TIMKEN

Where You Turn

Timken® Seamless Steel Tubing

Where You Turn

All around the world, customers like you turn to The Timken Company for innovation that moves them ahead of the competition. As the largest manufacturer of seamless alloy mechanical steel tubing in North America, we provide a wide array of solutions for a variety of industries, including aerospace, anti-friction bearings, automotive, construction equipment, defense, energy, farm machinery, machine tool, mining, rail and textile. Customers in these industries use our tubing to make finished steel components that help keep the world turning.

Timken® seamless mechanical steel tubing is produced in most standard carbon, alloy and intermediate alloy grades, as well as non-standard grades. Our approach to manufacturing integrates our melting, rolling, piercing and finishing operations and guarantees the finest quality control – from melt to finish. Available physical conditions include hot rolled and cold reduced, and our tubing can be supplied with a variety of annealing and hardening thermal treatments, including simultaneous outside diameter (OD) and inside diameter (ID) quenching.

Our tubing may be purchased in sizes recommended to clean up at finished part dimensions. This allows for optimum material utilization.

Because our vision is to create customer value through our knowledge of power transmission, we offer a broad selection of solutions beyond steel tubing. We also offer a complete line of precision steel components, from cut rings to finished assembly components and gearing components. Timken precision steel components are designed to meet your most demanding standards and tolerances to achieve optimum performance.

When you turn to Timken, you can expect more than just products. We leverage our global capabilities and over 100 years of technical expertise to generate new sources of value for customers. Using the combination of materials science, application engineering and processing capabilities, we are dedicated to improve customer performance. From manufacturing to warehousing to distribution, we offer you the value-added options you need for a competitive edge.

...For People

We have tremendous pride in our associates, and know that they are what makes Timken a recognized leader in the industry. Our highly-trained associates understand customer needs and use their metallurgical expertise to develop and deliver innovative steels that satisfy customer expectations.

...For Quality Management

Our quality management system drives us to better quality and cost, and ensures that our products meet the highest requirements. In fact, it keeps our products and processes on the edge of technology and has earned us both ISO 9001 and QS9000 registrations.

But our commitment to quality extends far beyond these distinctions. With over a century of experience in precision bearing manufacturing, we understand the critical role of quality steels

in the production of high-quality manufactured product. This knowledge enables us to effectively monitor the production of your steel during each stage of manufacturing to ensure it meets your specifications. This continual quality monitoring helps us recognize typical defects well before they ever reach final inspection…or the customer.

…For Research And Development

At Timken, one of our goals is to offer products that can be processed more effectively in our customers' plants. Our leadership position in research and development, our knowledge of manufacturing and our ability to anticipate and understand customer needs helps us achieve that goal every time.

Our wide range of in-house testing capabilities include:

