TO MARK PROGRESS

LADISH

Controlled Quality

FITTINGS

CATALOG NO. 55

SEAMLESS WELDING FITTINGS	FORGED STEEL FLANGES	LARGE DIAMETER FLANGES	LONG WELDING NECKS	FORGED STEEL FITTINGS

LADISH

Controlled Quality

STAINLESS AND ALLOY FITTINGS

TO MARK PROGRESS

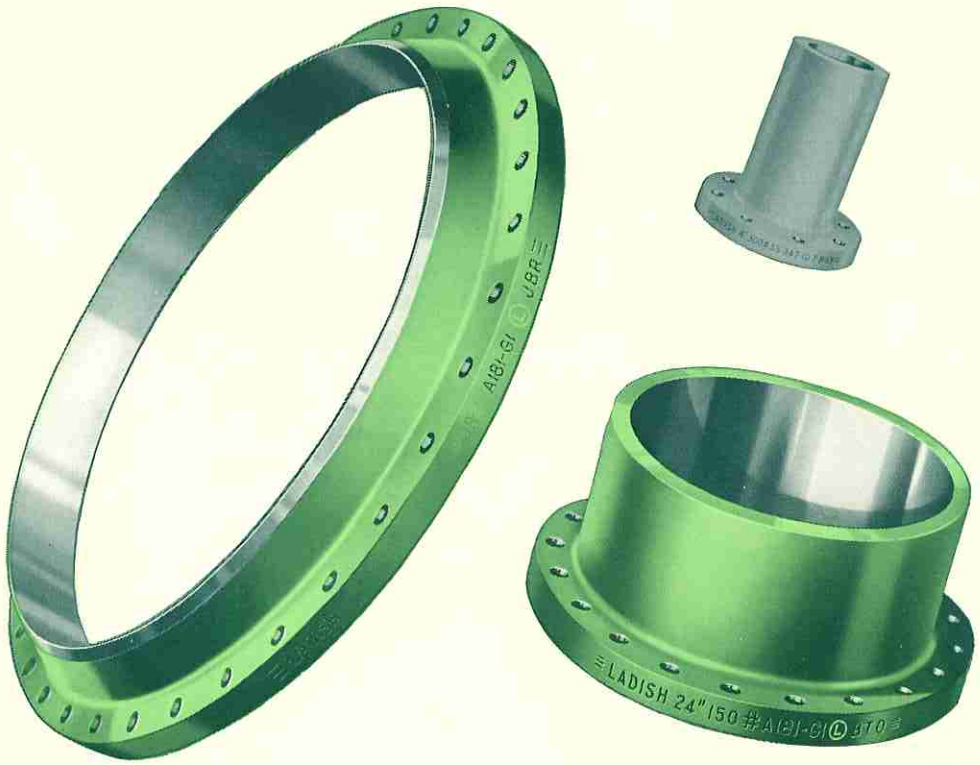
LADISH IS PREPARED TO SUPPLY YOUR

- CARBON STEELS
- CARBON-MOLYBDENUM STEELS
- CHROMIUM-MOLYBDENUM STEELS
- NICKEL STEELS
- CHROMIUM-NICKEL STEELS
- CHROMIUM-SILICON-MOLYBDENUM
- WROUGHT IRON
- CHROMIUM TYPE STAINLESS
- CHROMIUM-NICKEL STAINLESS
- MOLYBDENUM-TYPE STAINLESS
- WROUGHT ALUMINUM
- ALUMINUM-COPPER ALLOYS

SEAMLESS WELDING FITTINGS...STANDARD

FORGED STEEL FLANGES...150 POUNDS

FORGED STEEL FITTINGS...SCREWED AND

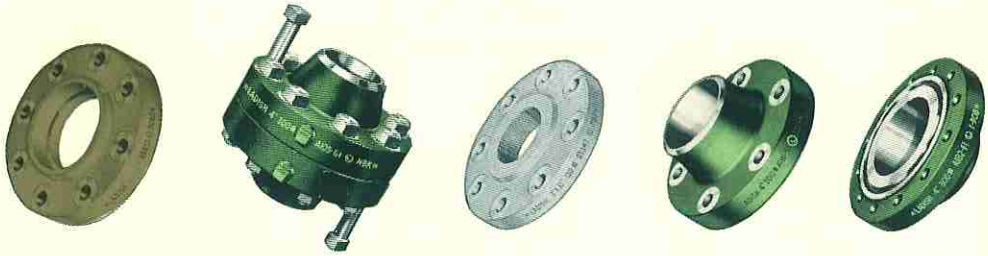


LARGE DIAMETER, TEMA & LONG WELDING NECK FLANGES

LADISH CAN PRODUCE FITTINGS IN A WIDE RANGE OF SIZES

COMPLETE MATERIAL REQUIREMENTS

WEIGHT THROUGH DOUBLE EXTRA STRONG



THROUGH 2500 POUNDS PRESSURE RATING

SOCKET-WELDING...2000 THROUGH 6000 POUNDS

CONSIDERATIONS AFFECTING MATERIAL SELECTION

In addition to those ever-present factors of pressure and temperature, today's piping engineer is frequently involved in design problems which are further complicated by such considerations as corrosion, contamination and catalytic action between the piping material and fluids or gases being conveyed through the lines.

