Precision engineered tubing for industry

- Stainless Steel
- Nickel Alloys

make the connection

RathGibson

A PCC Company

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Overview

Make the Connection

The RathGibson Group of Companies manufactures the finest quality Precision Engineered Tubing for Industry. Materials include Stainless Steel and Nickel Alloys. We offer PRECISION WELDED, WELDED & DRAWN, and SEAMLESS tubing in STRAIGHT LENGTHS, COIL, and U-BEND configurations.

We will meet the challenge of your most demanding requirements. We achieve this through a customer-focused philosophy that is shared by every RathGibson employee.

Our technical leadership drives our continuous improvement of production techniques and a quality system to meet every requirement.

Our unique capabilities include:

- Electropolishing
- Zinc clad lean duplex tubing
- Encapsulation of wire and fiber optics in coils
- Ability to manufacture coiled tubing up to 80,000 feet

RathGibson will continue to grow thanks to customers who appreciate our product diversification, world-class service, and our commitment to quality.

At RathGibson, we MAKE THE CONNECTION.

Available Tubing Size Ranges

Outside Diameter:
From 0.0625" (1.59 mm) to 8" (203.2 mm)

Wall Thickness:
From 0.010" (0.25 mm) to 0.225" (5.7 mm)

Straight Lengths:
Up to 90 feet (27 m)

Coil Sizes:
Up to 80,000 feet (24 km)

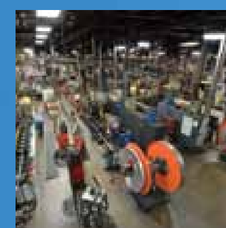
RathGibson has strategically placed locations all over the world in order to provide REAL SOLUTIONS in REAL TIME.

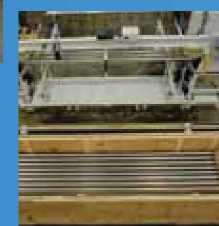
Corporate Headquarters
Lincolnshire, Illinois

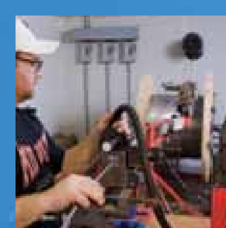
Manufacturing Facilities

- Janesville, Wisconsin
- North Branch, New Jersey
- Clarksville, Arkansas

Sales Offices
Strategically-located throughout the world







Janesville, Wisconsin

RathGibson

Center of excellence

- Chemical Process Industries (CPI)
- Nickel alloys
- Commercial
- High purity
- Solar
- U-Bend tubing

North Branch, New Jersey

RathGibson

Center of excellence

- Power generation
- Oil and gas
- Beverage
- Commercial

Clarksville, Arkansas

GTC

Center of excellence

- Seamless tubing
- Welded & drawn tubing

RathGibson is proud to be a member of Precision Castparts Corporation (PCC). As a PCC Energy company, RathGibson joins other world-leading brands in providing expert products and services to our global customers.

WYMAN GORDON · SPECIAL METALS · HACKNEY LADISH · SPECIAL METALS Welding Products Company · PCC Rollmet · KLAD

RathGibson has been a powerhouse in the Oil and Gas industries for decades. Our straight length and coil tubing is cost effective, while maintaining high strength and corrosion resistant characteristics. Customers also appreciate RathGibson's on-time delivery and various services, which include specific process plans as well as an advanced quality program.

Oil and Gas

ISO 9001:2008 REGISTERED

Downhole Applications

- Control Lines
- Chemical Injection Lines
- Hydraulic Lines
- Capillary Tubing
- Electrical Lines
- Tubing Encapsulated Conductor
- Intelligent Well Completions
- Multi-Line Flat Packs

Umbilical Applications

- Control Lines
- Flying Leads
- Electrical Lines
- Chemical Injection Lines
- Hydraulic Lines
- Lean Duplex Alloys

Products

- 304L
- 316L
- 825
- Zinc Clad Lean Duplex 19D
- Lean Duplex 2101
- Lean Duplex 2003
- Duplex 2205
- Super Duplex 2507
- 400
- 625
- 276

For availability in welded, welded & drawn, seamless, and U-Bend, please contact your RathGibson representative.

The escalation of the world's populations has increased the demand for additional energy sources. As companies build and expand power generation facilities, they choose to make the connection to RathGibson. High quality tubing and complete technical service are the reasons that customers trust RathGibson again and again.

Power Generation

ISO 9001:2008 REGISTERED

Applications

- U-Bend Feedwater Heaters
- Desalination
- Steam Condensers
- Heat Exchangers
- Steam Boilers
- Superheaters
- Instrumentation
- Pressure Coils

Products

- 304L
- 304LN
- 321
- 316L
- 20
- 317L
- 825
- 904L
- 6-Moly 254
- 6-Moly 6XN
- Lean Duplex 2304
- Lean Duplex 2101
- Lean Duplex 2003
- Duplex 2205
- Super Duplex 2507
- Super Duplex 100
- 439
- 29-4C
- 625
- 276
- 22

For availability in welded, welded & drawn, seamless, and U-Bend, please contact your RathGibson representative.

Providing solutions to renewable energy companies around the world is an on-going commitment for RathGibson. High quality products that meet a wide range of operating conditions, combined with industrial experience and technical expertise, make RathGibson the tubing manufacturer of choice.

Renewables

ISO 9001:2008 REGISTERED

Applications

- Solar
- Geothermal
- Wind
- Chemical Well Injections
- Heat Exchangers
- Steam Generators
- Steam Condensers
- U-Bend Feedwater Heaters
- Pressure Coils

Products

- 304L
- 316L
- 825
- 904L
- 6-Moly 254
- 6-Moly 6XN
- Lean Duplex 2003
- Duplex 2205
- 439
- S44627
- 446
- 29-4C
- 625

For availability in welded, welded & drawn, seamless, and U-Bend, please contact your RathGibson representative.

Companies throughout the world rely on RathGibson for outstanding tubing products, technical expertise and superior service. Solving your technical tubing challenges is our mission. RathGibson's vision is to be the preferred global solutions provider for precision stainless and specialty alloy tubing.

Chemical Processing/ Petrochemical

ISO 9001:2008 REGISTERED

Applications

- Heat Exchangers
- Steam Condensers
- Instrumentation
- Superheaters
- Desalination
- Feedwater Heaters
- Pressure Coils
- Steel Boilers
- Low pressure, full annealed applications

Products

- 304L
- 304LN
- 321
- 316L
- 20
- 317L
- 825
- 904L
- 6-Moly 254
- 6-Moly 6XN
- Lean Duplex 2304
- Lean Duplex 2101
- Lean Duplex 2003
- Duplex 2205
- Super Duplex 2507
- 439
- 29-4C
- 625
- 276
- 22

For availability in welded, welded & drawn, seamless, and U-Bend, please contact your RathGibson representative.

RathGibson knows the importance of surface finish in high purity applications. By carefully following regulations, RathGibson produces ultra high purity tubing that has been trusted in international installations. RathGibson manufactures tubing that fits the most demanding needs and requirements.

Food/Dairy/ Beverage/ Pharmaceutical

Beverage Products

304/304L

316/316L

Available as bright annealed mill finished straight lengths and coil lengths for the beverage industries.

Food/Dairy Products

304/304L

316/316L

Available mechanically polished to 20 μ-in Ra (0.5 μm) maximum ID and 30 μ-in Ra (0.8 μm) maximum OD surface roughness, exceeding ASTM A270-S2 and 3-A specification requirements.

Pharmaceutical High Purity Products

316/316L

Available as 100% bore-scoped and mechanically polished to 20 μ-in Ra (0.5 μm) maximum ID and 30 μ-in Ra (0.8 μm) maximum OD surface roughness exceeding ASTM A270-S2 and the stringent ASME BPE SF1 standard.

Pharmaceutical Ultra High Purity Products

True 10

True 15

Available in RathGibson's proprietary electropolishing processes for minimal ID surface anomalies producing surface finishes to 10 μ-in Ra (0.25 μm) or 15 μ-in Ra (0.4 μm) maximum ID and 30 μ-in Ra (0.8 μm) maximum OD exceeding ASTM A270-S2 and ASME BPE SF4 specification requirements. Ultra high purity products are cleaned in a certified ISO 14644-1 Class 5 cleanroom with 99.9999% pure electronics grade nitrogen purge, mylar patch, plastic capped ends, heat-sealed 6-mil poly sleeves and wood boxed for shipment.

Applications

- Evaporators
- Clean-In-Place (CIP)
- General Piping
- Heat Exchangers
- Sterilize-In-Place (SIP)
- Water-For-Injection (WFI)

ISO 9001:2008 REGISTERED
PED 97/23/EC APPROVED
AD 2000 - W0 APPROVED

RathGibson is proud to be the supplier of choice to countless companies in a variety of industries. Our relationships with reputable channel partners throughout the world has generated a network of distributors who are well-versed in RathGibson's products and applications. They ensure that RathGibson's tubing is delivered promptly to projects throughout the world.

General Commercial

ISO 9001:2008 REGISTERED

Applications

- Original Equipment Manufacturers (OEM)
- Instrumentation
- Mechanical
- Specialty Automotive
- Pulp and Paper

Products

- Austenitic Stainless Steel
- Super Austenitic Stainless Steel
- Duplex Stainless Steel
- Super Ferritics/Ferritics
- Nickel Alloys

For availability in welded, welded & drawn, seamless, and U-Bend, please contact your RathGibson representative.

Products by Alloy

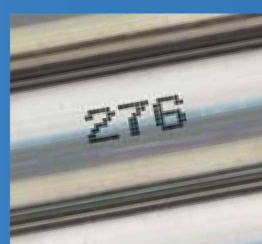
If your company needs tubing, you can rely on RathGibson. Thanks to our precision engineered manufacturing procedures, we easily and effectively respond to our customers' requirements, no matter how stringent they may be. Innovations in welding, bright annealing, and other processes allow us to continually expand the range of product solutions. RathGibson's engineers closely follow each phase of production and testing to ensure PRECISION WELDED, WELDED & DRAWN, and SEAMLESS STRAIGHT LENGTHS, COIL, AND U-BEND tubing of superior performance.

AUSTENITIC STAINLESS STEEL

- 304/304L/304H/304N/304LN
- 316/316L
- 317/317L
- 309S/309H
- 310S/310H
- 321/321H
- 347/347H

DUPLEX STAINLESS STEEL

- Duplex 2205
- Lean Duplex 19D
- Super Duplex 2507
- Super Duplex 100
- Lean Duplex 2003
- Lean Duplex 2101
- Lean Duplex 2304



NICKEL

- 20
- 200/201
- 276
- 400
- 600
- 22
- 625
- 686
- 59

SUPER AUSTENITIC STAINLESS STEEL

- 6-Moly 6XN
- 6-Moly 254
- 825
- 904L
- 800/800H/N08811

FERRITIC/ SUPER FERRITIC

- 29-4C
- S44627
- 439
- 444
- 446
- 18 SR

When you choose RathGibson as your tube supplier, you have entered into a partnership with a world-class organization. All of us at RathGibson are committed to providing the highest quality products and services in the industry. Our goal is to cost effectively meet and exceed your most demanding requirements.

TYPES

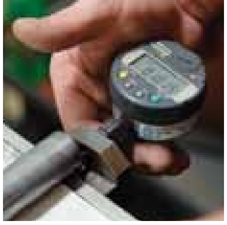
Precision Welded, Welded & Drawn, and Seamless
Straight Lengths, Coil, and U-Bend

FINISHES

- Full-finished and bright annealed
- Full-finished and polished
- Welded and bright annealed

TEMPERS

- Solution annealed (standard for most products)
- Hard drawn
- Dead soft
- Stress relieved
- Low residual stress



Quality

When you choose RathGibson to be your tube supplier, you have chosen excellence. Our dedication to total customer satisfaction is the driving force behind our comprehensive quality control program. Every step of order fulfillment, from sales to manufacturing and delivery is regulated by RathGibson's own standards to maintain high levels of consistency. Quality is ensured via detailed checklists, strict monitoring, and physical inspections.

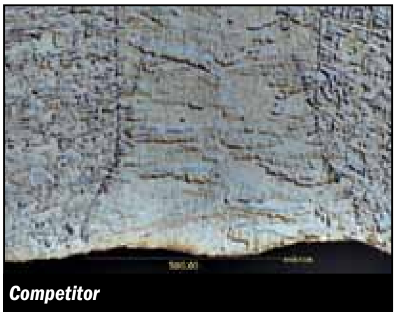
All RathGibson tubing is subject to internal test criteria that can meet or exceed ASTM, ASME, DIN, ECN, ISO and other industry specifications, as well as individual customer requirements. Rigorous testing is performed on raw materials in order to assure compliance to our specifications prior to processing. RathGibson has developed and maintained relationships with world-class suppliers of raw materials.

RathGibson's Commitment to Quality

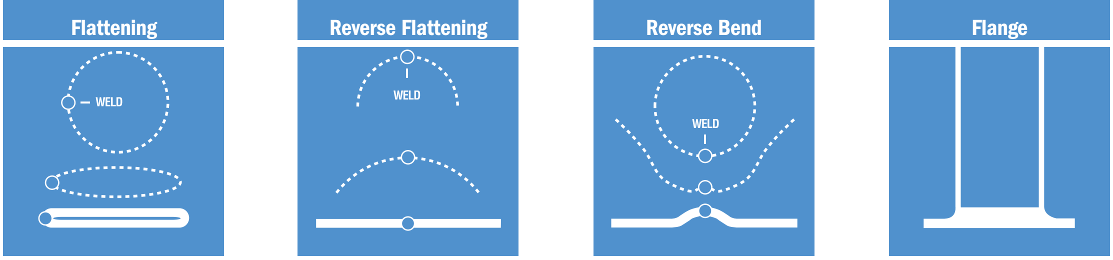
The results of RathGibson's commitment to quality can be seen in the superior characteristics and performance of our tubing. When comparing our 304L stainless steel alloy welded tubing with a competitor's product, the differences are distinct.