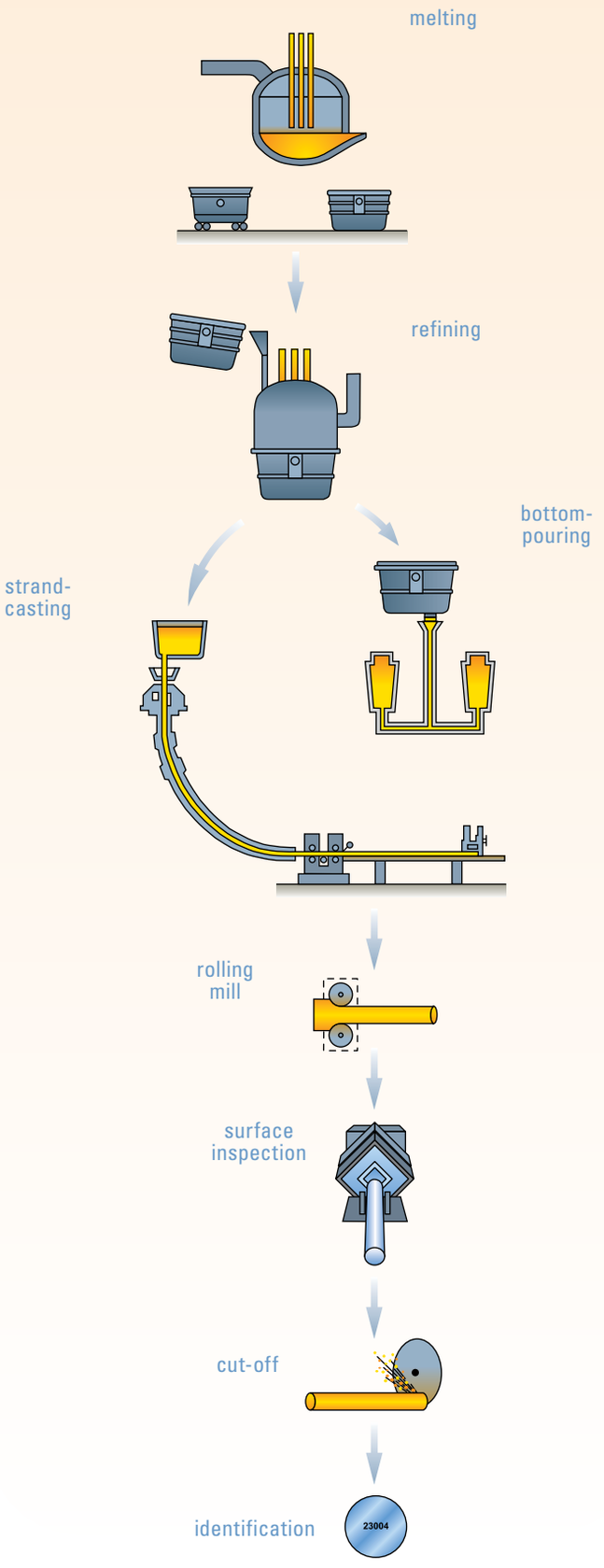
- Characterization of mechanical behavior.
- Characterization of how material processing history (temperature and forming, for instance) affects mechanical properties and component performance using the Gleeble Thermomechanical simulator.
- Characterization of material phases using X-ray techniques.
- Process simulation modeling capabilities and Finite Element Modeling.
- Unique characterization of material impurities using the proprietary Timken Ultrasonic Scanner.
- Definition of entire process stream requirements, including the customer.
- Definition of the effects of the process path history on mechanical, microstructural and fatigue characteristics.

For example, if given a cooling history from a customer's forming process, our technology experts can customize an alloy design to achieve both optimum machinability and mechanical properties…and costs.