Recent advances in both metallurgy and forging techniques have made available for these problems a wide range of ferrous and non-ferrous piping metals together with many special-duty alloys of each. Now by careful selection of the proper material for pipe and fittings it is possible to meet more effectively than ever before the requirements of practically any service condition.

Enumerated here are the broad classifications of materials and alloys most frequently used, and in which many individual items of the complete Ladish lines are being produced. On following pages of this section is a more complete breakdown of these classifications showing the applicable code and standards designations. Working with both the prime material manufacturers and important users of special piping in all fields, the Ladish Co. constantly carries on research and metallurgical studies to produce fittings in an ever wider range of materials. Consultation on specific applications and special problems is always available.

- ALUMINUM-MANGANESE ALLOYS
- DEOXIDIZED COPPER
- ARSENICAL COPPER
- RED AND YELLOW BRASSES
- FORGING BRASS
- EVERDUR BRONZE
- SILICON BRONZE
- MANGANESE BRONZE
- WROUGHT NICKEL
- NICKEL-COPPER ALLOYS
- INCONEL
- MONEL

TO YOUR SPECIFICATION FROM ANY FORGEABLE MATERIAL

ESSENTIAL PROPERTIES OF VARIOUS MATERIALS

CARBON AND INTERMEDIATE ALLOY STEELS

Carbon Steels which comprise the great proportion of forged and seamless welding fittings produced under A.S.T.M. specifications A181, A105, A106 and A234 are characterized by physical properties including strength, toughness and corrosion resistance for satisfactory operation under a wide range of temperature, pressure and chemical environments.

In addition to rigid inspection of chemical composition within the specified ranges, Ladish exercises control over uniformity, homogeneity, ingot patterns, melting practice and austenitic grain size. Where welding is involved for installation, safeguards are maintained to insure weldability.

Increasing the carbon content increases tensile strength—but when welding applications are required it is not desirable to have carbon above .35%.

Alloy Steels—These steels are used in applications where carbon steel is not adequate for reasons of high or low temperature, corrosion, ultimate strength or creep strength. Specifying the correct alloy composition is dependent on the characteristics of the material being used and the application being considered.

Chromium, Molybdenum and Nickel Alloy Steels—Chromium as an alloying agent is used primarily for increasing resistance to corrosion and oxidation. Adding Molybdenum promotes high-temperature or creep strength in steels and is effective in overcoming temper brittleness of chromium steels, while Nickel adds toughness at low temperatures. Alloys in this category usually range from 1 to 10 per cent Chromium, 0.4 to 1 per cent Molybdenum and 2 to 5 per cent Nickel in steels of medium and low carbon content. Various combinations of these elements are used to develop alloy steels possessing desired characteristics.

In addition to the above alloys the following elements when used in combination with other alloying elements affect properties in varying degree. Manganese from .30 to 1.50 per cent improves the hot working properties and slightly increases creep strength up to 950° F. Silicon up to 2 per cent in combination with other alloying elements improves the creep and other properties of steel, except resistance to corrosion, in the temperature range of 950° F. to 1200° F. Copper increases the resistance of steel to atmospheric corrosion.

HIGH ALLOY AND STAINLESS STEELS

Chromium Stainless—Usually any Carbon steel containing 11.0 per cent or more of Chromium is considered Stainless. Such steels couple good resistance to certain types of corrosion and erosion with ability to withstand high temperature stress up to approximately 1200° F.

Austenitic Stainless—Chromium-Nickel alloys, particularly of the 18-8 variety, are probably the most widely used of the Stainless steels for piping. These Austenitic Stainless steels have properties modified by the addition of Molybdenum, Columbium, Tantalum and Titanium to meet varying requirements.

Their corrosion resistance, strength, ductility, lack of scaling at high temperatures and toughness under sub-zero conditions are generally higher than any other common ferrous alloy. Stainless steels meet to a unique degree the peculiar needs of many divergent industries such as processing, food, drug, petroleum, chemical and power.