Metallographic Inspection

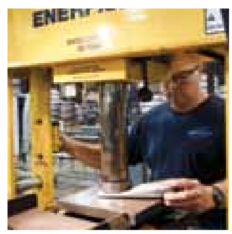
Transverse section of RathGibson laser welded 0.083" (2.11 mm) average wall tubing. The tube's ID surface is visible at the bottom. Note the weld recrystallization and the ID weld.



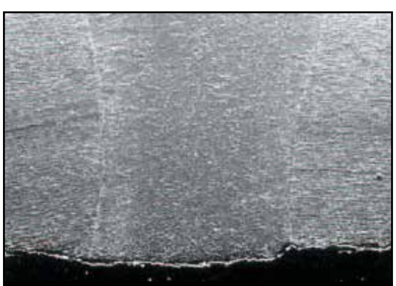
Transverse section of a competitor's laser welded 0.065" (1.65 mm) average wall tubing. The tube's ID surface is visible at the bottom. Note no discernable recrystallization or cold work and the ID is unforged.



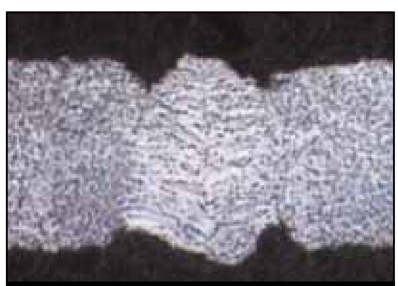
Above are some of the destructive test procedures routinely performed at RathGibson to ensure quality control and compliance to specifications.



Scanning Electron Microscopy


RathGibson

Secondary electron image of transverse section of RathGibson laser-welded 304L tubing after weld decay corrosion testing per ASTM A249-S7. Note the base-metal thinning in excess of weld thinning, as well as the lack of heat affected zone (HAZ) attack.

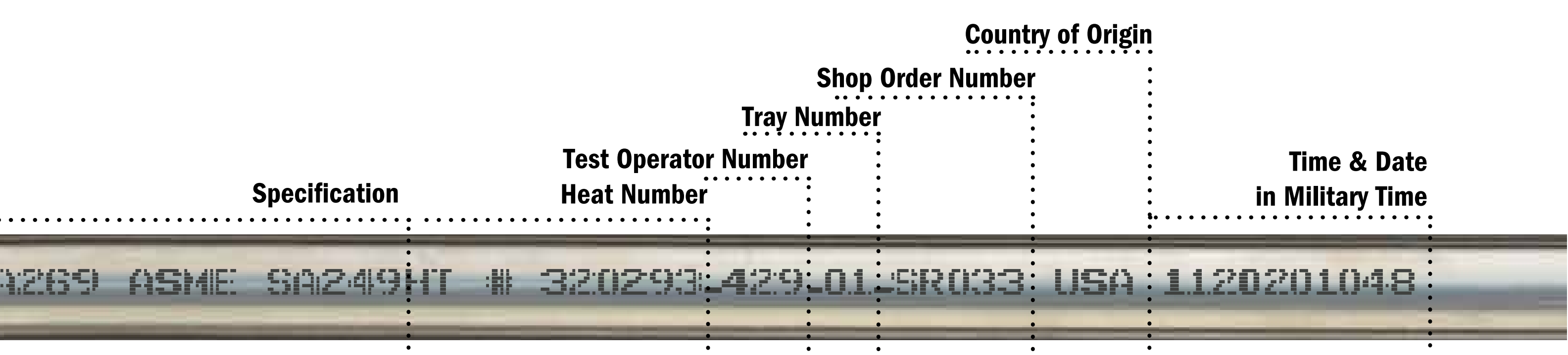

Competitor

Secondary electron image of transverse section of competitor's laser-welded 304L tubing after weld decay corrosion testing per ASTM A249-S7. Photo was taken from competitor's literature. Note the unrecrystallized weld, as well as the significant attack of the fusion boundary and HAZ during ASTM A249-S7 corrosion testing.

Optical Microscopy

RathGibson

Optical image of RathGibson's 304L laser welded product with complete weld recrystallization. Note that the weld is virtually indistinguishable from the base metal.



(ABOVE) Line marking is an important key to maintaining quality control and traceability. Complete product description, specifications, manufacturing and testing information are included.

Quality Tests Performed by RathGibson

Test		Type	Typical ASTM Specifications	Products	Who's performing the testing?
Strength	Tensile	Destructive	A370, E8	Standard	RathGibson
	Burst		–	Standard on coils	RathGibson
Hardness	Rockwell	Destructive	E18, A370	Standard	RathGibson
	Micro	Destructive	E92	Optional	RathGibson
Tube Integrity	Eddy Current (EC)	NDE	E309 E426	Standard	RathGibson
		NDE	A688	Optional	RathGibson
	Ultrasonic	NDE	E213	Optional	RathGibson and/or Independent Lab
	X-Ray	NDE	–	Optional	RathGibson and/or Independent Lab
	Stress Corrosion Cracking (SCC)	Destructive	G36	Optional	RathGibson
	Cross-sectioning	Destructive	–	Optional	RathGibson
	Dye Penetrant	NDE	–	Optional	RathGibson or Independent Contractor
Leak & Strength	Hydrostatic	NDE	A1016	Optional	RathGibson
Leak	Air Under Water (AUW)	NDE	A1016, A1047	Optional	RathGibson
	Pressure Decay (PD)	NDE	A1047	Optional	RathGibson
Bend Testing	Reverse Bend	Destructive	A370	Standard	RathGibson
	Flattening	Destructive	A370	Standard	RathGibson
	Reverse Flattening	Destructive	A370	Standard	RathGibson
	Flare	Destructive	A370	Standard	RathGibson
	Flange	Destructive	A370	Standard	RathGibson
Dimensional	OD, Wall, Straightness, Length	NDE	–	Standard	RathGibson
Metallurgical	Grain Size	Destructive	E112	Optional	RathGibson
	Sensitization	Destructive	A262/A or E	Optional	RathGibson
	Corrosion	Destructive	Alloy Dependent	Optional	RathGibson
	Phase balance or intermetallic	Destructive	E562, E1245	Optional	RathGibson
	Metallographic	Destructive	–	Optional	RathGibson
Positive Material Identification (PMI)	Alloy Verification	NDE	E1476	Standard	RathGibson

NDE = Non-Destructive Examination
*Additional strength, hardness, and destructive bend sampling is taken based on heat treatment lots or process changes.

Minimum Sampling*	Description
Heat-Lot Order	Finds the maximum amount of force required to pull the product to its failure point.
Heat-Lot Order	Ascertains the maximum amount of internal pressure a product is able to withstand before reaching its failure point.
Heat-Lot Order	An indentor is applied to a sample under a minor and then a major load. The difference in depth of penetration determines the placement of the material in relation to the Rockwell scale.
Heat-Lot Order	Calculated from the length of the impression made after a precision diamond indenter is applied into the material at a certain load.
100%	An encircling coil that the tubing is passing through is energized inducing eddy currents in the tubing. The presence of any discontinuities in the entire circumference of the tubular product will alter the normal flow of currents and this change is detected.
100%	
100%	As a transducer is passed over the pipe or tube, it releases pulsewaves. Imperfections are detected by analyzing the returning waves. This is standard testing for Titanium tubing.
100%	Especially useful in weld inspections.
	Testing for RathGibson's U-Bend tubing.
	Tests for bend-induced cracking in RathGibson's U-Bend tubing.
	Testing for RathGibson's U-Bend tubing.
100%	The inside of a tube or pipe is pressurized by a nearly incompressible liquid, and then examined for leaks or permanent shape changes.
100%	Air is injected and then the tube/pipe is placed underwater for visual leak detection.
100%	Air is injected and the air pressure within the pipe/tube is measured over time.
1500' or Heat-lot Order	Ductility, the physical property of sustaining large irreversible deformations without fracturing of the tube/pipe and/or the weld, is measured.
1500' or Heat-lot Order	The end of the tube is flared to a size greater than its OD to check for weak spots and ductility.
1500' or Heat-lot Order	Ductility, the physical property of sustaining large irreversible deformations without fracturing of the tube/pipe and/or the weld, is measured.
1500'	All these tests ascertain the integrity of any welds and the verification of wall thickness throughout the length of pipe.
Heat-lot Order	Grain Size is derived from a digital image analysis of the metal surface. It is generally considered that strength and toughness are found with fine-grained steels, while coarse-grained steels are considered to have better machinability.
Heat-lot Order	Sensitization involves the microstructural analysis of the product to see how it may respond to intergranular corrosion and stress corrosion cracking (SCC).
Heat-lot Order	RathGibson's Technical Services group will recommend which of the dozen different corrosion tests will be appropriate based upon alloy, application, and possible failure modes.
Heat-lot Order	Microscopic examinations from the weld cap to weld root to check for non-metallic or third phase precipitates.
Heat-lot Order	Mounted cross sections are magnified to determine condition, quality, structure, strength, corrosion, wear, and effectiveness of any treatments.
100%	Portable X-Ray Fluorescence (XRF)

Manufacturing Processes:

Welded Tubing

In our Janesville and North Branch manufacturing facilities, RathGibson's engineers oversee each step of the welding process in order to ensure that each tube exhibits superior characteristics and performs to exacting specifications.

Raw Materials

Suppliers are carefully selected to manufacture steel strips that

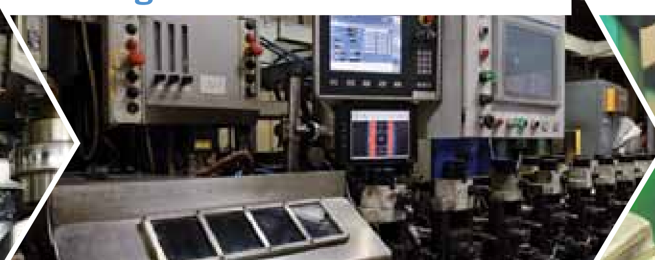
- Meet RathGibson's specifications
- Have typically <0.020% carbon
- Possess closely monitored dimensional tolerances, composition, physical properties, and mill finish

Forming

Precise strip alignment and series of roll sets

- Produce greater uniformity in weld structure
- Create consistent OD and wall tolerance
- Provide excellent concentricity
- Allow custom tooling

Welding



Fillers are never used in any of RathGibson's welding techniques.

Laser Beam Welding (LBW)

- Generates a weld that is precise, narrow, and deep penetrating
- Utilizes optical seam tracking to control beam placement
- Achieves more homogeneous microstructure
- Provides excellent corrosion resistance

Gas Tungsten Arc (TIG) Welding

- Performed in an oxygen-free environment to prevent oxidation in the weld
- Produces a strong, autogenous high quality weld
- Attains superior cosmetic properties

Plasma Arc Welding

- Offers excellent thick section penetration
- Results in smaller heat affected zones

Bead Refinement

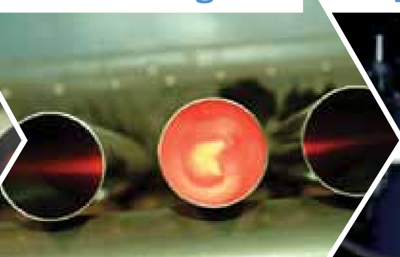
Bead refinement ensures

- Complete blending of the weld bead with parent material
- Highest levels of corrosion resistance for all tubing and pipe grades

RathGibson's proprietary method of cold working the weld includes

- Bead rolling
- Bead forging

Annealing



- Achieves specific properties
- Enhances the metal structure
- Assures a full finished, precision tube
- Results in homogenized weld
  - Looks and performs like the base metal
  - Reduces the chance for preferential corrosion

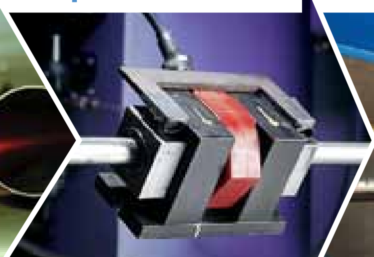
Bright Annealing

- Performed in-line
- Temperatures up to 2150°F (1177°C)
- Rapid screening using hardness testing

Off-line Annealing

- Standard for nickel-based alloys
- Temperatures up to 2110°F (1155°C)

Non-Destructive Examination (NDE) and Inspection



RathGibson tubing is subject to multi-point inspections during and after processing.

Eddy Current Inspection

- ASTM E426
- ASNT SNT-TC-1A
- Nickel alloy tubing tested twice

Line Marking

- On all RathGibson tubing unless specified otherwise
- Assures traceability
- Data can be specified by customers
- Typically includes
  - Alloy grade
  - Tubing size
  - Order number
  - Heat number
  - Specifications

Cut to Length

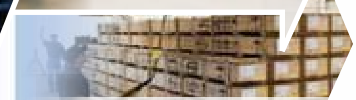
Tubing is cut inline to customer specifications

Packaging

Hex Boxes

Boxes

Wood Boxes



Tri-Wall Boxes

RathGibson offers different packaging options

- Hex
- Boxes
- Wood with optional plastic sleeving
- Tri-wall cardboard boxes

Seamless Tubing

Raw Materials

Large diameter tube hollows, purchased from qualified suppliers, are cut to size based on the finished tube outer diameter (OD), wall, and length. The hollows are pointed or swaged to allow for passing the metal through the drawing die.

Loading the Mandrel

A high strength metal mandrel is placed inside the tube hollow prior to passing the tube through the drawing die.

Lubrication

The tube is lubricated to reduce friction, protect against wear, and prevent corrosion prior to passing through the draw die.

Drawing

The hollow with the inserted mandrel is pulled through the draw die to obtain the desired wall thickness and OD.

Derodding

The tube then passes through a derodder which facilitates mandrel removal.