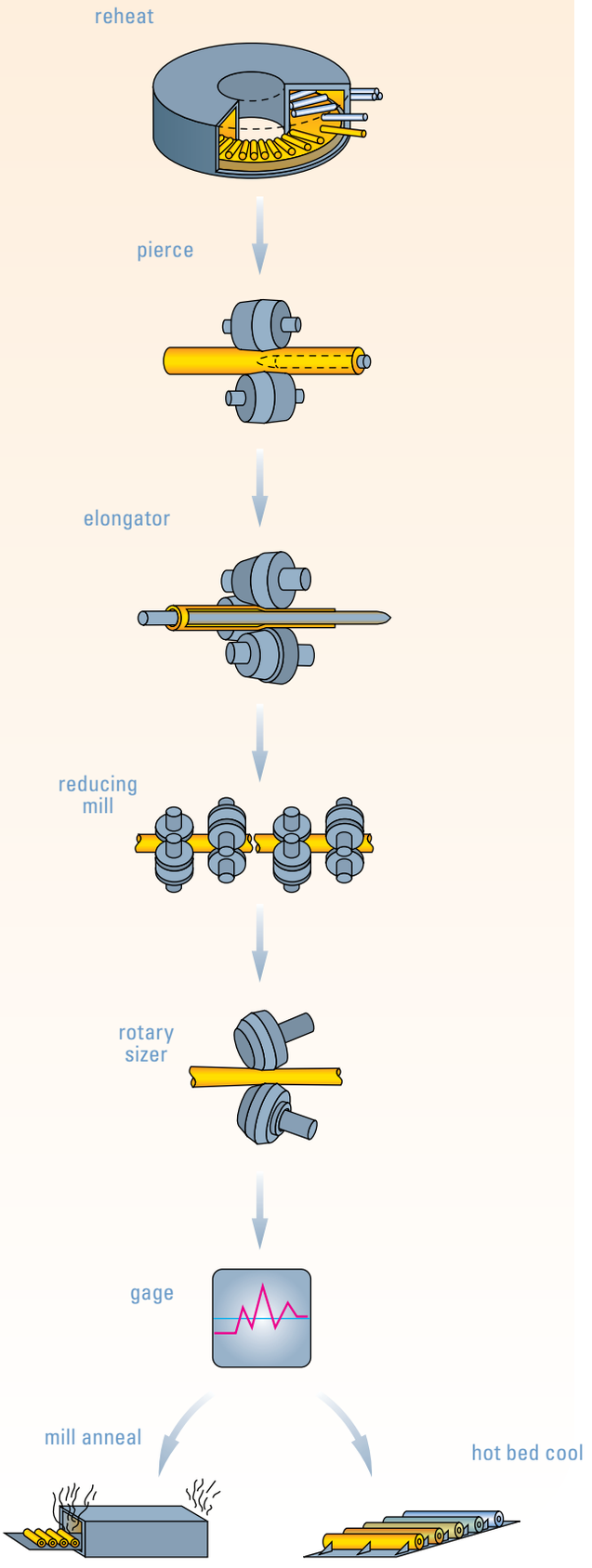
From Melt to Finish

Timken has the expertise to tailor every production heat to customer specification.

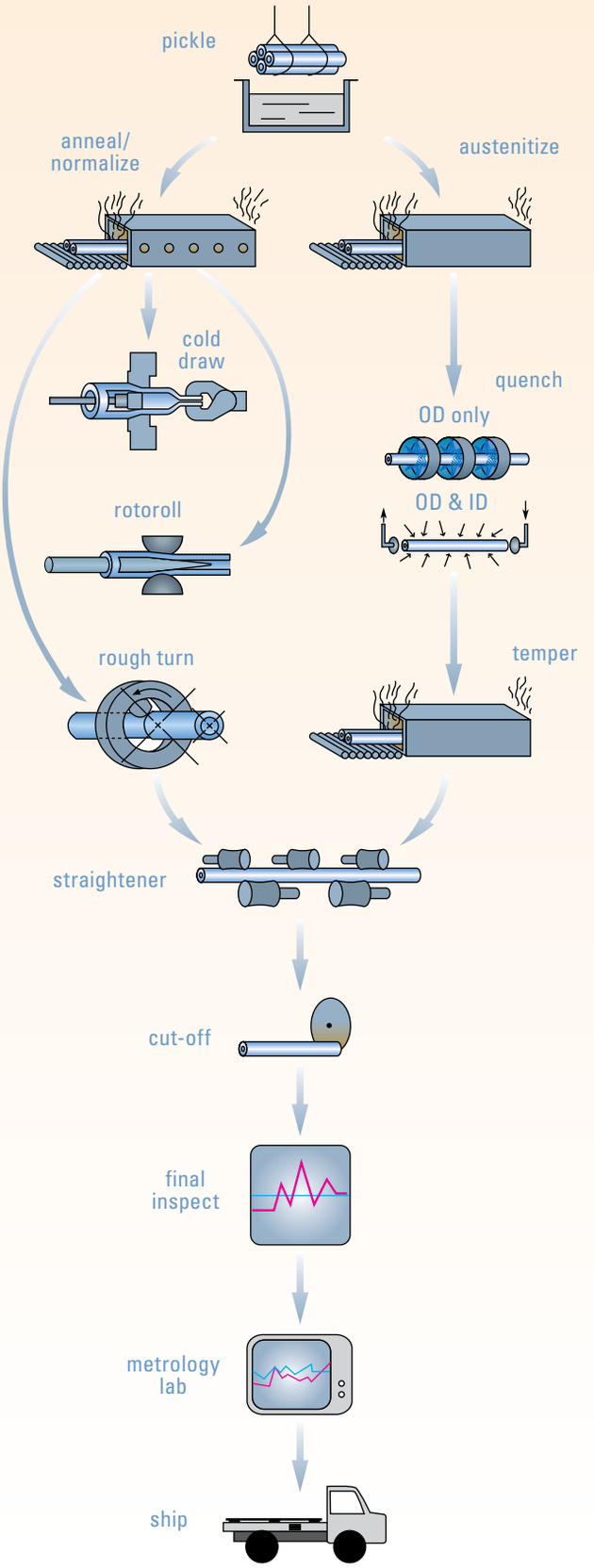
steel manufacturing



steel piercing



tube finishing



Markets We Serve

Automotive

More than 100 million motorists depend on our steel every day in the drivetrain of their vehicles. Timken® steel is most often used in critical automotive applications where high performance is required. As a high-volume carbon and alloy steel tubing manufacturer, we have the ability to deliver high-volume, quality steel for automotive production.