ALUMINUM AND ALUMINUM ALLOYS

Pure Wrought Aluminum—Due to its peculiar combination of light weight, high strength and thermal conductivity, Aluminum is becoming increasingly popular as a piping material. It also exhibits good resistance to many corrosive chemicals and maintains the stability of many materials piped through it such as fatty acids, edible oils, paints, varnishes and lacquers. Not only is Aluminum highly non-contaminating, but where the metal is dissolved it forms non-toxic compounds with most food and drug substances.

Aluminum Alloys—Considerable improvement in physical properties and stability in the presence of specific corrosives is obtained by alloying Aluminum with various elements such as Copper, Silicon, Manganese, Magnesium and Chromium. High purity Aluminum and certain widely used Aluminum alloys are amenable to certain types of heat treatment which serve to modify their properties and condition of strain in a direction favorable to improved performance under conditions of service and fabrication.

COPPER, BRASSES AND BRONZES

Wrought Copper is being used more extensively in piping applications due to its high resistance to many corrosive elements. In this form Deoxidized Copper is popular because of high workability and welding response. Arsenical Copper provides added resistance to certain specific corrosive agents.

Brasses combine good hot working characteristics with high resistance to corrosive action of many sulphides, increasing as zinc content is raised. Good strength characteristics are exhibited by brasses in which copper content is maintained at levels of 60 to 70 per cent. Copper-Silicon-

Manganese alloy (i.e., Everdur) combines the strength of mild steel with corrosion resistance of Copper.

Bronzes—Modified by the addition of phosphorus as a deoxidant, Admiralty Bronze, Aluminum Bronze and some Red Brasses are particularly resistant to salt water attack. Aluminum Bronzes further possess high resistance to corrosive action of many acid solutions. Copper-Nickel alloys are becoming more frequently used where resistance to alkaline solutions is required.

NICKEL, MONEL AND INCONEL

Wrought Nickel—Stronger and more ductile than many structural steels, Nickel resists attack of more corrosives and is particularly useful in protecting the color, flavor, odor and purity of sensitive solutions. It has proven most successful in handling caustic compounds.

Monel—This Nickel-Copper alloy combines high strength properties with unusual resistance against such industrial corrosives as dilute sulphuric, hydrochloric, hydrofluoric and phosphoric acids. It is also resistant to brine and caustic soda solutions.

Inconel combines the corrosion resistance, strength and toughness characteristics of Nickel with the extra resistance to heat and oxidation of Chromium. It exhibits pronounced resistance to corrosion by many inorganic and organic compounds as well as many oxidizing acid and alkaline solutions.

CONDENSED TABLE OF PIPING SPECIFICATIONS

While not exhaustive, the following tabulation attempts to group the more commonly used material specifications for pipe and tubes, forgings and plates used in pipe and related installations.

MATERIAL OR ALLOY	SPECIFICATION OR STANDARDS DESIGNATION		GRADE OR TYPE	SYMBOL	NOMINAL COMPOSITION	MINIMUM PHYSICAL REQUIREMENTS
CARBON STEELS	ASTM	A53	A		Low Carbon Steel, Refer to Specification for complete analysis	TS 48,000 YP 30,000 El. 2"--35 to 21% (Dependent upon wall thickness)
			B		Low Carbon Steel, Refer to Specification for complete analysis	TS 60,000 YP 35,000 El. 2"--30 to 18% (Dependent upon wall thickness)
		A83	Type A		0.06-0.18% C, 0.27-0.63% Mn	Refer to ASTM specification
		A105	I		0.35% C max., 0.90% Mn max.	TS 60,000 YP 30,000 El. 2"--25% Red. 38%
			II		0.35% C max., 0.90% Mn max.	TS 70,000 YP 36,000 El. 2"--22% Red. 30%
CARBON STEEL FOR LOW TEMPERATURE SERVICE	Ladish Specification for Forged Fittings and Flanges			L-50F	0.35% C max., 0.90% Mn 0.15-0.35% Si	TS 60,000 YP 30,000 El. 2"--25% Red. 38% Charpy--15 ft.-lbs. at minus 50° F.
CARBON STEELS	ASTM	A106	A		0.25% C max., 0.30-0.90% Mn	TS 48,000 YP 30,000 El. 2" {Longitudinal--35 to 21% {Transverse--25 to 22.5% (Dependent upon wall thickness)
			B		0.30% C max., 0.35-1% Mn	TS 60,000 YP 35,000 El. 2" {Longitudinal--30 to 18% {Transverse--16.5 to 14.5% (Dependent upon wall thickness)
		A120			Low Carbon Zinc Coated Steel, Refer to Specification for complete analysis	Refer to ASTM specification
		A134			Low Carbon Steel, Refer to Specification for complete analysis	Refer to ASTM specification
		A135	A		Low Carbon Steel, Refer to Specification for complete analysis	TS 48,000 YP 30,000 El. 2"--35 to 21% (Dependent upon wall thickness)