Physical Properites of Alloys for Seamless Tubing

Alloys	UNS Designation	ASTM Specification	Tensile Strength (min.)		Yield Strength 0.2% Offset (min.)
			MPa	ksi	Mpa
304	S30400	A213, A269, A312, A632	515	75	205
304L	S30403	A213, A269, A312, A632	485	70	170
304H	S30409	A213, A269, A312, A632	515	75	205
310S	S31000	A213, A269, A312, A632	515	75	205
316	S31600	A213, A269, A312, A632	515	75	205
316L	S31603	A213, A269, A312, A632	485	70	170
316H	S31609	A213, A269, A312, A632	515	75	205
317	S31700	A213, A269, A312, A632	515	75	205
317L	S31703	A213, A269, A312, A632	485	70	170
321	S32100	A213, A269, A312, A632	515	75	205
347	S34700	A213, A269, A312, A632	515	75	205
Duplex 2205	S31808	A789	620	90	450
400	N04400	B165	480	70	195
600	N06600	B163	550	80	240
625 GR 1 (Annealed)	N06625	B444	827	120	414
625 GR 2 (Solution Annealed)	N06625	B444	827	120	276
800	N08800	B163	520	75	205
825	N08825	B423	586	85	240

* OD over 1.0" TS>87, YS>58, no hardness requirement 1.0" OD and under

Seamless tubing is manufactured at Greenville Tube, our Clarksville, Arkansas facility. The stringent production process generates tubing that is microstructurally homogeneous throughout its OD and wall. Customers from different industries rely on Greenville Tube's quick delivery of high quality products.

Cleaning

After the drawing process, the seamless tube is cleaned in an environmentally-safe non-chlorinated closed-loop degreasing system.

Bright Solution Annealing

The tube is bright solution annealed, a process that includes heating and cooling the tube in an inert atmosphere.

Cutting and Mechanical Polishing

The tube may go through the drawing process several times to reach the final product size. Once the tube is at the final size, it is straightened and sent to the finishing department. Depending on customer specifications, several finishing operations, including cutting to size and mechanical polishing, may be performed.

Line Marking

All RathGibson seamless tubing is 100% eddy current tested and stenciled with the required manufacturing information.

Boxing

RathGibson's seamless tubing is packaged and shipped in accordance with customer specifications.

Yield Strength 0.2% Offset (min.)	Elongation in 2" (min.)	Grain Size Requirement	Max. Hardness	Modulus of Elasticity ($x10^6$ psi)	Mean Coefficient of Thermal Expansion (in/in/°F$x10^{-6}$)	Thermal Conductivity (BTU-in/ft^2-hr-°F)
ksi	%					
30	35	-	92 Rb	28	9.2	116
25	35	-	92 Rb	28	9.2	116
30	40	7 or coarser	92 Rb	28	9.2	116
30	40	-	90 Rb	29	9.2	116
30	35	-	90 Rb	28	9.2	116
25	35	-	90 Rb	28	9.2	116
30	35	7 or coarser	90 Rb	28	9.2	116
30	35	-	90 Rb	28	9.2	116
25	35	-	90 Rb	28	9.2	116
30	35	-	90 Rb	29	9.2	-
30	35	-	90 Rb	29	9.2	116
65	30	-	28 Rc, 30 Rc*	27.5	7.6	180
28	35	-	-	26	7.7	168
35	30	-	-	30	6.9	103
60	30	-	-	30	7.1	68
40	30	-	-	30	7.1	68
30	30	-	-	-	7.9	80
35	30	-	-	28	7.7	77

Welded & Drawn Tubing

Welded & drawn tubing from RathGibson begins with the same high quality welded straight lengths and coiled tubing that has been chosen for countless installations throughout the world.

The tubing is bathed in lubricant before it is drawn through a die.

Tubing may be drawn several times in order to meet strict customer specifications for size, strength and finish.

The drawing process provides the following advantages:

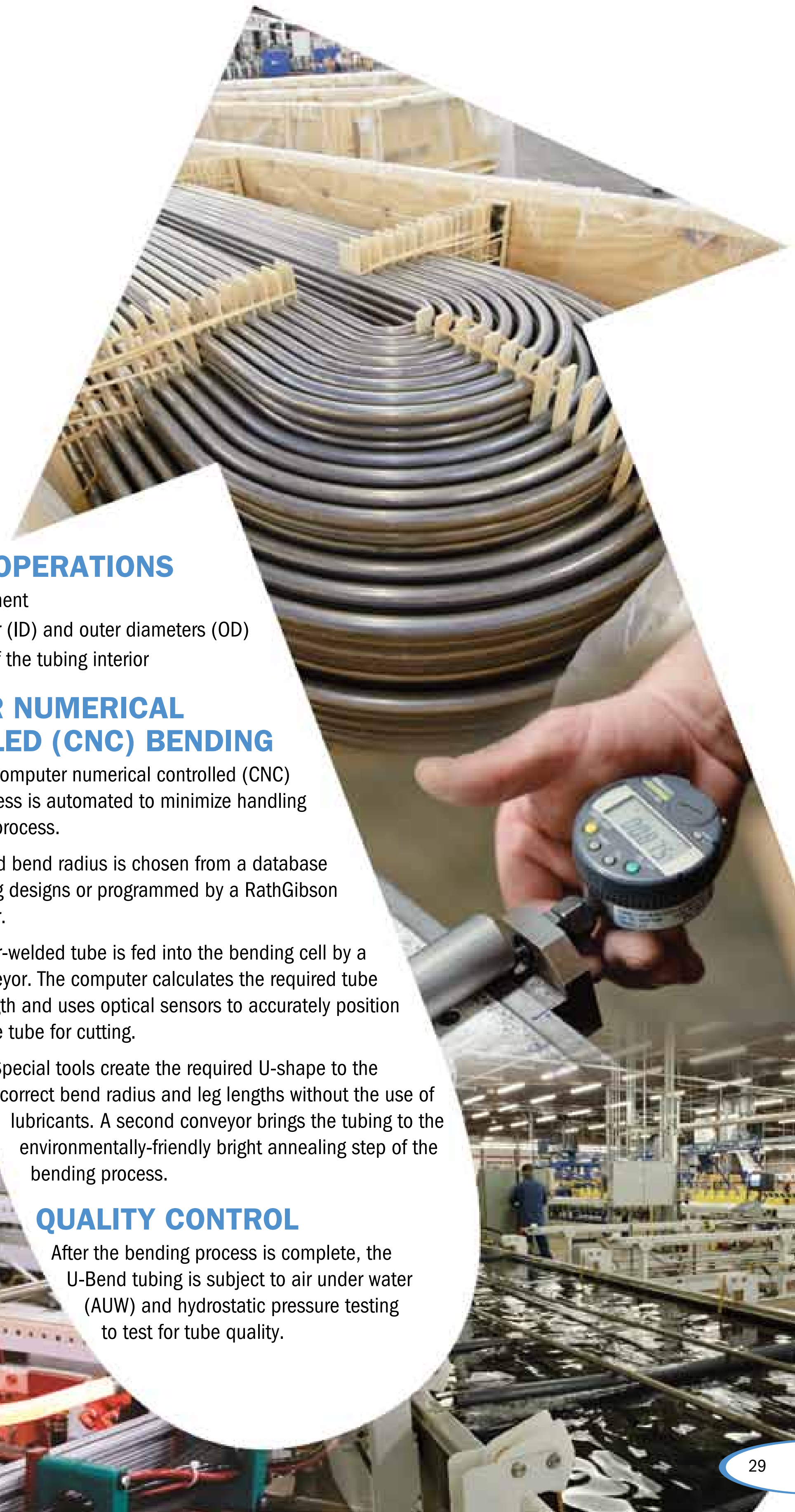
- Heavier wall to outer diameter (OD) ratios
- Additional strength
- Exceptional dimensional control
- Superior surface finish
- Enhanced bending, flaring, and formability of tubing
- Greater control over ovality

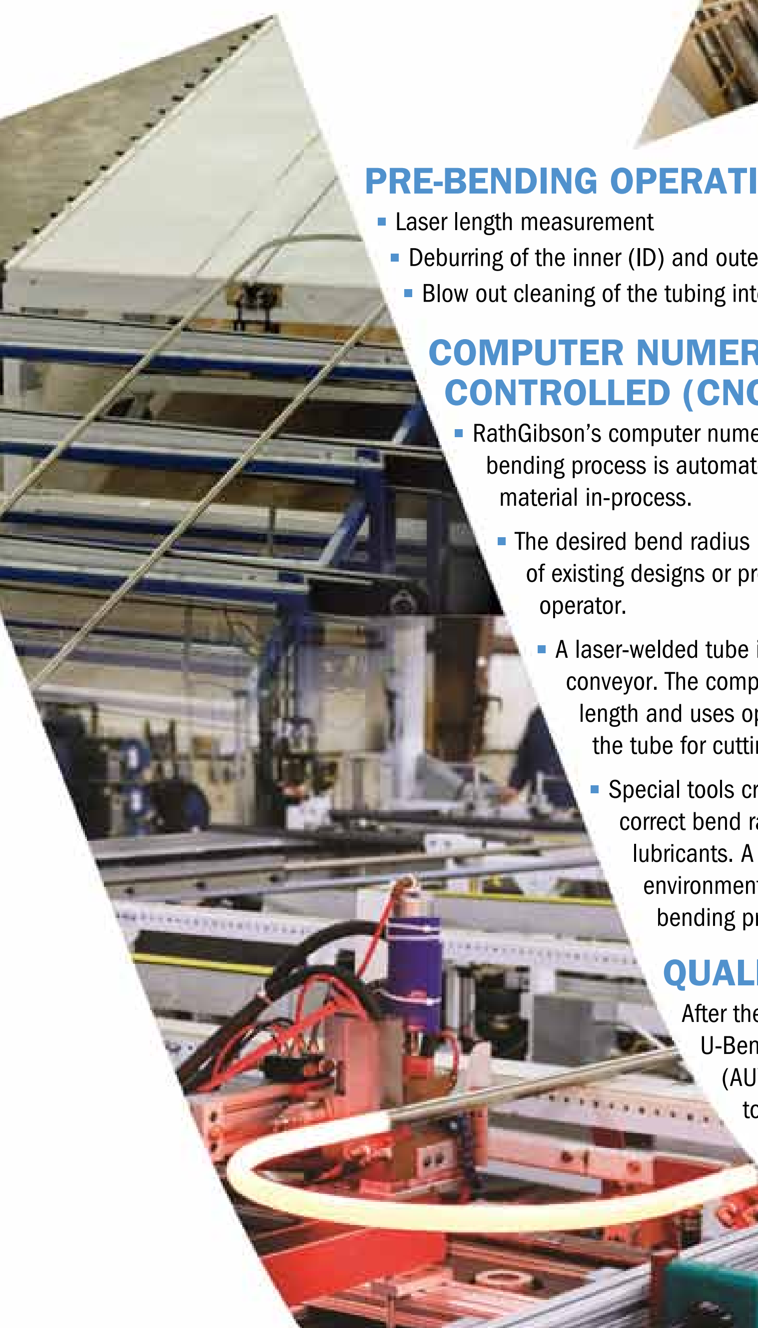
Each drawing operation is followed by an annealing operation. The additional cold work and annealing result in "seamless" quality.

Welded & drawn processes are performed in RathGibson's North Branch, New Jersey; Janesville, Wisconsin; and Clarksville, Arkansas facilities.

U-Bend Tubing

RathGibson U-Bend tubing offers lower than 5,000 psi residual stress for stress corrosion cracking (SCC) sensitive applications.





PRE-BENDING OPERATIONS

- Laser length measurement
- Deburring of the inner (ID) and outer diameters (OD)
- Blow out cleaning of the tubing interior

COMPUTER NUMERICAL CONTROLLED (CNC) BENDING

- RathGibson's computer numerical controlled (CNC) bending process is automated to minimize handling material in-process.
- The desired bend radius is chosen from a database of existing designs or programmed by a RathGibson operator.
- A laser-welded tube is fed into the bending cell by a conveyor. The computer calculates the required tube length and uses optical sensors to accurately position the tube for cutting.
- Special tools create the required U-shape to the correct bend radius and leg lengths without the use of lubricants. A second conveyor brings the tubing to the environmentally-friendly bright annealing step of the bending process.

QUALITY CONTROL

After the bending process is complete, the U-Bend tubing is subject to air under water (AUW) and hydrostatic pressure testing to test for tube quality.

Zinc Clad Lean Duplex Tubing

RathGibson's unique cladding process for subsea umbilical tubing starts with large reels of lean duplex stainless steel tubing.

The tubing is fed through a shot blast chamber for the abrasive blasting of the tubing surface. Not only does this prepare the surface of the tubing for cladding, it also removes contaminates.

The blasted tubing leaves the chamber and enters the die chamber. Here, the tube is introduced to two zinc rods at the extruder. Very precise, prescribed temperatures and pressures are required for the extrusion or cladding to take place.

A cooling water chamber is the next step in the process.

The mechanisms that pull the tubing from the start-up reel all the way onto the take-up wheel are in the next chamber.

The tubing's alloy, size, and manufacturer are line-marked onto the tubing to ensure complete traceability.

After production has ended, the take-up reel proceeds to Final Acceptance Testing (FAT) prior to shipment to the customer.

Encapsulated Tubing

For optimal downhole protection, companies connect to RathGibson for encapsulated tubing.

Encapsulated tubing, also known as tubing encapsulated conductor (T.E.C.) line, begins with spools of metal strip and electrical wire or fiber optics.

The electrical wire or fiber optics are simultaneously fed with the metal strip into custom-made weld mills.