Our steel can be found in bearings, gears, shafts, sleeves, collars, hubs, axles, constant velocity joints, torque converters, one way clutch assemblies and other transmission, transfer-case and driveline applications. In addition, we are a leading producer of crankshaft steels and precision steel components – such as precision cut tubing, green machined components and finished parts produced from Timken tubing.

Bearing

Timken began making steel in 1917 to serve the unmet quality needs of the bearing market. Today, we continue to lead the way by offering the largest variety of bearing materials in the industry, designed to meet the most demanding application requirements. As a value-added service, we also warehouse a variety of tube sizes at our Tryon Peak facility in Columbus, N.C. to better meet our customers' requirements.

Distribution

Our global Authorized Distribution Network includes more than 300 locations in North America and supplies the broadest range of carbon and alloy steel tubing available. By providing these products through a distribution network, we support the material and maintenance requirements of a wide variety of end users.

Energy

Our steel is designed to withstand the hostile environment beneath the surface of the earth. We specialize in making corrosion-resistant alloy tubing for applications involving oil and gas exploration and production. This includes long length tubing and heavy wall drill pipe.

In particular, Timken's Impact™ series of steel grades provide durable solutions for harsh operating environments. The strength and toughness of these grades result in longer component life and dependability. Tailored specifically for down-hole applications, the family of Impact steels meets or exceeds the requirements of the National Association of Corrosion Engineers (NACE) standard.

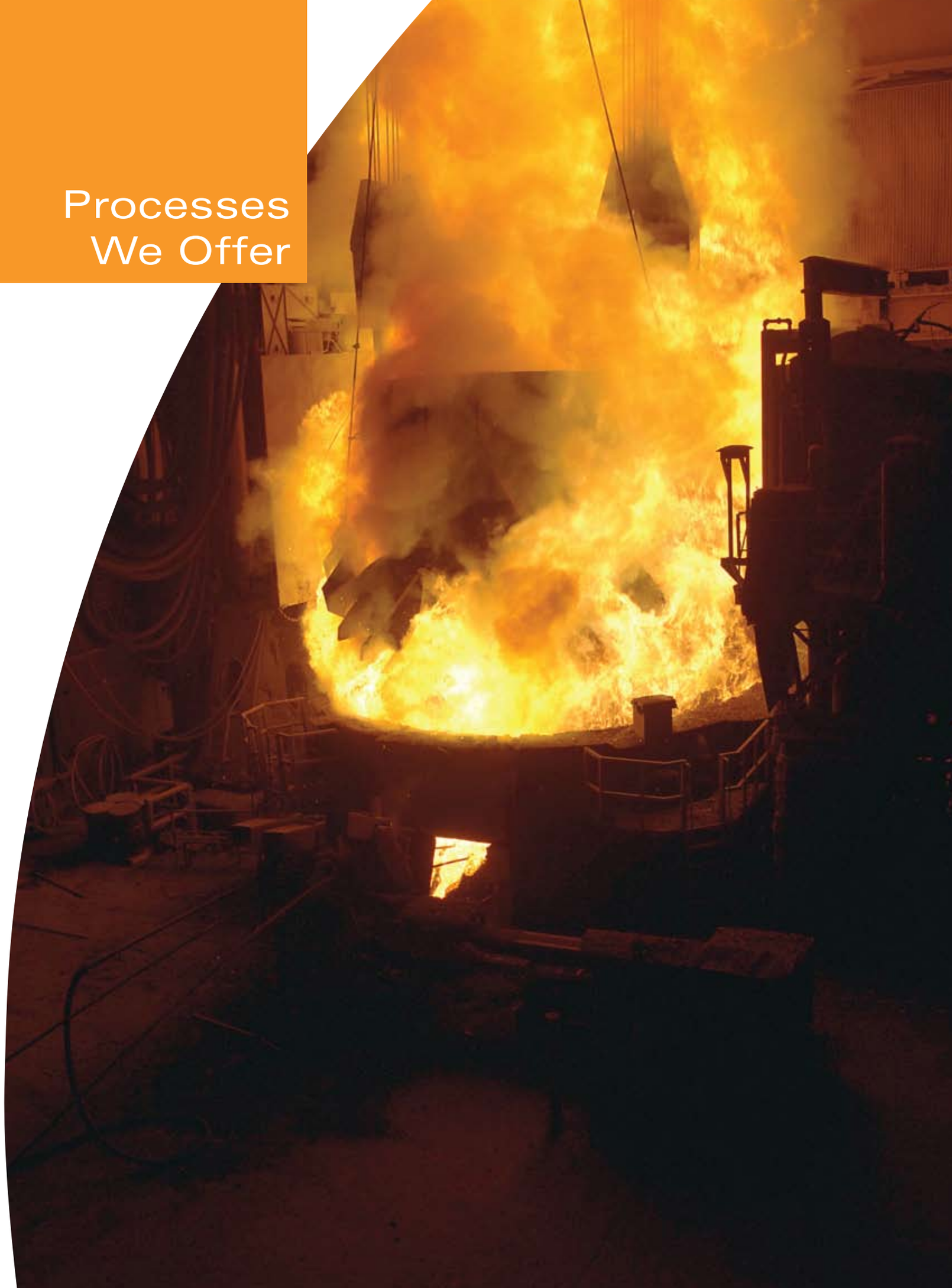
Other applications where you will find Timken steel include drill collars, drill bits and tool joints in the drill string, along with packers, gas lift mandrels and blast joints in the production string.