CONDENSED TABLE OF PIPING SPECIFICATIONS (Continued)

MATERIAL OR ALLOY	SPECIFICATION OR STANDARDS DESIGNATION		GRADE OR TYPE	SYMBOL	NOMINAL COMPOSITION	MINIMUM PHYSICAL REQUIREMENTS
CARBON STEELS	ASTM	A135	B		Low Carbon Steel, Refer to Specification for complete analysis	TS 60,000 YP 35,000 El. 2"—30 to 18% (Dependent upon wall thickness)
		A139	A		Low Carbon Steel, Refer to Specification for complete analysis	TS 48,000 YP 30,000 El. 2"--35 to 21% (Dependent upon wall thickness)
			B		Low Carbon Steel, Refer to Specification for complete analysis	TS 60,000 YP 35,000 El. 2"--30 to 18% (Dependent upon wall thickness)
		A155	C45		0.15% C max.	Refer to ASTM specification
			C50		0.20% C max.	Refer to ASTM specification
			C55		0.25% C max.	Refer to ASTM specification
		A178	Type A		0.08-0.18% C max., 0.30-0.60% Mn	Refer to ASTM specification
		A179			0.08-0.18% C, 0.30-0.60% Mn	Refer to ASTM specification
		A181	I		0.35% C max., 0.90% Mn max.	TS 60,000 YP 30,000 El. 2"--22% Red. 35%
			II		0.35% C max., 0.90% Mn max.	TS 70,000 YP 36,000 El. 2"--18% Red. 24%
		A192			0.08-0.18% C, 0.30-0.60% Mn	Refer to ASTM specification
		A210			0.35% C max., 0.80% Mn max.	TS 60,000 YP 37,000 El. 2"--25 to 15% (Dependent upon wall thickness)
		A212	A		0.33% C max., 0.90% Mn max.	TS 65,000 to 77,000 YP 35,000 El. 2"--24%
			B		0.35% C max., 0.15-0.30% Si	TS 70,000 to 82,000 YP 38,000 El. 2"--22%
		A214			0.18% C max., 0.30-0.60% Mn	Refer to ASTM specification
		A226			0.08-0.18% C, 0.30-0.60% Mn	Refer to ASTM specification
CARBON STEEL FOR LOW TEMPERATURE SERVICE	Ladish Specification for Seamless Welding Fittings			L-50F	0.30% C max., 0.29-1.06% Mn 0.10-0.30% Si	TS 60,000 YP 35,000 El. 2"--30% Charpy--15 ft.-lbs. at minus 50° F.
CARBON STEELS	ASTM	A285	B		0.22% C max., 0.80% Mn max.	TS 50,000 to 60,000 YP 0.5 TS to 27,000 Min. El. $2" -- \frac{1,500,000}{TS}$ %
			C		0.30% C max., 0.80% Mn max.	TS 55,000 to 65,000 YP 0.5 TS to 30,000 Min. El. $2" -- \frac{1,500,000}{TS}$ %

CONDENSED TABLE OF PIPING SPECIFICATIONS (Continued)