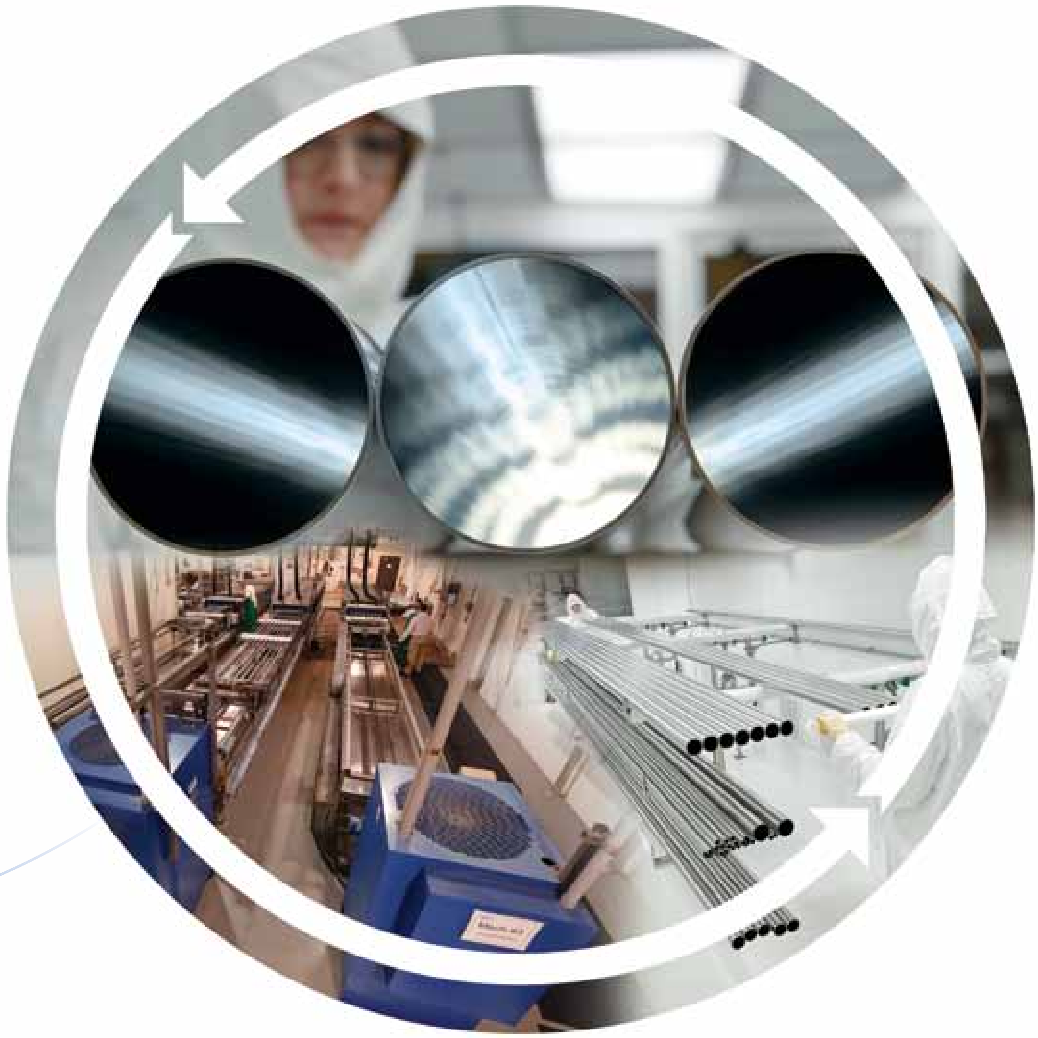
A series of rollers gently work the strip into tubing which is formed around the wire.

The tube formation continues in the same manner as all RathGibson welded tubing.

Automatic seam welding completes the encapsulation process.

Electropolishing

RathGibson's innovative and proprietary electropolishing process is performed in the Janesville facility.



Our exclusive process begins when the tube is filled with an electrolyte.

A cathode, attached to the end of a copper rod, is introduced into the tube's interior.

High current density electricity is used in combination with special electrolyte solutions to electrochemically remove metal from the surface, resulting in a smooth, flat, easily cleanable surface. Surface roughness values of less than 15µ-in Ra (0.4µ) are easily achieved. Corrosion resistance is improved by the increased concentration of chromium at the surface.

A series of nitric acid and deionized water rinses flushes away the electrolyte, as well as any residue.

Tubes are then visually inspected and packaged in an ISO 14644-1 Class 5 clean room, which is ideal for ultra-high purity applications.

Mechanical Polishing

Mechanically polished tubing from RathGibson may be used in the food, dairy, beverage, pharmaceutical, biopharmaceutical, chemical, petrochemical, power generation, and solar industries.

The mechanical polishing process starts with the simultaneous deburring of both ends of a tube.

To achieve the desired interior surface finish, an abrasive material, fitted onto a pneumatic polishing head, rotates within the tube for many cycles. Any interior residue is removed by blowing a clean wipe through the tube before visual inspection.

The ends of the tube are capped to protect the interior during the OD mechanical polishing process.

Two heads spin the tube before it enters the polisher. RathGibson employs two multiple-head mechanical polishing centers.

Each OD polishing head uses wet polish, which is composed of lubricant and rough grit that is recirculated and filtered. As the tube travels from head to head, the grit gets progressively finer.

Air blows off any residual lubricant as the tube exits the polishing area.

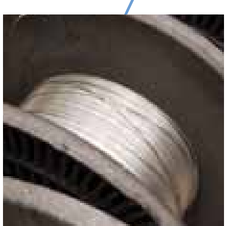
An experienced RathGibson operator examines the tube's exterior and interior for residuals.

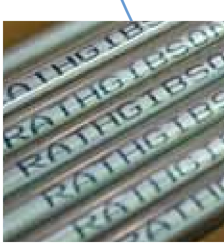
After final visual inspection, both ends are vinyl capped.

The tube is line marked with its alloy, size, weld, and manufacturer to ensure complete traceability.

RathGibson's standard OD mechanical polish finish is a guaranteed maximum 30 μ-in Ra (0.8 μm). For special applications, a maximum surface roughness of 10 μ-in Ra (0.25 μm) is also available. For protection during shipment, the tube is heat sealed in a poly-sleeve.

Product Information

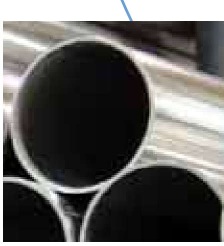




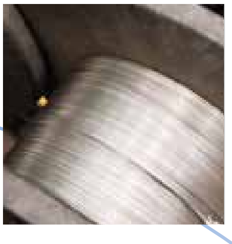
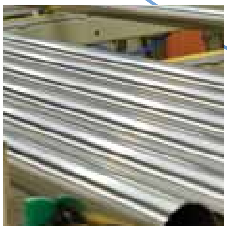
Products	Sizes		
	OD	Wall	Lengths and/or coils
Welded Austenitic Steam Boiler, Superheater, Heat Exchangers, Condenser Tubes, & Feedwater Heaters Specifications: ASTM-A249, ASME-SA249, ASTM-A688, ASME-SA688	3/16" (4.76 mm) to 4" (101.6 mm) *metric sizes available*	0.020" (0.51 mm) to 0.220" (5.59 mm)	Random or cut lengths up to 90' (27.4 m) **Coils to 1-1/2" OD**
Welded Duplex or Ferritic Boiler, Superheater, Heat Exchangers, Condenser Tubes, & Feedwater Heaters Specifications: ASTM-A789, ASME-SA789, ASTM-A803, ASME-SA803	3/16" (4.76 mm) to 4" (101.6 mm) *metric sizes available*	0.020" (0.51 mm) to 0.220" (5.59 mm)	Random or cut lengths up to 68' (20.7 m) **Coils to 1-1/2" OD**
Welded Heat Exchangers & Condensers Specifications: ASTM-A789 and ASME-SA789	0.5" (12.7 mm) to 4" (101.6 mm) *metric sizes available*	0.020" (0.51 mm) to 0.150" (3.81 mm)	Cut lengths to 60' (18.3 m)
Pressure & Corrosion Tubing Meets or exceeds requirements for welded Specifications: ASTM-A269, ASTM-A1016, and ASTM-A632	1/16" (1.59 mm) to 4" (101.6 mm) *metric sizes available*	0.010" (0.25 mm) to 0.220" (5.59 mm)	Random or cut lengths up to 90' (27.4 m) **Coils to 1-1/2" OD**
Pressure & Corrosion Tubing Meets or exceeds requirements for welded Specification: ASTM-A789	1/16" (1.59 mm) to 4" (101.6 mm) *metric sizes available*	0.010" (0.25 mm) to 0.220" (5.59 mm)	Random or cut lengths up to 40' (12.2 m) **Coils to 1-1/2" OD**
Pressure & Corrosion Tubing Meets or exceeds requirements for welded Specifications: ASTM-B704, ASME-SB704, ASTM-B705, ASME-SB705	1/16" (1.59 mm) to 4" (101.6 mm) *metric sizes available*	0.010" (0.25 mm) to 0.220" (5.59 mm)	Random or cut lengths up to 40' (12.9 m) **Coils to 1-1/2" OD**

Grades	Standard Tolerances		
	OD	**Wall**	**Lengths**
304/304L/304H 316/316L 317/317L Ferritics	Under 1" (25.4 mm) ±0.004" (0.10 mm) 1" (25.4 mm) to 1-1/2" (38.1 mm) ±0.006" (0.15 mm) >1-1/2" (38.1 mm) to 2" (50.8 mm) ±0.008" (0.20 mm) >2" (50.8 mm) to 2-1/2" (63.5 mm) ±0.010" (0.25 mm) >2-1/2" (63.5 mm) to 3" (76.2 mm) ±0.012" (0.30 mm) 3" (76.2 mm) to 4" (101.6 mm) ±0.015" (0.38 mm)	±10%	Randoms up to +2" (50.8 mm) Cuts +1/8" (3 mm) /-0" **Coils to 80,000' (24,384 m)**
Duplex 2205 Ferritics	<1-1/2" (38.1 mm) ±0.005" (0.13 mm) 1-1/2" (38.1 mm) to 3" (76.2 mm) ±0.010" (0.25 mm) 3-1/2" (88.9 mm) to 4" (101.6 mm) ±0.015" (0.38 mm)	±10%	Randoms up to +2" (50.8 mm) Cuts +1/8" (3 mm) /-0" **Coils to 80,000' (24,384 m)**
Lean Duplex 2003 Lean Duplex 2101 Lean Duplex 2304	< 1/2" (12.7 mm) +/-0.005" (0.13 mm) 1/2" (12.7 mm) to <1-1/2" (38.1 mm) +/-0.005" (0.13 mm) 1-1/2" (38.1 mm) to <3-1/2" (88.9 mm) +/-0.010" (0.25 mm) >3-1/2" (88.9 mm) to 4.00" (101.6 mm) +/-0.015" (0.38 mm)	+/-15% +/-10%	+1/8" (3 mm)/-0"
304/304L/304H 316/316L 317/317L	<1-1/2" (38.1 mm) ±0.005" (0.13 mm) 1-1/2" (38.1 mm) to 3" (76.2 mm) ±0.010" (0.25 mm) 3-1/2" (88.9 mm) to 4" (101.6 mm) ±0.015" (0.38 mm)	±10%	Randoms up to +2" (50.8 mm) Cuts +1/8" (3 mm) /-0" **Coils to 80,000' (24,384 m)**
Super Duplex 2507 Duplex 2205	<1-1/2" (38.1 mm) ±0.005" (0.13 mm) 1-1/2" (38.1 mm) to 3" (76.2 mm) ±0.010" (0.25 mm) 3-1/2" (88.9 mm) to 4" (101.6 mm) ±0.015" (0.38 mm)	±10%	Randoms up to +2" (50.8 mm) Cuts +1/8" (3 mm) /-0" **Coils to 80,000' (24,384 m)**
625 825	<5/8" (15.9 mm) ±0.005" (0.127 mm) 5/8" to 1-1/2" ±0.007" >1-1/2" (38.1 mm) to 3" (76.2 mm) ±0.010" (0.25 mm) >3" (76.2 mm) to 4" (101.6 mm) ±0.015" (0.38 mm)	±15% ±12.5%	Randoms up to +2" (50.8 mm) Cuts +1/8" (3 mm) /-0" **Coils to 80,000' (24,384 m)**

Product Information



Products	Sizes	
	OD	**Wall**
Beverage Tubing	1/4" (6.35 mm) 5/16" (7.94 mm) 3/8" (9.53 mm) 1/2" (12.7 mm) *metric sizes available*	0.020" (0.51 mm) to 0.028" (0.71 mm)
Instrumentation Tubing Specifications: ASTM-A269 and ASTM-A632	1/16" (1.59 mm) to 1/2" (12.7 mm) *metric sizes available*	0.010" (0.25 mm) to 0.065" (1.65 mm)
Food/Dairy Tubing **Pharmaceutical Tubing** **High Purity Tubing** **Ultra High Purity Tubing** Specifications: ASTM-A269, ASTM-A270, and ASME BPE	1/2" (12.7 mm) to 8" (203.2 mm)	0.049" (1.24 mm) to 0.109" (2.77 mm)
Subsea Umbilical Tubing Specifications: ASTM-A789 and ASTM-A790	3/8" (9.53 mm) to 1-1/2" (38.1 mm)	0.039" (0.99 mm) to 0.125" (3.18 mm)