Industrial

We make steel tubulars for a variety of industrial applications where performance is critical. Applications include heavy wall hydraulic cylinders, hollow shafts, bearings, gears, auger drive shafts, collars, piston pins, military gun barrels, missile body housings, and a variety of other annular shaped components.

With over 300 different grades of steel, our manufacturing flexibility allows us to produce many grades in smaller quantities(determined at the time the order is placed). This includes cold-drawn tubing with unique geometrical cross-sections, such as rectangular, hexagonal, or oval ID or OD.

Processes We Offer



PRIMARY PROCESSES

HOT ROLLING

Hot rolled tubing has a surface finish comparable to hot rolled bars, plates or sheets of equal thickness. Light mill oxide covers both the outside and inside surfaces. Hot rolled tubing can be produced to outside diameter and wall dimensions with stated tolerances.

When a quotation for this highly specialized product is requested, we work closely with the customer to gain as much knowledge as possible about the end use. This enables us to apply materials with optimum dimensions to reduce costs.

COLD DRAWING

Cold drawn tubing is produced from hot rolled tubes that have been carefully inspected and properly surface-conditioned. Cold drawing consists of pulling a tube through a die and over a mandrel, reducing the diameter and wall thickness. Tubing is cold drawn for one or more of the following reasons: closer dimensional accuracy, better surface finish, smaller sizes than can be hot rolled, or to achieve certain mechanical properties. Cold working also imparts higher strength to the tubing and tends to improve machinability of carbon and lean-alloy steel.

ROTOROLLING® (Cold Pilgered)

Rotorolled tubing is produced from hot rolled tube shells that are conditioned for further reducing. Rotorolled tubes are produced on a machine designed to make large reductions of the cross-sectional area in one pass of the tube. The machine operates by cold swaging the tube between semicircular dies containing tapering grooves. The dies rock back and forth while the tube is advanced and rotated between rocking cycles over a long tapering mandrel. The developed contour of the die grooves forms a tapering circular pass that ends in a constant-diameter ironing section that establishes the OD of the finished tube.

Rotorolled tubing is a premium product with a surface condition superior to those obtained by cold drawing. Machinability is excellent. Dimensional tolerances are very uniform. Our ability to obtain large reduction ratios allows superior mechanical properties to be achieved.

Wall thickness of up to one-third of the outside diameter can be produced.

Timken hot rolling process

ROUGH TURNING

Turned tubing is produced by machining the outside surface of the hot rolled tubing. This process removes surface defects and decarburization from the outside, but the inside diameter surface retains the hot rolled finish. This is accomplished in a machine where the tools are mounted in a ring and rotated around the tube. The only motion of the tube is lateral, through the ring and past the rotating tools. Turned tubing is used extensively in automatic screw machines for manufacture into ball and roller bearing races and for special applications where advantages can be taken of the close outside tolerance or clean outside surface. Any hot rolled size up to 8 inches OD can be rough turned. Surface finish approaches 125 RMS or better.

THERMAL TREATMENT PROCESSES

ANNEALING

Annealing is heating uniformly to a temperature within or above the critical range and cooling at a controlled rate to a temperature under the critical range. This treatment is used to produce a definite microstructure, usually one designed for best machinability. It is also used to remove stresses; induce softness; and alter ductility, toughness or other mechanical properties.

HOT BED COOLING

This is the standard process of air cooling the tubing immediately following piercing on a special table or hot bed that continuously advances the tubing as additional tubes are finished. Tubing that is hot bed cooled may require additional thermal treatment to obtain optimum machinability or required mechanical properties.