MATERIAL OR ALLOY	SPECIFICATION OR STANDARDS DESIGNATION		GRADE OR TYPE	SYMBOL	NOMINAL COMPOSITION	MINIMUM PHYSICAL REQUIREMENTS
CARBON STEELS	API	5L	A		0.30-0.90% Mn	TS 48,000 YP 30,000 El. 2"--35 to 21% (Dependent upon wall thickness)
			B		0.30% C max., 0.35-1.50% Mn	TS 60,000 YP 35,000 El. 2"--30 to 18% (Dependent upon wall thickness)
			C		0.35-1.50% Mn	TS 75,000 YP 40,000 El. 2"--20%
		5LX	X42		0.33% C max., 1.28% Mn max.	TS 60,000 YP 42,000 El. 2"--20%
CARBON-MOLYBDENUM STEELS	ASTM	A335	Si-Mo	P15	1.15-1.65% Si, 0.50% Mo	TS 60,000 YP 30,000 El. 2" {Longitudinal--30 to 18% Transverse--20 to 18% (Dependent upon wall thickness)
		A182	C-Mo	F1	0.20-0.30% C max., 0.50% Mo	TS 70,000 YP 40,000 El. 2"--25% Red. 35%
		A204	A		0.25% C max., 0.50% Mo	TS 65,000 to 77,000 YP 37,000 El. 2"--25%
			B		0.27% C max., 0.50% Mo	TS 70,000 to 85,000 YP 40,000 El. 2"-- 23%
		A335	C-Mo	P1	0.10-0.20% C, 0.50% Mo	TS 55,000 YP 30,000 El. 2" {Longitudinal--30 to 18% Transverse--20 to 18% (Dependent upon wall thickness)
		A209	T1		0.10-0.20% C, 0.50% Mo	TS 55,000 YP 30,000 El. 2"--30 to 18% (Dependent upon wall thickness)
			T1a		0.15-0.25% C, 0.50% Mo	TS 60,000 YP 32,000 El. 2"--30 to 18% (Dependent upon wall thickness)
			T1b		0.14% C max., 0.50% Mo	TS 53,000 YP 28,000 El. 2"--30 to 18% (Dependent upon wall thickness)
		A250	T1		0.10-0.20% C, 0.50% Mo	TS 55,000 YP 30,000 El. 2"--30 to 18% (Dependent upon wall thickness)
			T1a		0.15-0.25% C, 0.50% Mo	TS 60,000 YP 32,000 El. 2"--30 to 18% (Dependent upon wall thickness)
			T1b		0.14% C max., 0.50% Mo	TS 53,000 YP 28,000 El. 2"--30 to 18% (Dependent upon wall thickness)

CONDENSED TABLE OF PIPING SPECIFICATIONS (Continued)

MATERIAL OR ALLOY	SPECIFICATION OR STANDARDS DESIGNATION		GRADE OR TYPE	SYMBOL	NOMINAL COMPOSITION	MINIMUM PHYSICAL REQUIREMENTS
CHROMIUM COPPER NICKEL ALUMINUM STEELS FOR LOW TEMPERATURE SERVICE	Ladish Specification for Seamless Welding Fittings			L-150F	0.12% C max., 0.65-0.90% Mn, .020% P max., .020% S max., 0.15-0.30% Si, 0.65-0.90% Cr, 0.45-0.65% Cu, 0.70-0.90% Ni, 0.10-0.25% Al	TS 60,000 YP 35,000 El. 2"--30% Charpy-- 15 ft.-lbs. at minus 150° F.
	Ladish Specification for Forged Fittings and Flanges			L-150F	0.12% C max., 0.65-0.90% Mn, .020% P max., .020% S max., 0.15-0.30% Si, 0.65-0.90% Cr, 0.45-0.65% Cu, 0.70-0.90% Ni, 0.10-0.25% Al	TS 60,000 YP 30,000 El. 2"--25% Charpy--15 ft.-lbs. at minus 150° F.
CHROMIUM-MOLYBDENUM and CHROMIUM-VANADIUM STEELS	ASTM	A335	Cr-Mo	P3	1.75% Cr, 0.75% Mo	TS 60,000 YP 30,000 El. 2" {Longitudinal--30 to 18% Transverse--20 to 18% (Dependent upon wall thickness)
			Cr-Mo	P3b	2% Cr, 0.50% Mo	TS 60,000 YP 30,000 El. 2" {Longitudinal--30 to 18% Transverse--20 to 18% (Dependent upon wall thickness)
			4-6% Cr	P5	4-6% Cr, 0.50% Mo	TS 60,000 YP 30,000 El. 2" {Longitudinal--30 to 18% Transverse--20 to 18% (Dependent upon wall thickness)
			4-6% Cr-Si-Mo	P5b	4-6% Cr, 1-2% Si, 0.50% Mo	TS 60,000 YP 30,000 El. 2" {Longitudinal--30 to 18% Transverse--20 to 18% (Dependent upon wall thickness)
			4-6% Cr-Mo-Ti	P5c	4-6% Cr, 0.50% Mo, Ti or Cb Stabilized	TS 60,000 YP 30,000 El. 2" {Longitudinal--30 to 18% Transverse--20 to 18% (Dependent upon wall thickness)
			Cr-Si-Mo	P11	1.25% Cr, 0.50% Mo, 0.50-1% Si	TS 60,000 YP 30,000 El. 2" {Longitudinal--30 to 18% Transverse--20 to 18% (Dependent upon wall thickness)
			7% Cr	P7	7% Cr, 0.50% Mo	TS 60,000 YP 30,000 El. 2" {Longitudinal--30 to 18% Transverse--20 to 18% (Dependent upon wall thickness)
			9% Cr	P9	9% Cr, 1% Mo	TS 60,000 YP 30,000 El. 2" {Longitudinal--30 to 18% Transverse--20 to 18% (Dependent upon wall thickness)
		A182	1% Cr ½% Mo	F12	1% Cr, 0.50% Mo	TS 70,000 YP 40,000 El. 2"--20% Red. 30%
			4-6% Cr	F5	4-6% Cr, 0.50% Mo	TS 90,000 YP 65,000 El. 2"--22% Red. 50%
			13% Cr	F6	13% Cr, 1% Si max.	TS 85,000 YP 55,000 El. 2"--25% Red. 60%