	Grades	Standard Tolerances		
Lengths and/or coils		**OD**	**Wall**	**Lengths**
Random or cut lengths up to 40' (12.2 m)	304/304L 316L	±0.005" (0.13 mm)	±10%	Randoms up to +2" (50.8 mm) Cuts +1/8" (3 mm) -0" **Coils to 15,000' (4,572 m)**
Random or cut lengths up to 40' (12.2 m)	304/304L/304H 316/316L 317/317L	±0.005" (0.13 mm)	±10%	Randoms up to +2" (50.8 mm) Cuts +1/8" (3 mm) -0"
20' (6.1 m) stock lengths. Other lengths available upon request.	304/304L 316/316L	1/2" (12.7 mm) ± 0.005" (0.13 mm)	±10%	+1/8" (3 mm) -0"
		3/4" (19.1 mm) ± 0.005" (0.13 mm)	±10%	+1/8" (3 mm) -0"
		1" (25.4 mm) ± 0.005" (0.13 mm)	±10%	+1/8" (3 mm) -0"
		1-1/2" (38.1 mm) ± 0.008" (0.20 mm)	±10%	+1/8" (3 mm) -0"
		2" (50.8 mm) ± 0.008" (0.20 mm)	±10%	+1/8" (3 mm) -0"
		2-1/2" (63.5 mm) ± 0.010" (0.25 mm)	±10%	+1/8" (3 mm) -0"
		3" (76.2 mm) ± 0.010" (0.25 mm)	±10%	+1/8" (3 mm) -0"
		4" (101.6 mm) ± 0.015" (0.38 mm)	±10%	+1/8" (3 mm) -0"
		6" (152.4 mm) ± 0.030" (0.76 mm)	±10%	+1" (25.4 mm) -0"
		8" (203.2 mm) +0.061" (1.55 mm), -0.031" (0.79 mm)	±10%	+1" (25.4 mm) -0"
Cut lengths to 60' (18.3 m) **Coils to 1-1/2" OD**	Lean Duplex 19D Super Duplex 2507 Lean Duplex 2003 Lean Duplex 2101	±0.005" (0.127 mm)	±10%	**Coils to 80,000' (24,384 m)**

Tube Weight for Austenitic Stainless Steels in Pounds Per Foot

Tube OD (in)	Wall Thickness (inches and gauges)												
	0.008	0.010	0.012	0.020	0.028	0.035	0.049	0.065	0.083	0.109	0.120	0.134	0.140
	33	31	30	25	22	20	18	16	14	12	11	10	–
0.063	0.0047	0.0057	0.0066	0.0092	0.0106	–	–	–	–	–	–	–	–
0.094	0.0074	0.0090	0.0106	0.0160	0.0199	0.0223	–	–	–	–	–	–	–
0.125	0.0100	0.0123	0.0146	0.0226	0.0293	0.0339	–	–	–	–	–	–	–
0.156	0.0127	0.0157	0.0186	0.0293	0.0386	0.0457	0.0565	0.0638	–	–	–	–	–
0.188	0.0155	0.0191	0.0228	0.0362	0.0482	0.0577	0.0734	0.0862	–	–	–	–	–
0.250	0.0208	0.0258	0.0308	0.0496	0.0670	0.0812	0.1062	0.1296	0.1494	–	–	–	–
0.313	0.0263	0.0326	0.0390	0.0632	0.0860	0.1049	0.1395	0.1738	0.2058	–	–	–	–
0.375	0.0316	0.0393	0.0469	0.0765	0.1048	0.1283	0.1722	0.2172	0.2613	–	–	–	–
0.438	0.0370	0.0461	0.0551	0.0901	0.1238	0.1520	0.2055	0.2614	0.3176	–	–	–	–
0.500	0.0424	0.0528	0.0631	0.1035	0.142	0.175	0.238	0.305	0.373	–	–	–	–
0.540	–	–	–	–	–	–	0.259	0.333	0.409	0.506	0.543	–	–
0.563	0.0478	0.0596	0.0712	0.1170	0.161	0.199	0.272	0.349	0.429	–	0.573	0.619	0.638
0.625	0.0532	0.0662	0.0793	0.1304	0.180	0.223	0.304	0.392	0.485	–	0.652	0.707	0.730
0.675	–	–	–	–	–	–	0.331	0.427	0.530	0.665	0.718	0.781	0.806
0.750	0.0639	0.0797	0.0955	0.1574	0.218	0.270	0.370	0.480	0.597	0.753	0.814	0.889	0.920
0.840	–	–	–	0.177	0.245	0.304	0.418	0.543	0.677	0.859	0.931	1.020	1.056
0.875	–	–	–	0.1843	0.256	0.317	0.436	0.568	0.709	0.900	0.977	1.07	1.11
1.000	–	–	–	0.2113	0.293	0.364	0.502	0.655	0.820	1.04	1.13	1.25	1.30
1.050	–	–	–	–	–	–	0.529	0.690	0.865	1.106	1.203	1.323	1.373
1.125	–	–	–	0.2382	0.331	0.411	0.568	0.743	0.932	1.19	1.30	1.43	1.48
1.250	–	–	–	0.2652	0.369	0.458	0.634	0.830	1.04	1.34	1.46	1.61	1.68
1.315	–	–	–	–	–	–	0.669	0.876	1.10	1.42	1.55	1.71	1.77
1.375	–	–	–	0.2921	0.407	0.506	0.700	0.918	1.15	1.48	1.62	1.79	1.86
1.500	–	–	–	0.3191	0.444	0.553	0.766	1.00	1.26	1.63	1.78	1.97	2.05
1.625	–	–	–	–	–	0.600	0.832	1.09	1.38	1.78	1.94	2.15	2.24
1.660	–	–	–	–	–	–	0.851	1.12	1.41	1.82	1.99	2.20	2.29
1.750	–	–	–	–	–	0.647	0.899	1.18	1.49	1.92	2.10	2.33	2.43
2.000	–	–	–	–	–	0.741	1.03	1.35	1.71	2.22	2.43	2.69	2.80
2.125	–	–	–	–	–	0.789	1.09	1.44	1.82	2.36	2.59	2.87	2.99
2.250	–	–	–	–	–	0.836	1.16	1.53	1.932	2.51	2.75	3.05	3.18
2.375	–	–	–	–	–	0.883	1.22	1.61	2.05	2.66	2.91	3.23	3.37
2.500	–	–	–	–	–	0.930	1.29	1.70	2.16	2.80	3.07	3.41	3.59
2.625	–	–	–	–	–	–	1.36	1.79	2.27	2.95	3.24	3.59	3.75
2.750	–	–	–	–	–	–	1.427	1.88	2.38	3.10	3.40	3.77	3.93
2.875	–	–	–	–	–	–	1.49	1.96	2.49	3.25	3.56	3.95	4.12
3.000	–	–	–	–	–	–	1.55	2.05	2.61	3.39	3.72	4.14	4.31
3.500	–	–	–	–	–	–	–	2.40	3.05	3.98	4.37	4.86	5.07
4.000	–	–	–	–	–	–	–	2.75	3.5	4.57	5.10	5.58	5.82
6.000	–	–	–	–	–	–	–	–	5.29	6.92	7.60	8.46	8.84
8.000	–	–	–	–	–	–	–	–	–	9.27	–	–	–

The formulas used to calculate the weights shown is:
Pounds per foot = 10.78 (D-t) t
Where: D = Outside diameter, inches
t = Wall Thickness, inches

OVERALL SIZE RANGE
1/16" (1.59 mm) to 8" (203.2 mm) OD,
33 to 9 gauge Schedules 5–40

Metric sizes also available.
Stock Lengths = 20 feet (6.1 m). Others available.

Tube Weight for Austenitic Stainless Steels in Kilograms Per Meter

Tube OD (mm)	Tube OD (in)	Wall Thickness (mm and inches)													
		0.20	0.25	0.30	0.51	0.71	0.89	1.24	1.65	2.11	2.77	3.05	3.40	3.56	mm
		0.008	0.01	0.012	0.02	0.028	0.035	0.049	0.065	0.083	0.109	0.12	0.134	0.14	inches
1.6	0.063	0.0071	0.0086	0.0099	0.014	0.016	–	–	–	–	–	–	–	–	
2.4	0.094	0.0111	0.0136	0.0159	0.024	0.030	0.033	–	–	–	–	–	–	–	
3.2	0.125	0.0151	0.0186	0.0219	0.034	0.044	0.051	–	–	–	–	–	–	–	
4.0	0.156	0.0191	0.0236	0.0279	0.044	0.058	0.068	0.085	0.095	–	–	–	–	–	
4.8	0.188	0.0232	0.0287	0.0341	0.054	0.075	0.086	0.110	0.129	–	–	–	–	–	
6.4	0.250	0.0312	0.0387	0.0461	0.074	0.100	0.121	0.159	0.194	0.224	–	–	–	–	
8.0	0.313	0.0394	0.0489	0.0583	0.095	0.129	0.157	0.209	0.260	0.308	–	–	–	–	
9.5	0.375	0.0474	0.0589	0.0703	0.115	0.157	0.192	0.258	0.325	0.391	–	–	–	–	
11.1	0.438	0.0555	0.0691	0.0825	0.135	0.185	0.228	0.308	0.391	0.475	–	–	–	–	
12.7	0.500	0.0635	0.0791	0.0945	0.155	0.213	0.263	0.357	0.456	0.558	–	–	–	–	
13.7	0.540	–	–	–	–	–	–	0.388	0.498	0.612	0.758	0.813	–	–	
14.3	0.563	0.0716	0.0892	0.1067	0.175	0.242	0.298	0.406	0.522	0.643	–	0.858	0.927	0.955	
15.8	0.624	0.0795	0.0991	0.1185	0.195	0.369	0.333	0.455	0.586	0.724	–	0.976	1.059	1.093	
17.1	0.675	–	–	–	–	–	–	0.495	0.640	0.793	0.995	1.075	1.170	1.208	
19.1	0.750	0.0958	0.1194	0.1429	0.236	0.326	0.404	0.554	0.718	0.893	1.127	1.220	1.332	1.378	
21.3	0.840	–	–	–	0.265	0.367	0.455	0.625	0.813	1.014	1.286	1.394	1.526	1.581	
22.2	0.875	–	–	–	0.276	0.383	0.474	0.653	0.849	1.061	1.347	1.462	1.602	1.660	
25.4	1.000	–	–	–	0.315	0.439	0.545	0.752	0.981	1.228	1.567	1.704	1.872	1.942	
26.7	1.050	–	–	–	–	–	–	0.791	1.033	1.295	1.655	1.801	1.980	2.060	
28.6	1.125	–	–	–	0.357	0.496	0.615	0.851	1.112	1.395	1.787	1.946	2.140	2.220	
31.8	1.250	–	–	–	0.397	0.552	0.686	0.949	1.243	1.563	2.010	2.190	2.410	2.510	
33.4	1.315	–	–	–	–	–	–	1.001	1.311	1.650	2.120	2.310	2.550	2.650	
34.9	1.375	–	–	–	0.437	0.608	0.757	1.048	1.374	1.730	2.230	2.430	2.680	2.790	
38.1	1.500	–	–	–	0.478	0.665	0.827	1.147	1.505	1.897	2.450	2.670	2.950	3.070	
41.3	1.625	–	–	–	–	–	0.898	1.246	1.636	2.060	2.670	2.910	3.220	3.350	
42.2	1.660	–	–	–	–	–	–	1.274	1.673	2.110	2.730	2.980	3.300	3.430	
44.5	1.750	–	–	–	–	–	0.968	1.345	1.767	2.230	2.890	3.160	3.490	3.640	
50.8	2.000	–	–	–	–	–	1.110	1.542	2.030	2.570	3.330	3.640	4.030	4.200	
54.0	2.125	–	–	–	–	–	1.180	1.641	2.160	2.730	3.550	3.880	4.300	4.480	
57.2	2.250	–	–	–	–	–	1.251	1.740	2.290	2.900	3.770	4.120	4.570	4.770	
60.3	2.375	–	–	–	–	–	1.321	1.839	2.420	3.070	3.980	4.370	4.840	5.050	
63.5	2.500	–	–	–	–	–	1.392	1.938	2.550	3.240	4.200	4.610	5.120	5.330	
66.7	2.625	–	–	–	–	–	–	2.040	2.680	3.400	4.420	4.850	5.390	5.610	
69.9	2.750	–	–	–	–	–	–	2.140	2.820	3.570	4.640	5.090	5.660	5.900	
73.0	2.875	–	–	–	–	–	–	2.230	2.950	3.740	4.860	5.330	5.930	6.180	
76.2	3.000	–	–	–	–	–	–	2.330	3.080	3.910	5.080	5.580	6.200	6.460	
88.9	3.500	–	–	–	–	–	–	–	3.600	4.580	5.960	6.540	7.280	7.590	
101.6	4.000	–	–	–	–	–	–	–	4.130	5.250	6.840	7.510	8.360	8.720	
152.4	6.000	–	–	–	–	–	–	–	–	7.920	10.360	11.380	12.680	13.247	
203.2	8.000	–	–	–	–	–	–	–	–	–	13.888	–	–	–	

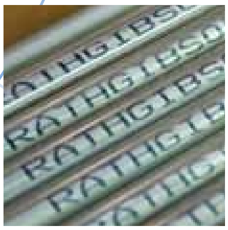
The formulas used to calculate the weights shown is: Kilograms per meter = 0.0250 (D-t) t

Where: D = Outside diameter, millimeters t = Wall Thickness, millimeters

Weight Conversion Factors

To determine weights of tubing made of other alloys, multiply weight per foot shown in the Pipe Size Range and Tube Size Range tables by the applicable conversion factor shown below.