MILL ANNEALING

Mill annealing is a controlled cooling of the tubing immediately following piercing which produces – in some low and medium carbon alloy grades – the optimum hardness and microstructure for machinability.

NORMALIZING

In this process, steel is heated uniformly to a temperature at least 99° F (37° C) above the critical range and cooling in air to room temperature. This treatment produces a recrystallization and refinement of the grain structure and gives the product uniformity in hardness and structure.

PROCESS TEMPERING

Process tempering is performed to improve subsequent fabrication of the material (machining, cold working, etc.). See Tempering.

QUENCHING (QUENCH HARDENING)

This processes heats steel uniformly to a temperature above the critical range and cools it rapidly in a liquid medium.

SPHEROIDIZE ANNEALING

This special type of annealing requires an extremely long cycle. Spheroidize annealing is used to produce a globular condition of the carbide and maximum softness for best machinability in some analyses or to maximize cold formability.

STRESS FREE

This designates tubing that has been hot rotary straightened. Minimal straightening stresses develop in hot rotary straightening, so stress relief tempering is not needed. Cold rotary straightening and stress relieving can substitute for hot rotary straightening.

STRESS RELIEVING

Stress relieving is a final thermal treatment used when stress-free material is desired. Its purpose is to restore elastic properties and minimize distortion on subsequent machining or hardening operations. This treatment is usually applied on material that has been heat treated (quenched and tempered). Normal practice is to heat to a temperature 99° F (37° C) lower than the tempering temperature used to establish mechanical properties and hardness.

TEMPERING

Tempering heats uniformly to a temperature under the critical range, holding at that temperature for a designated period of time and cooling in air. This treatment is used to produce one or more of the following end results:

- To soften material for later machining or cold working. Also referred to as a Process Temper.
- To improve ductility and relieve stresses resulting from prior treatment or cold working.
- To produce the desired mechanical properties or structure in the second step of a double treatment.

OTHER PROCESSES

COLD STRAIGHTENING

This process is used to achieve straightness tolerances by deflecting the product until plastic deformation occurs. Cold straightening may be achieved either on rotary straightening equipment or by press straightening.

CUT OFF

Cut off is used primarily to cut the tubing to the length required by the customer and to obtain metallurgical samples for testing required by the customer's specifications.

PICKLING

Pickling removes the scale formed on the surface of the tube during piercing or heat treatment by utilizing a chemical action in sulfuric acid. After the acid bath, the tubing is rinsed in water.

TESTING

Product testing includes eddy current (external surfaces), ultra-sonic(internal surfaces) and through-wall testing. Testing of material properties include hardness, strength, toughness and cleanness testing.

Glossary of Terms

Billet – *An intermediate as-rolled product that is rolled down to a smaller finished steel.*

Bloom – *The first stage of steel after bottom-pouring or strand-casting. After the bloom is rolled, it becomes a billet.*

Bottom Pour – *Filling an ingot mold from the bottom. This process minimizes reoxidation and reduces turbulence and flash. It also results in improved surface finish.*

Degassing – *Putting liquid steel in a vacuum before the teeming process to remove hydrogen gas.*

EAF furnace – *Electric arc furnace. In the EAF – which is Timken's primary melting vessel – steel scrap is melted by passing electricity through carbon electrodes.*

Elongator – *This machine fine-tunes the wall dimension of the rough shell coming from the piercer. This unit has three rolls that will control the OD of the tube shell while a mandrel is in the ID. With control of the OD and ID, a wall is made.*

Gaging – *Several different types of equipment are in place on the different tube mills to measure full length OD and wall of the hot rolled tube.*

Guaranteed Tubing Size (GTS) – *Based on the part's critical finished dimensions and critical machining position. Required critical dimensions are: 1) maximum finished OD, 2) minimum finished ID, 3) maximum finished part length and 4) contour length, or the length of the major OD or ID that has significantly larger OD or smaller ID than the rest of the part. Critical finished part dimensions and machining positions influence the amount of cleanup, the size tolerances and the tube eccentricity variables. These variables are then factored into the tube size calculation.*

Hardenability – *Ability of steel to harden to a specific depth. A steel's hardenability is controlled by the alloys contained within the steel.*