CONDENSED TABLE OF PIPING SPECIFICATIONS (Continued)

MATERIAL OR ALLOY	SPECIFICATION OR STANDARDS DESIGNATION		GRADE OR TYPE	SYMBOL	NOMINAL COMPOSITION	MINIMUM PHYSICAL REQUIREMENTS
CHROMIUM-MOLYBDENUM and CHROMIUM-VANADIUM STEELS	ASTM	A182	9% Cr	F9	9% Cr, 1% Mo	TS 100,000 YP 70,000 El. 2"--20% Red. 40%
			Cr-Mo	F22	2.25% Cr, 1% Mo.	TS 70,000 YP 40,000 El. 2"--20% Red. 30%
		A213	Cr-Mo	T3	1.75% Cr, 0.75% Mo	TS 60,000 YP 25,000 El. 2"--30 to 18% (Dependent upon wall thickness)
			Cr-Mo	T5	4-6% Cr, 0.50% Mo	TS 60,000 YP 25,000 El. 2"--30 to 18% (Dependent upon wall thickness)
			7% Cr	T7	7% Cr, 0.50% Mo, 0.50-1% Si	TS 60,000 YP 25,000 El. 2"--30 to 18% (Dependent upon wall thickness)
			9% Cr	T9	9% Cr, 1% Mo, 0.50-1% Si	TS 60,000 YP 25,000 El. 2"--30 to 18% (Dependent upon wall thickness)
			Cr-Si-Mo	T11	1.25% Cr, 0.50% Mo, 0.75% Si	TS 60,000 YP 25,000 El. 2"--30 to 18% (Dependent upon wall thickness)
			Cr-Mo	T12	1% Cr, 0.50% Mo	TS 60,000 YP 25,000 El. 2"--30 to 18% (Dependent upon wall thickness)
			Cr-Mo	T3b	2% Cr, 0.50% Mo	TS 60,000 YP 25,000 El. 2"--30 to 18% (Dependent upon wall thickness)
			Cr-Mo-Ti	T5c	4-6% Cr, 0.50% Mo, Ti Stabilized	TS 60,000 YP 25,000 El. 2"--30 to 18% (Dependent upon wall thickness)
			Cr-Va	T17	1% Cr, 0.15% Va	TS 60,000 YP 25,000 El. 2"--30 to 18% (Dependent upon wall thickness)
			Cr-Mo	T21	3% Cr, 0.90% Mo	TS 60,000 YP 25,000 El. 2"--30 to 18% (Dependent upon wall thickness)
			Cr-Mo	T22	2.25% Cr, 1% Mo	TS 60,000 YP 25,000 El. 2"--30 to 18% (Dependent upon wall thickness)
		A335	Cr-Mo	P2	0.60% Cr, 0.60% Mo	TS 55,000 YP 30,000 El. 2" {Longitudinal--30 to 24% Transverse--20 to 18% (Dependent upon wall thickness)

CONDENSED TABLE OF PIPING SPECIFICATIONS (Continued)