UNS	Common	Factor
S30403	Alloy 304L	1.00
N02200	Nickel 200	1.130
N04400	Alloy 400	1.119
N06022	Alloy 22	1.091
N06059	Alloy 59	1.091
N06600	Alloy 600	1.067
N06625	Alloy 625	1.070
N06686	Alloy 686	1.105
N08020	Alloy 20	1.025
N08367	6-Moly 6XN	1.021
N08800	Alloy 800	1.018
N08825	Alloy 825	1.028
N08904	Alloy 904L	1.007
N10276	Alloy 276	1.126
S20100	Alloy 201	0.996
S30908	Alloy 309	1.018
S31008	Alloy 310	1.018
S31254	6-Moly 254	1.021
S31803/S32205	Duplex 2205	1.000
S32001	Lean Duplex 19D	0.979
S32003	Lean Duplex 2003	0.979
S32100	Alloy 321	1.039
S32750	Super Duplex 2507	1.000
S34700	Alloy 347	1.011
S34800	Alloy 348	1.014
S43035	Ferritic 439	0.975
S44400	Ferritic 444 (18-2)	0.982
S44627	Super Ferritic S44627	0.982
S44735	Super Ferritic 29-4C	0.972



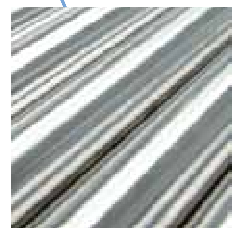
Product Alloy Specifications*

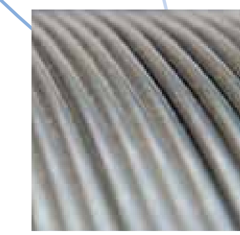
ASTM	ASME
A213	SA213
A249	SA249
A268	SA268
A269	–
A270	–
A312	SA312
A511	–
A530	SA530
A554	–
A632	–
A688	SA688
A789	SA789
A790	SA790
B161	SB161
B163	SB163
B165	SB165
B167	SB167
B338	SB338
B407	SB407
B423	SB423
B444	SB444
B468	SB468
B514	SB514
B515	SB515
B516	SB516
B517	SB517
B619	SB619
B626	SB626
B673	SB673
B674	SB674
B675	SB675
B676	SB676
B677	SB677
B704	SB704
B705	SB705
B725	–
B730	–

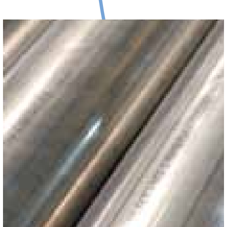
**For a table of alloys and their corresponding ASTM specifications, please see page 44. For information on alloys and their corresponding ASME specifications, please contact your RathGibson representative.*

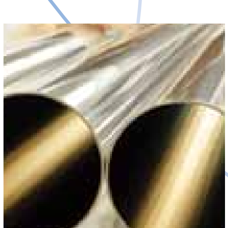
General Product Specifications

ASTM	ASME
A450	SA450
A999	SA999
A1016	SA1016
B751	SB751
B775	SB775
B829	SB829









Barlow's Formula for Calculating Burst Pressures

The ASTM tubing specifications do not include any recommended service pressure or any elevated temperature pressure requirements. However, throughout the tubing and pipe industry, Barlow's Formula is commonly used to estimate the theoretical internal room temperature burst pressure of the tubing.

Simply stated, Barlow's Formula is:
$P = 2St/OD$

Where:
P = Burst pressure, psi

S = Tensile strength of material, psi
(75,000 psi for types 304 & 316)

t = Wall thickness, inches

OD = Outside diameter, inches

Specific burst pressure technical guides are available. Please contact your RathGibson representative.

Pipe Weight in Pounds Per Foot (304 normalized) and Size Range

		Pipe Schedules				
NPS inches	OD inches	5	10	40	80	160
1/8	0.405	–	0.189 @ 0.049"	*0.249 @ 0.068"	*0.319 @ 0.095"	–
1/4	0.540	–	0.334 @ 0.065"	*0.430 @ 0.088"	*0.542 @ 0.119"	–
3/8	0.675	–	0.429 @ 0.065"	*0.575 @ 0.091"	*0.748 @ 0.126"	–
1/2	0.840	0.545 @ 0.065"	0.680 @ 0.083"	*0.862 @ 0.109"	*1.10 @ 0.147"	*1.32 @ 0.187"
3/4	1.050	0.693 @ 0.065"	0.868 @ 0.083"	1.15 @ 0.113"	*1.52 @ 0.157"	*1.96 @ 0.218"
1	1.315	0.879 @ 0.065"	1.42 @ 0.109"	1.70 @ 0.133"	*2.20 @ 0.179"	*2.88 @ 0.250"
1-1/4	1.660	1.12 @ 0.065"	1.83 @ 0.109"	2.30 @ 0.140"	3.04 @ 0.191"	–
1-1/2	1.900	1.29 @ 0.065"	2.11 @ 0.109"	2.57 @ 0.145"	3.68 @ 0.200"	–
2	2.375	1.63 @ 0.065"	2.67 @ 0.109"	3.7 @ 0.154"	5.09 @ 0.218"	–
2-1/2	2.875	1.98 @ 0.083"	3.58 @ 0.120"	5.87 @ 0.203"	–	–
3	3.500	3.07 @ 0.083"	4.39 @ 0.120"	8.01 @ 0.226"	–	–
3-1/2	4.000	3.52 @ 0.083"	5.04 @ 0.120"	9.23 @ 0.226"	–	–

Stock Lengths: 20 or 21 feet depending on alloys. Other lengths available.
Weight (lbs/ft) = 10.78 (D-t) t
Where: D = Outside diameter, inches
t = Minimum wall thickness, inches

* Welded & Drawn or Seamless only size.

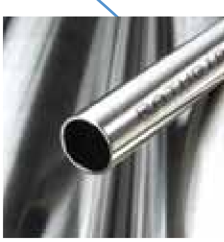
Pipe Weight in Kilograms Per Meter (304 normalized) and Size Range

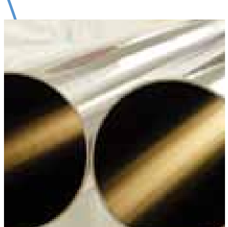
		Pipe Schedules				
NPS inches	**OD inches**	**5**	**10**	**40**	**80**	**160**
1/8	0.405	–	0.281 @ 0.049"	*0.370 @ 0.068"	*0.475 @ 0.095"	–
1/4	0.540	–	0.498 @ 0.065"	*0.642 @ 0.088"	*0.808 @ 0.119"	–
3/8	0.675	–	0.640 @ 0.065"	*0.857 @ 0.091"	*1.116 @ 0.126"	–
1/2	0.840	0.813 @ 0.065"	1.014 @ 0.083"	*1.286 @ 0.109"	*1.644 @0.147"	*1.970 @ 0.187"
3/4	1.050	1.033 @ 0.065"	1.295 @ 0.083"	1.708 @ 0.113"	*2.262 @ 0.157"	*2.926 @ 0.218"
1	1.315	1.311 @ 0.065"	2.121 @ 0.109"	2.536 @ 0.133"	*3.281 @ 0.179"	*4.296 @ 0.250"
1-1/4	1.660	1.673 @ 0.065"	2.728 @ 0.109"	3.433 @ 0.140"	4.527 @ 0.191"	–
1-1/2	1.900	1.924 @ 0.065"	3.150 @ 0.109"	4.106 @ 0.145"	5.485 @ 0.200"	–
2	2.375	2.422 @ 0.065"	3.985 @ 0.109"	5.518 @ 0.154"	7.586 @ 0.218"	–
2-1/2	2.875	3.739 @ 0.083"	5.334 @ 0.120"	8.751 @ 0.203"	–	–
3	3.500	4.576 @ 0.083"	6.544 @ 0.120"	11.938 @ 0.226"	–	–
3-1/2	4.000	5.245 @ 0.083"	7.512 @ 0.120"	13.761 @ 0.226"	–	–

Weight (kg/m) = 0.0250(D-t)t
Where: D = Outside diameter, millimeters
t = Minimum wall thickness, millimeters

* Welded & Drawn or Seamless only size.

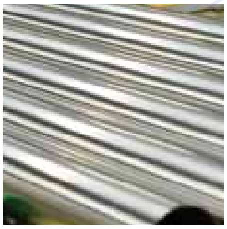
Physical Properties of Alloys in the Annealed Condition at -20°F to +100°F





Alloys	UNS Designation	ASTM Specification	Tensile Strength (min.)	
			MPa	ksi
304	S30400	A249 A312	515	75
304L	S30403	A270 A312	485	70
304H	S30409	A249 A312	515	75
304N	S30451	A249	550	80
304LN	S30453	A249, SA249, A688, SA688	515	75
316	S31600	A249 A312	515	75
316L	S31603	A270 A312	485	70
316H	S31609	A249	515	75
316LN	S31653	A249 A312	515	75
317	S31700	A249 A312	515	75
317L	S31703	A249 A312	515	75
309S	S30908	A249 A312	515	75
309H	S30909	A249	515	75
310S	S31008	A249 A312	515	75
310H	S31009	A249 A312	515	75
321	S32100	A249	515	75
321H	S32109	A249	515	75
347	S34700	A249 A312	515	75
347H	S34709	–	515	75
Duplex 2205	S32205	A789 A790	655	95
Duplex 2205	S31803	A789 A790	620	90
Lean Duplex 19D	S32001	A789 A790	620	90
Super Duplex 2507	S32750	A789 A790	800	116
Lean Duplex 2003	S32003	A789 A790	690	100
Lean Duplex 2101	S32101	A789 A790	650	94

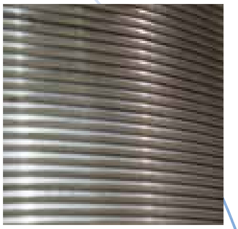
†Hardness values adjusted to comply with MR-0175 ‡Annealed Condition



Yield Strength 0.2% Offset (min.)		Elongation in 2 inches (min.)	Grain Size Requirement	Max Hardness	Modulus of Elasticity (x10⁶ psi)	Mean Coefficient of Thermal Expansion (in/in/°F x 10⁻⁶)	Thermal Conductivity (BTU-in/ft²-hr-°F)
MPa	ksi	%					
205	30	35	–	90 Rb	28.0	9.2	116
170	25	35	–	90 Rb	28.0	9.2	116
205	30	35	7 or coarser	90 Rb	28.0	9.2	116
240	35	30	–	90 Rb	28.4	–	–
205	30	35	–	90 Rb	28.0	9.2	116
205	30	35	–	90 Rb	28.0	9.2	116
170	25	–	–	90 Rb	28.0	9.2	116
205	30	–	7 or coarser	90 Rb	–	–	–
205	30	35	–	90 Rb	–	9.2	116
205	30	35	–	90 Rb	28.0	9.2	116
205	30	35	–	90 Rb	28.0	9.2	116
205	30	35	–	90 Rb	29.0	9.2	116
205	30	35	6 or coarser	–	29.0	9.2	–
205	30	35	–	90 Rb	29.0	9.2	116
205	30	35	6 or coarser	90 Rb	29.0	9.2	116
205	30	35	–	90 Rb	29.0	9.2	–
205	30	35	7 or coarser	90 Rb	29.0	9.2	–
205	30	35	–	90 Rb	28.0	9.2	116
205	30	35	7 or coarser	90 Rb	28.0	9.2	–
485	70	25	–	28 Rc 30.5† Rc	27.5	7.6	180
450	65	25	–	28 Rc 30.5† Rc	27.5	7.6	180
450	65	25	–	30 Rc	–	7.6	180
550	80	15	–	32 Rc	27.5	7.2	98
485	70	30	–	28 Rc	27.5	7.2	120
530	77	30	–	30 Rc	27.5	7.6	180

*for 0.049" average wall

Physical Properties of Alloys in the Annealed Condition at -20°F to +100°F *continued*



Alloys	UNS Designation	ASTM Specification	Tensile Strength (min.)	
			MPa	ksi
Lean Duplex 2304 OD = 1" & under	S32304	A789 A790	690	100
Lean Duplex 2304 OD > 1"	S32304	A789 A790	600	101
Super Duplex 100	S32760	A789 A790	–	109
20	N08020	B464 B468	551	80
200	N02200	B725 B730	308[‡]	55
201	N02201	B725 B730	345	50
276	N10276	B619 B626	690	100
400	N04400	B725 B730	480[‡]	70
600	N06600	B516 B517	550	80
22	N06022	B619 B626	690	100
625 GR 1 (Annealed)	N06625	B704 B705	827	120
625 GR 2 (Solution Annealed)	N06625	B704 B705	690	100
686	N06686	B619 B626	690	100
59	N06059	B619 B626	690	100
6XN	N08367	B675	690	100
254	S31254	A249 A312	675	98
825	N08825	B704 B705	586	85
904L	N08904	A249 A312	490	71
904L	N08904	B673 B674	490	71
800	N08800	B514 B515	520	75
800H	N08810	B514 B515	450	65
N08811	N08811	B514 B515	450	65
29-4C	S44735	A268	515	75
S44627	S44627	A268	450	65
439	S43035	A268	415	60
444	S44400	A268	415	60
446	S44660	A268	–	85

[†]Hardness values adjusted to comply with MR-0175 [‡]Annealed Condition

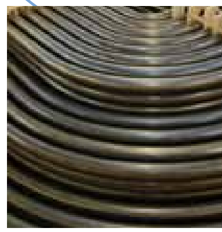
Yield Strength 0.2% Offset (min.) MPa	Yield Strength 0.2% Offset (min.) ksi	Elongation in 2 inches (min.) %	Grain Size Requirement	Max Hardness	Modulus of Elasticity (x10⁶ psi)	Mean Coefficient of Thermal Expansion (in/in/°F x 10⁻⁶)	Thermal Conductivity (BTU-in/ft²-hr-°F)
450	58	30	–	28 Rc 30.5† Rc	27.5	7.6	180
400	58	30	–	28 Rc 30.5† Rc	27.5	7.6	180
–	80	25	–	31 Rc	–	7.5	156
241	35	30	–	–	28.0	8.3	148
105‡	15	35‡	–	–	30.0	7.4	533
80	12	35‡	–	–	30.0	7.4	533
283	41	40	–	–	29.8	6.8	67.9
195‡	28	35‡	–	–	26.0	7.7	168
240	35	30	–	–	30.0	6.9	103
310	45	45	–	–	30.3	6.7	118
414	60	30	–	–	30.0	7.1	68
276	40	30	–	–	30.0	7.1	68
310	45	45	–	–	30.0	6.7	118
310	45	45	–	–	30.5	6.7	118
310	45	30	–	–	28.3	8.5	116
310	45	40	–	96 Rb	28.0	8.5	90
240	35	30	–	–	28.0	7.7	77
215	31	35	–	90 Rb	28.0	8.5	79
215	31	35	–	–	–	8.5	79
205	30	30	–	–	–	7.9	80
170	25	30	5 & coarser	–	–	7.9	80
170	25	30	5 & coarser	–	–	7.9	80
415	60	10*	–	100 Rb	28.0	5.2	119
275	40	12*	–	95 Rb	29.0	5.2	116
205	30	20	–	90 Rb	29.0	5.6	168
275	40	12*	–	100 Rb	–	7.7	186
–	–	12*	–	25 Rc	–	5.2	119

