbon & Alloy

PIPE SIZE	O.D. IN INCHES	PIPE SCHEDULES															
		5s	5	10s	10	20	30	40s & STD	40	60	80s & XH	80	100	120	140	160	DBL XXH
1/8	.405		.035 .1396	.049 .1880	.049 .1880			.068 .2470	.068 .2470		.095 .3175						
1/4	.540		.049 .2594	.065 .3328	.065 .3328			.088 .4259	.088 42.88		.119 .5401	.119 .5401					
3/8	.675		.065 .4274	.065 .4274	.065 .4274			.091 .5729	.091 .5729		.126 .7457	.126 .7457					
1/2	.840	.065 .5430	.065 .5430	.083 .6773	.083 .6773			.109 .8589	.109 .8589		.147 1.098	.147 1.098				.187 1.316	.294 1.730
3/4	1.050	.065 .6902	.065 .6902	.083 .8652	.083 .8652			.113 1.141	.113 1.141		.154 1.487	.154 1.487				.218 1.955	.308 2.464
1	1.315	.065 .8759	.065 .8759	.109 1.417	.109 1.417			.133 1.695	.133 1.695		.179 2.192	.179 2.192				.250 2.870	.358 3.693
1-1/4	1.660	.065 1.118	.065 1.118	.109 1.822	.109 1.822			.140 2.294	.140 2.294		.191 3.025	.191 3.025				.250 3.800	.382 5.263
1-1/2	1.900	.065 1.286	.065 1.286	.109 2.104	.109 2.104			.145 2.743	.145 2.743		.200 3.665	.200 3.665				.281 4.904	.400 6.468
2	2.375	.065 1.619	.065 1.619	.109 2.663	.109 2.663			.154 3.687	.154 3.687		.218 5.069	.218 5.069				.344 7.532	.436 9.113
2-1/2	2.875	.083 2.498	.083 2.498	.120 3.564	.120 3.564			.203 5.847	.203 5.847		.276 7.733	.276 7.733				.375 10.11	.552 13.82
3	3.500	.083 3.057	.083 3.057	.120 4.372	.120 4.372			.216 7.647	.216 7.647		.300 10.35	.300 10.35				.438 14.46	.600 18.76
3-1/2	4.000	.083 3.505	.083 3.505	.120 5.019	.120 5.019			.226 9.195	.226 9.195		.318 12.62	.318 12.62					.636 23.06
4	4.500	.083 3.952	.083 3.952	.120 5.666	.120 5.666			.237 10.89	.237 10.89		.337 15.12	.337 15.12		.438 19.18		.531 22.72	.674 27.80
4-1/2	5.000							.247 12.66			.355 17.78						
5	5.563	.109 6.409	.109 6.409	.134 7.842	.134 7.842			.258 14.75	.258 14.75		.375 20.97	.375 20.97		.500 27.29		.625 33.27	.750 38.91
6	6.625	.109 7.656	.109 7.656	.134 9.376	.134 9.376			.280 19.15	.280 19.15		.432 28.84	.432 28.84		.562 36.73		.719 45.78	.864 53.66
7	7.625							.301 23.76			.500 38.40						.875 63.67
8	8.625	.109 10.01	.109 10.01	.148 13.52	.148 13.52	.250 22.57	.277 24.93	.322 28.82	.322 28.82	.406 35.97	.500 43.79	.500 43.79	.594 51.43	.719 61.28	.812 68.39	.906 75.39	.875 73.10
9	9.625							.342 34.22			.500 49.18						
10	10.75	.134 15.34	.134 15.34	.165 18.83	.165 18.83	.250 28.30	.307 34.56	.365 40.86	.365 40.86	.500 55.25	.500 55.25	.594 65.03	.719 77.75	.844 90.13	1.000 105.1	1.125 116.7	1.000 105.1
11	11.75							.375 45.98			.500 60.64						
12	12.75	.156 21.18	.165 22.38	.180 24.39	.180 24.39	.250 33.69	.330 44.18	.375 50.03	.406 54.03	.562 73.84	.500 66.03	.688 89.46	.844 108.3	1.000 126.7	1.125 141.0	1.312 161.8	1.000 126.7
14	14.00	.156 23.28		.188 27.99	.250 37.06	.312 46.04	.375 55.08	.375 55.08	.438 64.03	.594 85.84	.500 72.77	.750 107.1	.938 132.1	1.094 152.2	1.250 171.8	1.406 190.9	
16	16.00	.165 28.17		.188 32.05	.250 42.45	.312 52.76	.375 63.16	.375 63.16	.500 83.55	.656 108.5	.500 83.55	.844 137.9	1.031 166.4	1.219 194.2	1.438 225.7	1.594 247.5	
18	18.00	.165 31.72		.188 36.10	.250 47.84	.312 59.49	.438 82.92	.375 71.25	.562 105.6	.750 139.5	.500 94.33	.938 172.5	1.156 209.9	1.375 246.4	1.562 276.8	1.781 311.4	
20	20.00	.188 40.15		.218 46.49	.250 53.23	.375 79.33	.500 105.1	.375 79.33	.594 124.3	.812 168.0	.500 105.1	1.031 210.8	1.281 258.5	1.500 299.1	1.750 344.3	1.969 382.7	
24	24.00	.218 55.89		.250 64.01	.250 64.01	.375 95.50	.562 142.0	.375 95.50	.688 172.9	.969 240.6	.500 126.7	1.219 299.4	1.531 370.8	1.812 433.4	2.062 487.6	2.344 547.2	
26	26.00				.312 86.40	.500 137.4		.375 103.6			.500 137.4						
28	28.00				.312 93.12	.500 148.2	.625 184.4	.375 111.7									
30	30.00	.250 80.18		.312 99.85	.312 99.85	.500 159.0	.625 197.9	.375 119.8			.500 159.0						
32	32.00				.312 106.6	.500 169.8	.625 211.4	.375 127.8	.688 232.2		.500 169.8						
34	34.00				.312 113.3	.500 180.6	.625 224.9	.375 135.9	.688 247.1								
36	36.00				.312 120.0		.625 238.3	.375 144.0	.750 285.0		.500 191.3						
40	40.00							.375 160.2			.500 212.9						
44	44.00							.375 176.4			.500 234.5						
48	48.00							.375 192.5			.500 256.0						

WEIGHT FACTORS FOR NICKEL AND OTHER ALLOYS (APPLY TO NUMBERS SHOWN IN RED)

Titanium	.570	20Mo-6*	1.021
Carbon Steel	0.993	Alloy 800	1.025
7MOPlus*	0.997	Alloy 825	1.039
Alloy 2205	0.997	Alloy 625	1.066
304	1.000	Alloy 600	1.074
Type 330	1.014	Hastelloy C-22	1.098
AL-6XN® Alloy	1.017	Hastelloy C-276	1.129
20cb-3*	1.021		

52" & LARGER – WALL THICKNESS/LBS. PER FOOT

52	.375 208.7	.500 277.6	.625 346.1	.750 414.4	.875 482.2
56	.375 224.9	.500 299.1	.625 373.1	.750 446.7	.875 520.0
60	.375	.500	.625	.750	.875

*Registered trademark of Carpenter Technology Corp.
Hastelloy is a trademark of Haynes International
AL-6XN is a registered trademark of Allegheny Ludlum Steel Corp.

TOP NUMBER IN EACH ROW: WALL THICKNESS IN INCHES
BOTTOM NUMBER IN EACH ROW: STEEL WEIGHT IN LBS PER FOOT

Index by Alloy

Index by UNS Number