MATERIAL OR ALLOY	SPECIFICATION OR STANDARDS DESIGNATION		GRADE OR TYPE	SYMBOL	NOMINAL COMPOSITION	MINIMUM PHYSICAL REQUIREMENTS
CHROMIUM-MOLYBDENUM and CHROMIUM-VANADIUM STEELS	ASTM	A335	Cr-Mo	P12	1% Cr, 0.50% Mo	TS 60,000 YP 30,000 El. 2" {Longitudinal--30 to 18% Transverse--20 to 18% (Dependent upon wall thickness)
CARBON-NICKEL STEELS	AISI	2317	3½% Ni	2317	0.15-0.20% C, 3.25-3.75% Ni	Refer to AISI specification
		2517	5% Ni	2517	0.15-0.20% C, 4.75-5.25% Ni	Refer to AISI specification
CHROMIUM-SILICON-MOLYBDENUM STEELS	ASTM	A335	Si-Mo	P15	1.15-1.65% Si, 0.50% Mo	TS 60,000 YP 30,000 El. 2" {Longitudinal--30 to 18% Transverse--20 to 18% (Dependent upon wall thickness)
		A213	Cr-Si-Mo	T11	1.25% Cr, 0.75% Si, 0.50% Mo	TS 60,000 YP 25,000 El. 2"--30 to 18% (Dependent upon wall thickness)
			Cr-Si-Mo	T5b	4-6% Cr, 1-2% Si, 0.50% Mo	TS 60,000 YP 25,000 El. 2"--30 to 18% (Dependent upon wall thickness)
WROUGHT IRON	ASTM	A72			Refer to Specification for complete analysis	TS 40,000 YP 24,000 El. 8"--9%
	API	5L			Refer to Specification for complete anaylsis	Refer to API specification
STAINLESS ALL CHROMIUM	ASTM	A268	Type 410	TP410	11.50-13.50% Cr	TS 60,000 YP 30,000 El. 2"--20%
			Type 430	TP430	14-18% Cr	TS 60,000 YP 35,000 El. 2"--20%
			Type 446	TP446	23-30% Cr	TS 70,000 YP 40,000 El. 2"--18%
STAINLESS-NICKEL CHROMIUM	ASTM	A312	Cr-Ni	TP304	18% Cr, 8% Ni	TS 75,000 YP 30,000 El. 2" {Longitudinal--35 to 21% Transverse--25 to 22.5% (Dependent upon wall thickness)
			Cr-Ni-Ti	TP321	18% Cr, 10% Ni, Ti Stabilized	TS 75,000 YP 30,000 El. 2" {Longitudinal--35 to 21% Transverse--25 to 22.5% (Dependent upon wall thickness)
			Cr-Ni-Cb	TP347	18% Cr, 10% Ni, Cb Stabilized	TS 75,000 YP 30,000 El. 2" {Longitudinal--35 to 21% Transverse--25 to 22.5% (Dependent upon wall thickness)
		A182	Cr-Ni	F304	18% Cr, 8% Ni	TS 75,000 YP 30,000 El. 2"--45% Red. 50%

CONDENSED TABLE OF PIPING SPECIFICATIONS (Continued)

MATERIAL OR ALLOY	SPECIFICATION OR STANDARDS DESIGNATION		GRADE OR TYPE	SYMBOL	NOMINAL COMPOSITION	MINIMUM PHYSICAL REQUIREMENTS
STAINLESS-NICKEL CHROMIUM	ASTM	A182	Cr-Ni-Cb	F347	18% Cr, 10% Ni, Cb Stabilized	TS 75,000 YP 30,000 El. 2"--45% Red. 50%
			Cr-Ni-Mo	F316	18% Cr, 12% Ni, 2-3% Mo	TS 75,000 YP 30,000 El. 2"--45% Red. 50%
		A213 A312	Cr-Ni	TP304	18% Cr, 8% N	TS 75,000 YP 30,000 El. 2"--35 to 21% (Dependent upon wall thickness)
			Cr-Ni-Cb	TP347	18% Cr, 10% Ni, Cb Stabilized	TS 75,000 YP 30,000 El. 2"--35 to 21% (Dependent upon wall thickness)
			Cr-Ni-Mo	TP316	18% Cr, 12% Ni, 2-3% Mo	TS 75,000 YP 30,000 El. 2"--35 to 21% (Dependent upon wall thickness)
			Cr-Ni-Ti	TP321	18% Cr, 10% Ni, Ti Stabilized	TS 75,000 YP 30,000 El. 2"--35 to 21% (Dependent upon wall thickness)
WROUGHT ALUMINUM ALLOYS	ASTM	B221	2S 990A	2SO	0.20% Cu, 0.10% Mn, 0.10% Zn, balance Aluminum	TS 15,500 max. El. 4 × Diam--25%
				2SF •		TS 13,000 to 17,000
		B209 B210 B221	3S MIA	3SO	1-1.50% Mn, balance Aluminum	TS 19,000 max. El. 2"--18 to 23% (Dependent upon wall thickness)
				3SF •		TS 16,000 to 21,000
		B210 B221	24S CG42A	24SO	1.20-1.80% Mg, 3.80-4.90% Cu, balance Aluminum	TS 35,000 max. YS 19,000 max. El. 4 × Diam.--12%
				24ST4		TS 57,000 to 70,000 (Dependent upon wall thickness) YS 42,000 to 52,000 (Dependent upon wall thickness) El. 4 × Diam.--12 to 10% (Dependent upon wall thickness)
		B221	25S CS41A	25SO	0.40-1.20% Mn, 3.90-5% Cu, balance Aluminum	TS 30,000 max. YS 18,000 max. El. 4 × Diam.--12%
				25ST6		TS 60,000 to 68,000 (Dependent upon wall thickness) YS 53,000 to 60,000 (Dependent upon wall thickness) El. 4 × Diam.--7%
		B210	52S GR20A	52SO	2.20-2.80% Mg, balance Aluminum	TS 35,000 max.
				52SF •		TS 35,000 nominal
		B209 B210 B221	61S GS11A	61SO	0.15-0.40% Cu, 0.70% Fe, 0.15-0.35% Cr, balance Aluminum	TS 22,000 max. YS 16,000 max. El. 2"--14 to 18%
				61SF •		TS 30,000 nominal YS 16,000 nominal El. 4 × Diam.--16% nominal
				61ST6		TS 38,000 YS 35,000 El. 2"--6 to 14%

• As fabricated.