*for 0.049" average wall

Composition (%) of Austenitic Stainless Steel Alloys

Grade	304	304L	304H	304N	304LN	316	316L
UNS Designation	S30400	S30403	S30409	S30451	S30453	S31600	S31603
Carbon (C) Max.	0.08	0.030*	0.04–0.10	0.08	0.030*	0.08	0.030*
Manganese (Mn) Max.	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Phosphorous (P) Max.	0.045	0.045	0.045	0.045	0.045	0.045	0.045
Sulphur (S) Max.	0.030	0.030	0.030	0.03	0.03	0.030	0.030
Silicon (Si) Max.	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Chromium (Cr)	18.0–20.0	18.0–20.0	18.0–20.0	18.0–20.0	18.0–20.0	16.0–18.0	16.0–18.0
Nickel (Ni)	8.0–11.0	8.0–12.0	8.0–11.0	8.0–11.0	8.0–11.0	10.0–14.0	10.0–14.0
Molybdenum (Mo)	–	–	–	–	–	2.00–3.00	2.00-3.00
Nitrogen (N)	–	–	–	0.10–0.16	0.10–0.15	–	–
Iron (Fe)	Bal.	Bal.	Bal.	–	–	Bal.	Bal.
Other Elements	–	–	–	–	–	–	–

* Maximum carbon content of 0.04% acceptable for drawn tubes; For A270 products, 0.035 is acceptable.
ASTM A249 UNS limits. Limits may differ in other specifications and do no reflect RathGibson purchase requirements.

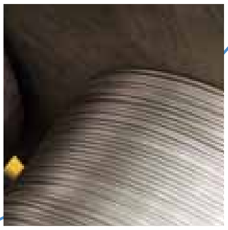


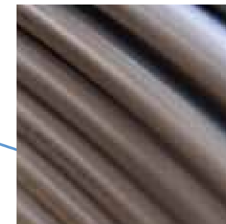
	317	317L	309S	309H	310S	310H	321	321H	347	347H
	S31700	S31703	S30908	S30909	S31008	S31009	S32100	S32109	S34700	S34709
	0.08	0.030*	0.08	0.04–0.10	0.08	0.04–0.10	0.08	0.04–0.10	0.08	0.04–0.10
	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
	0.04	0.04	0.045	0.045	0.045	0.045	0.04	0.04	0.04	0.04
	0.03	0.03	0.030	0.030	0.030	0.030	0.03	0.03	0.03	0.03
	1.00	1.00	1.00	1.00	1.00	1.00	0.75	0.75	0.75	0.75
	18.0–20.0	18.0–20.0	22.0–24.0	22.0–24.0	24.0–26.0	24.0–26.0	17.0–20.0	17.0–20.0	17.0–20.0	17.0–20.0
	11.0–14.0	11.0–15.0	12.0–15.0	12.0–15.0	19.0–22.0	19.0–22.0	9.0–12.0	9.0–12.0	9.0–13.0	9.0–13.0
	3.0–4.0	3.0–4.0	–	–	–	–	–	–	–	–
	–	–	–	–	–	–	0.1 Max.	0.1 Max.	–	–
	Bal.	Bal.	Bal.	Bal.	Bal.	Bal.	Bal.	Bal.	Bal.	Bal.
	–	–	–	–	–	–	Ti = 5(C+N) to 0.70%	Ti = 4(C+N) to 0.60%	Cb+Ta = 10 x C–1.10	Cb+Ta = 8 x C-1.10

Composition (%) of Duplex Stainless Steel Alloys

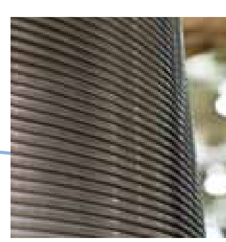
Grade	Duplex 2205	Lean Duplex 19D
UNS Designation	S31803/S32205†	S32001
Carbon (C) Max.	0.030	0.030
Manganese (Mn) Max.	2.00	4.0–6.0
Phosphorous (P) Max.	0.030	0.040
Sulphur (S) Max.	0.020	0.030
Silicon (Si) Max.	1.00	1.00
Chromium (Cr)	22.0–23.0	19.5–21.5
Nickel (Ni)	4.5–6.5	1.0–3.0
Molybdenum (Mo)	3.0–3.5	0.60
Nitrogen (N)	0.14–0.20	0.05–0.17
Iron (Fe)	Bal.	Bal.
Copper (Cu)	–	–
Other Elements	–	–

* Zinc Clad for Subsea Umbilical Tubing
† S32205 is the more restrictive chemistry and is shown
‡ PREN=% Cr + 3.3*% Mo + 16*% N

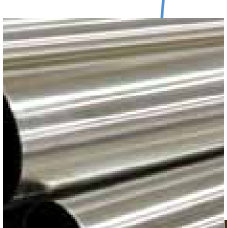




Lean Duplex 2003	Lean Duplex 2101	Lean Duplex 2304	Super Duplex 2507	Super Duplex 100
S32003	S32101	S32304	S32750	S32760
0.030	0.040	0.030	0.030	0.05
2.00	4.0–6.0	2.50	1.20	1.00
0.030	0.040	0.040	0.035	0.030
0.020	0.030	0.040	0.020	0.010
1.00	1.00	1.00	0.80	1.00
19.5–22.5	21.0–22.0	21.5–24.5	24.0–26.0	24.0–26.0
3.00–4.00	1.35–1.70	3.00–5.50	6.0–8.0	6.0–8.0
1.50–2.00	0.10–0.80	0.05–0.60	3.0–5.0	3.0–4.0
0.14–0.20	0.20–0.25	0.05–0.20	0.24–0.32	0.20–0.30
Bal.	–	Bal.	Bal.	Bal.
–	0.10–0.80 Max.	0.05–0.60 Max.	0.50	0.50–1.00
–	–	–	–	W 0.50–1.00, PREN≥40[‡]



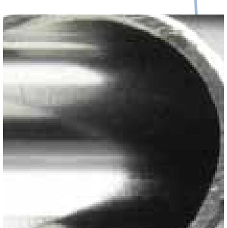
Composition (%) of Nickel Alloys



Grade	20	200	201
UNS Designation	N08020	N02200	N02201
Nickel (Ni)	32.0–38.0	99.0 Min. (Plus Cobalt)	99.0 Min. (Plus Cobalt)
Chromium (Cr)	19.00–21.00	–	–
Iron (Fe)	Bal.	0.40 Max.	–
Molybdenum (Mo)	2.00–3.00	–	–
Aluminum (Al) Max.	–	–	–
Cobalt (Co) Max.	–	–	–
Tungsten (W)	–	–	–
Vanadium (V) Max.	–	–	–
Copper (Cu) Max.	3.00–4.00	0.25	0.25
Manganese (Mn) Max.	2.00	0.35	0.35
Niobium (Nb) plus Tantalum (Ta)	8xC–1.00	–	–
Carbon (C) Max.	0.07	0.15	0.02
Nitrogen (N) Max.	–	–	–
Silicon (Si) Max.	1.00	0.35	0.35
Sulphur (S) Max.	0.035	0.01	0.01
Phosphorous (P) Max.	0.045	–	–
Other Elements	–	–	–

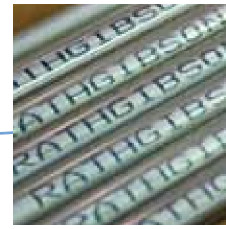
276	400	600	22	625	686	59
N10276	N04400	N06600	N06022	N06625	N06686	N06059
Bal.	63.0 Min. (Plus Cobalt)	72.0 Min. (Plus Cobalt)	Bal.	58.0 Min. (Plus Cobalt)	Bal.	Bal.
14.5–16.5	–	14.0–17.0	20.0–22.5	20.0–23.0	19.0–23.0	22.0–24.0
4.0–7.0	2.5 Max.	6.0–10.0	2.0–6.0	5.0 Max.	5.0 Max.	1.50
15.0–17.0	–	–	12.5–14.5	8.0–10.0	15.0–17.0	15.0–16.5
–	–	–	–	0.40	–	0.1–0.4
2.5	–	–	2.5	1.0	–	0.3
3.0–4.5	–	–	2.5–3.5	–	3.0–4.40	–
0.35	–	–	0.35	–	–	–
–	28.0–34.0	0.5	–	0.75	–	0.50
1.0	2.00	1.0	0.5	0.50	0.75	0.5
–	–	–	–	3.15–4.15	–	–
0.010	0.3	0.15	0.015	0.10	0.010	0.010
–	–	–	–	–	–	–
0.08	0.5	0.5	0.08	0.5	0.08	0.010
0.03	0.024	0.015	0.02	0.015	0.02	0.010
0.04	–	–	0.02	0.015	0.04	0.015
–	–	–	–	–	–	–

Composition (%) of Super Austenitics, Super Ferritics/Ferritics



Grade	6XN	254	825	904L	800
UNS Designation	N08367	S31254	N08825	N08904	N08800
Nickel (Ni)	23.5–25.5	17.5–18.5	38.0–46.0	23.0–28.0	30.0–35.0
Chromium (Cr)	20.0–22.0	19.5–20.5	19.5–23.5	19.0–23.0	19.0–23.0
Iron (Fe)	Bal.	Bal.	22.0 Min.	Bal.	39.5 Min.
Molybdenum (Mo)	6.00–7.00	6.0–6.5	2.5–3.5	4.0–5.0	–
Aluminum (Al) Max.	–	–	0.2	–	0.15–0.60
Cobalt (Co) Max.	–	–	–	–	–
Tungsten (W)	–	–	–	–	–
Vanadium (V) Max.	–	–	–	–	–
Copper (Cu) Max.	0.75	0.50 - 1.00	1.5–3.0	1.00–2.00	0.75
Manganese (Mn) Max.	2.00	1.00	1.0	2.00	1.5
Niobium (Nb) plus Tantalum (Ta)	–	–	–	–	–
Carbon (C) Max.	0.030	0.020	0.05	0.020	0.10
Nitrogen (N) Max.	0.18–0.25	0.18–0.25	–	0.10	–
Silicon (Si) Max.	1.00	0.80	0.5	1.00	1.00
Sulphur (S) Max.	0.030	0.010	0.03	0.035	0.015
Phosphorous (P) Max.	0.040	0.030	–	0.045	–
Other Elements	–	–	–	–	–

*N08811 Al + Ti 0.85 – 1.20
**(Ti + Cb) 0.20 – 1.00, & 6 (C+N) min
‡0.015 Max. for OD<0.500" and for T<0.049"
†Nickel & Copper



800H	N08811	29-4C	S44627	439	444	446	18 SR
N08810	N08811	S44735	S44627	S43035	S44400	S44600	–
30.0–35.0	30.0–35.0	1.00	$0.5^{\dagger}$	0.50	1.00	0.50 Max.	–
19.0–23.0	19.0–23.0	28.00–30.00	25.0–27.5	17.0–19.0	17.5–19.5	23.0–30.0	18.0
39.5 Min.	39.5 Min.	Bal.	Bal.	Bal.	Bal.	Bal.	–
–	–	3.60–4.20	0.75–1.50	0	1.75–2.50	–	–
0.15–0.60	0.15–0.60*	–	–	0.15	–	–	2.0
–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–
0.75	0.75	–	0.2	–	–	–	–
1.5	1.5	1.00	0.40	1.00	1.00	1.50 Max.	0.30
–	–	**	0.05–0.20	–	–	–	–
0.05–0.10	0.06–0.10	0.030	$0.01^{\dagger\ddagger}$	0.07	0.025	0.12 Max.	0.04
–	–	0.045	0.015	0.04	0.035	0.10–0.25	–
1.00	1.00	1.00	0.40	1.00	1.00	0.75 Max.	1.00
0.015	0.1015	0.030	0.02	0.030	0.030	0.03 Max.	–
–	–	0.040	0.02	0.040	0.040	0.04 Max.	–
–	–	–	–	–	–	–	–

Glossary

ANNEALING
The controlled process of heating and cooling a metal to achieve a reduction in hardness, remove stress, and to homogenize the material.

ASM (American Society for Materials International)
A professional society of Material Scientists and Engineers dedicated to the collection and distribution of information about materials and manufacturing processes.

ASME (American Society of Mechanical Engineers)
An organization of engineers dedicated to the preparation of design code requirements, and material and testing standards. Adopts, sometimes with minor changes, specifications prepared by ASTM. The adopted specifications are those approved for use under the ASME Boiler and Pressure Code and are published by ASME in Section II of the ASME Code. The ASME specifications have the letter "S" preceding the "A" or the "B", of the ASTM specifications. The "SA" series are for iron base materials, while the "SB" series are for other materials such as nickel base, copper, etc.

ASTM (American Society for Testing and Materials)
A body of industry professionals involved in writing universally accepted steel material and test specifications and standards. The "A" series of material specifications are for iron base materials, while the "B" series are for other materials such as nickel base, copper, etc.

AUSTENITE
A non-magnetic metallurgical phase having a face-centered cubic crystalline structure. Except for steel compositions having at least 6% nickel, austenite is typically only present at temperatures above 1333°F (723°C).