CONDENSED TABLE OF PIPING SPECIFICATIONS (Continued)

MATERIAL OR ALLOY	SPECIFICATION OR STANDARDS DESIGNATION		GRADE OR TYPE	SYMBOL	NOMINAL COMPOSITION	MINIMUM PHYSICAL REQUIREMENTS
ALUMINUM-COPPER ALLOYS‡	ASTM	B111	Type B	Type B	76-79% Cu, 1.80-2.50% Al, 0.02-0.10% As	
			Type C	Type C	76-79% Cu, 1.80-2.50% Al, 0.02-0.10% Sb	
			Type D	Type D	76-79% Cu, 1.80-2.50% Al, 0.02-0.10% P	
COPPER	ASTM	B13	Arsenical		99.40% Cu Min., 0.15-0.50% As	Refer to ASTM specification
			Non-Arsenical		99.90% Cu Min.	Refer to ASTM specification
		B42	Annealed		99.9% Cu, 0.04% P	Refer to ASTM specification
		B75	Type DLP		99.9% Cu Min., 0.004-0.012% P	Refer to ASTM specification
			Type DHP		99.9% Cu Min., 0.015-0.040% P	Refer to ASTM specification
BRASS-Red Brass	ASTM	B43		Red Brass	84-86% Cu, 0.06% Pb max., 0.05% Fe max.	Refer to ASTM specification
FORGING BRASS	ASTM	B124	Alloy No. 5	Frg. Brass	59% Cu, 38% Zn, 0.50% Pb, 1.0% Sn	Refer to ASTM specification
EVERDUR 1010				Everdur	96% Cu, 3% Si, 1% Mn	
NICKEL	ASTM	B160		Nickel	99% Ni Min	TS 60,000 to 80,000 YS 15,000 to 60,000 El. 2"--35 to 10%
		B161				TS 55,000 to 70,000 YS 15,000 to 50,000 El. 2"--40 to 10%
MONEL	ASTM	B164	Class A	Monel	63-70% Ni, 24-31% Cu	TS 70,000 to 110,000 YS 25,000 to 85,000 El. 2"--35 to 10%
		B165				TS 70,000 to 85,000 YS 28,000 to 65,000 El. 2"--35 to 10%
INCONEL	ASTM	B166		Inconel	72% Ni Min., 14-17% Cr, 6-10% Fe	TS 80,000 to 120,000 YS 30,000 to 90,000 El. 2"--35 to 7%
		B167				TS 80,000 YS 30,000 El. 2"--35%
INCONEL X†				Inconel X	Nickel Base, 15% Cr, 7% Fe, 2.50% Ti, 1% (Cb + Ta), 0.70% Al	
HASTELLOY B‡				Hastelloy B	Nickel Base, 28% Mo, 5.50% Fe	
COR-TEN††				Cor-Ten	0.12% C max., 0.20-0.50% Mn, 0.05% S max., 0.07-0.15% P, 0.25-0.55% Cu, 0.25-0.75% Si, 0.50-1.25% Cr, 0.65% Ni max.	TS 70,000 nominal YP 50,000 nominal El. 2"--22% nominal
YOLOY††				Yoloy	0.15% C max., 0.60% Mn max., 0.75-1.25% Cu, 1.50-2% Ni, 0.05-1% P, 0.05% S max.	TS 75,000 nominal YP 55,000 nominal El. 2"--22% nominal
TRI-TEN††				Tri-Ten	0.25% C max., 1.30% Mn max., 0.045% P max., 0.05% S max., 0.10-0.30% Si, 0.30-0.60% Cu, 0.50-1% Ni	TS 70,000 nominal YP 50,000 nominal El. 2"--22% nominal
CARBON MANGANESE					0.21-0.28% C, 1.00-1.35% Mn, 0.15-0.30% Si	TS 80,000 nominal YP 52,000 nominal El. 2"--25% nominal

†† Trade names for high strength structural steels. Other comparable grades are manufactured by various steel producers.

† Heat-resistant alloy.
‡ Corrosion-resistant alloy.

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