AUSTENITIC
These grades of stainless steels (300 Series plus some 200) have chromium (roughly 18% to 30%) and nickel (roughly 6% to 20%) as their major alloying additions. They have excellent ductility and formability at all temperatures, excellent corrosion resistance, and good weldability. In the annealed condition they are nonmagnetic. Some have the ability to be hardened by cold rolling as a final step. These grades are usually non-magnetic and are used for applications requiring good general corrosion resistance such as food processing, chemical processing, kitchen utensils, pots and pans, brewery tanks, sinks, wheel covers and hypodermic needles.

BEND TEST
A test for determining relative soundness and ductility of a metal to be formed. The specimen is bent over a specified diameter through a specified angle. In welded tubing the weld is of primary interest.

BRIGHT ANNEALING
A heat treat process performed in a carefully controlled furnace atmosphere resulting in a clean, smooth, scale free metal surface. During typical annealing, the heated steel combines with oxygen in the air to form an oxide layer on the steel's surface. In bright annealing, the steel is heated in a furnace filled with gases, such as hydrogen or nitrogen, or in a vacuum, to prevent oxide scale formation. The material comes out of the bright anneal furnace with the same surface as it had when it went into the furnace. The process eliminates the need for the old fashioned acid bath pickling operations.

BURST PRESSURE
The internal pressure that will cause a piece of tubing to fail by exceeding the plastic limit and tensile strength of the material from which the tube is fabricated.

COLD SINKING
The process of pulling a tube through a carbide die to reduce the diameter of the tube. Small tubes with very high thickness-to-diameter ratios are commonly produced this way in long lengths. The sinking of the tube is done at room temperature (i.e.: "Cold").

CONCENTRICITY
Used to describe tubing where the center of its inside diameter is consistent with the center of its outside diameter resulting in no variation of wall thickness. By virtue of the fact that welded tubing is fabricated from precision rolled flat stock, concentricity is inherent with a roll-formed, welded tube.

DEBURRING
Removal of a small ridge of metal formed by upset during a machining or cutting operation.

DUPLEX STAINLESS STEELS
Stainless Steels exhibiting both austenitic and ferritic phases and characteristics.

DESTRUCTIVE TESTING
Any of the mechanical tests performed on an expendable sample of tubing to check physical properties. These tests include: tensile, yield, elongation, hardness, flare, flattening, bend and burst.

ECCENTRICITY
Opposite of concentricity, resulting in variations of wall thickness.

EDDY CURRENT TESTING
A nondestructive testing procedure which is a continuous process performed on the tubular products during fabrication and in final inspection. It is by nature an electrical test that utilizes fluctuations in magnetic field strength to check tubing (against a calibrated standard) for possible defects such as holes, cracks, gouges, etc. on both inside and outside surfaces of the tube. All eddy current testing at RathGibson is done in accordance with ASTM-E 426.

ELECTROPOLISHING
An electrochemical method of surface finish enhancement in which the metal to be polished is exposed to a suitable electrolyte, typically an acid solution, while a carefully controlled current is passed between the object and a cathode. The object to be polished is the anode, and polishing is accomplished through the uniform removal of surface metal that goes into solution. Surface finish roughness of less than 0.000,010-inch (10 micro-inch) is attainable.

FERRITE
A metallurgical phase of iron having a body-centered cubic crystalline structure. It is soft, magnetic, and less susceptible to certain corrosion cracking than austenite.

FERRITE NUMBER
A calculated value indicating the relative ability of a particular chemical composition of steel to form ferrite upon solidification from the molten state. The higher the ferrite number the higher the percent of ferrite formed. Several different ferrite number formulas have been developed and should not be interchanged.

FERRITIC STAINLESS STEEL
A magnetic grade of stainless steel having a microstructure consisting of ferrite, including some of the 200 and 400 series stainless steels. Hardness can be increased slightly by cold work, but not by heat treatment. At lower temperatures ductility and formability is significantly less than that of austenitic grades. As the only major alloying element is chromium (10 to 30% depending on specific grade), these steels are relatively inexpensive to produce and are common in automotive exhaust and ornamental applications.

GAS TUNGSTEN ARC WELDING (GTAW)
An arc welding process that uses an arc between a tungsten electrode (nonconsumable) and the weld pool (base metal of strip). A high quality full fusion weld is achieved. The process can be performed with or without the addition of filler material. The GTAW process is also commonly referred to as Tungsten Inert Gas (TIG) welding.

HARDNESS
Resistance to deformation or indentation. Materials with little resistance are called soft; and those with high resistance are called hard. Finer grained structures are harder than larger grained structures. Measured in steel by scientific instruments as follows:

Brinell machine for sizes over 1/2" in diameter or thickness. Based on measurement of the diameter of the indentation of a standard size ball under a standard applied load.

Rockwell machine for sizes under 1/2" in diameter or thickness. Based on a measurement of the depth of penetration of a standard indentor under a standard applied load.

"B" scale-for soft materials such as brass, stainless steel (1/8" ball @ 100Kg load)

"T" scale-for very thin (<0.040" thick) soft materials that normally use the "B" scale (1/16" ball @ 15, 30 or 45 Kg load)

"C" scale-for harder materials such as high strength steel, tool steel, duplex stainless steel, martensitic and precipitation hardening stainless steel (diamond @ 150 Kg load)

"N" scale-for very thin (<0.040") harder materials that normally use the "C" scale (diamond @ 15, 30 or 45 Kg load)

Hardness correlates well with strength; since harder materials are stronger.

HEAT
A steel lot produced by a furnace with one chemical composition. Steel melting is a batch process and each batch is a heat. Also known as a melt of steel. In austenitic stainless steels a heat is typically about 200,000 pounds of material, and will yield approximately 8 coils of 25,000 pounds each. Nickel base materials are typically melted in heats of 10,000 to 50,000 pounds, yielding 2 to 5 coils of 5,000 to 25,000 pounds each.

HEAT NUMBER
An identifying number assigned to the product of one melting (e.g.: 721299).

HUEY TEST
A corrosion test for evaluating intergranular corrosion resistance by boiling in refluxed 65% nitric acid for five consecutive 48-hour periods, each period starting with fresh acid. The weight of metal lost is converted into loss in ipy (inches per year) or ipm (inches per month). ASTM-A262 Practice C.

HYDROSTATIC TESTING
A nondestructive test procedure that checks for holes, cracks or porosity. Tubing is pressurized internally with water to a high pressure, but does not exceed material yield strength.

ID
Inside diameter of a tubular product. It is also known as the opening or bore of a tube or pipe.

INTERGRANULAR CORROSION
Corrosion that occurs at the grain boundaries in austenitic stainless steels that have been heated to and held at temperatures between 850° F and 1450° F. Slow cooling through this range can also result in sensitization to intergranular corrosion. Usually caused by precipitation of chrome carbides.

ISO (International Organization for Standardization)
Prepares specifications. Both Canada and the U.S.A. are ISO members and participate in the ISO specification development.

KSI
Common engineering abbreviation for thousands of pounds per square inch. A measurement of stress in a material.

LASER BEAM WELDING (LBW)
A fusion joining process that produces coalescence of materials with the heat obtained from a concentrated beam of coherent, monochromatic light impinging on the joint to be welded. Generally an autogenous weld with no filler metal added.

LINE MARKING
A continuous strip of information that is printed with an inert ink along the longitudinal surface of the tube after final inspection. This data includes ASTM spec number, material identification, size and wall thickness, as well as a heat number identity. Full traceability is possible with any line marked product.

MEAN COEFFICIENT OF THERMAL EXPANSION
This is the amount that a material will 'grow' in size when subjected to a temperature rise. It is measured in inches/inch/°F. This number multiplied by the length of the tubing (in inches) and by the temperature rise (in °F) indicates how much the tube length will expand (in inches). If the temperature decreases, the tube will shrink by a similar amount.

MODULUS OF ELASTICITY
A ratio of stress to strain. Used in engineering calculations to determine rigidity and deflections. The higher the number, the more rigid the item will be for a given load. The units are in pounds per square inch (psi).

NiDI
Abbreviation for the Nickel Development Institute. A group of engineering professionals dedicated to the distribution

of information regarding the selection and application of nickel alloyed materials.

NONDESTRUCTIVE TESTING
See "Eddy Current Testing" or "Hydrostatic Testing".

OD
Outside diameter of a tubular product.

ORBITAL WELD
A circumferential, full fusion butt or girth weld used to join together two lengths of tubing. It is a GTAW welding process similar in nature to the longitudinal weld seam of a welded tubular product.

OVALITY
A quantitative measurement of how 'round' a tube is by comparing width to height. Limits are specified on the appropriate ASTM specification of a product.

OXIDATION
An electro-chemical reaction in which oxygen attacks a metal surface to form a metallic oxide, such as rust or the protective layer on stainless steel.

PASSIVATION
A protective layer of oxides on the surface of a metal, which resists corrosion. This passive oxide layer is the chief reason why stainless steels have such good corrosion resistant properties. It is a natural phenomenon, but can be accelerated by special passivating solutions that can be applied to tubular products by an optional process.

PROFILOMETER
An instrument that quantitatively measures surface roughness and reports height and/or depth of surface ridges.

RECRYSTALLIZATION
(1) Formation of a new, strain-free grain structure from that existing in cold worked metal, usually accomplished by heating (solution annealing of austenitic stainless steels). (2) The change from one crystal structure to another, as occurs when heating or cooling through a critical temperature. As in the change of an as-welded dendritic structure to an equi-axed grain structure, similar to that of the parent material.

REFLECTIVITY
A measure of the optical properties or "brightness" of a metallic surface expressed in terms of the percentage of the impinging illumination that is reflected back from that surface.

ROUGHNESS AVERAGE (Ra)
An expression of measured surface roughness or texture, typically, of a polished or machined metal surface. The arithmetic average value of the departure (peaks and valleys) of a surface profile from the center-line throughout the sampling length, generally expressed in micro-inch (0.000,001-inch) or micro-meter (or micron) (0.0003937-inch) units.

SCHEDULE, PIPE
A means of indicating the wall thickness of pipe sizes, as set forth in ASME B36.1 and ASTM A530 and B775. Commonly available pipe schedules are Schedules 5, 10, 20, 40, and 80. The actual wall thickness of a schedule number varies with the nominal pipe size or diameter (e.g.: 0.5" Sch 40 = 0.109" while 2" Sch 40 = 0.154"). A higher number schedule indicates a thicker wall for a particular pipe diameter.

SEAMLESS TUBING
Tubular product that is made by piercing or hot extrusion to form the tube hollows. Further reduction of the tube hollows is accomplished by cold drawing or tube reducing to the final finish and size. Initial steel billet or ingot is cast.

SPRINGBACK
The tendency of a material deformed under load to return to its original shape when the load is removed, like a rubber band returning to its unstretched condition when an applied load is released. Springback occurs in the elastic deformation regime, or at loads less than the yield strength of the material.

STAINLESS STEEL
The broad classification of iron-based alloys (50% minimum iron) containing at least 10% chromium that are known for their excellent corrosion and heat resistance. Other elements are also added to form alloys for special purposes, in addition to the corrosion resistance imparted by chromium. Some of these elements are: nickel for increased corrosion resistance, ductility and workability; molybdenum for increased corrosion resistance, particularly resistance to pitting, increased creep strength and high temperature strength; columbium and titanium for stabilization; sulfur and selenium for improved machinability.

STRESS CORROSION CRACKING
Catastrophic failure by generally intergranular cracking occurring in stainless steels and other metals. It is caused by combined action of a corrosive environment and stress, often without outward appearance of general corrosion attack.

TENSILE STRENGTH
A short form of "ultimate tensile strength". The maximum load per unit area that a material is capable of withstanding before it fails (pulls apart). Units are in psi.

TENSILE TESTING
A procedure used to determine the load at which a material will begin to plastically deform (the tensile yield strength) and ultimately at which it will break (the ultimate tensile strength). Resulting test values are a ratio of applied load (pounds) to cross-sectional area of the test sample (square inches) and are expressed in units of pounds per square inch (psi) or in metric units of megaPascals (MPa).

TIG (Tungsten Inert Gas)
A welding process that uses a non-consumable tungsten electrode to provide an electric arc to melt a work piece. Inert gases are used to shield the arc and the weld puddle to prevent oxidation during cooling. Used for heat exchanger, condenser and sanitary tubing.

TUBING DIMENSIONS
OD Outside Diameter
ID Inside Diameter
Wall thickness or gauge
All tube dimensions are specific; pipe dimensions are nominal.
Specific – actual measurement in inches
Nominal – theoretical or stated value of a dimension

ULTIMATE TENSILE STRENGTH
The stress in pounds per square inch (psi) that causes the material to fracture.

ULTRASONIC TESTING
The scanning of material with an ultrasonic beam, during which reflections from faults in the material can be detected: a powerful nondestructive test method.

WELD DECAY TEST
A corrosion test developed for the black liquor industries (pulp/paper, sugar refining) to detect susceptibility of stainless steel weldments to attack by boiling hydrochloric acid cleaning solutions. Test results are reported as a ratio of the change in thickness of the weld to the change in thickness of the base material. A ratio of 1.0:1 indicates no difference between weld and base metal. A ratio of 1.25:1 indicates that the weld thickness changed by 25% more than the base material did.

WELDED TUBING
Tubular products which are roll formed and then joined continuously along a longitudinal seam by a material fusion process. The process employed at RathGibson is Gas Tungsten Arc Welding (GTAW). See "Gas Tungsten Arc Welding" and "Laser Beam Welding" (LBW).

YIELD STRENGTH
The load per unit area that a material can withstand before permanent deformation (nonelastic) occurs. It is conventionally determined by a 0.2% offset from the modulus slope on a stress/strain diagram. Units are in psi and referenced to 0.2% offset in most literature.

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