Ingot – *The steel form that is removed from the ingot mold.*

Piercer – *This is the heart of the tube mill, where a solid billet is made into a tube with rough OD and wall dimensions. The mill consists of two barrel rolls set at a feed angle that will pull the billet into the mill and rotary forge the steel over an internal tool to form the tube.*

Reducing Mill – *This unit steps the OD down to a near-final circumference. At this point, the shell is oval. The roll passes are cut in an oval shape to allow for adjustments to be made to size without causing surface defects.*

Refining – *A process step in which the steel is stirred to ensure homogenous temperature and chemistry. Heat and alloys can be added and degassing performed in this step.*

Reheat Furnace – *All mills are equipped with a rotary hearth furnace where the product is rotated through a number of heated zones. The furnace is equipped with control systems to automatically adjust furnace temperatures.*

Rotary Sizer – *This two roll machine applies light pressure to the OD of the tube while spinning it through the equipment. This will round up the tube from its previous oval shape.*

Scale-free – *The absence of loose scale on a hot finished tube, typically achieved through pickling or blasting.*

Straightener – *A two-roll or multi-roll machine that the tube is rotated through to ensure that the product meets the straightness tolerance specified by the customer. The tube is helically advanced by the rolls which are adjusted to bend the tube progressively as it moves through the machine. Initial bends and/or bows in the tube are removed, and a straight tube is produced.*

Strand Cast – *Another term for "continuous cast." A method of teeming in which steel is continuously cast directly into bloom form.*

Tapping – *The act of pouring liquid steel from the EAF into a ladle.*

Teeming – *The act of pouring liquid steel from a ladle into a mold or tundish.*

Tundish – *The vessel used to transfer steel from the ladle into a continuous cast mold.*

Rotary Forging

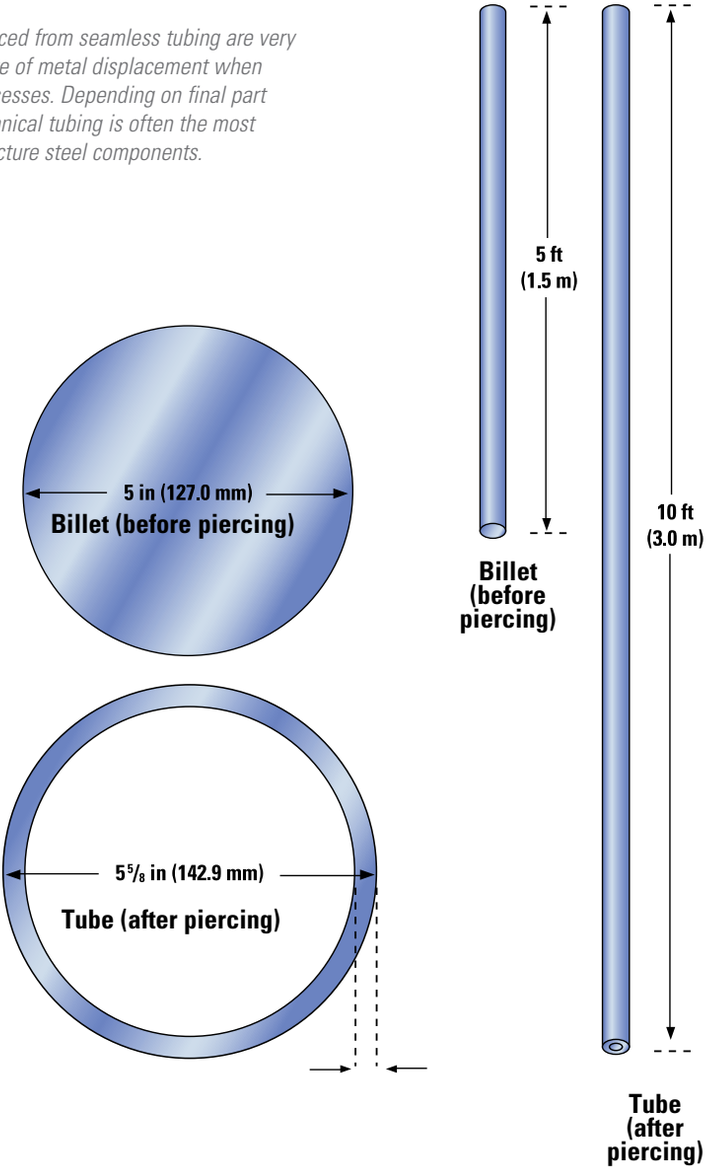
Piercing a seamless steel tube is a forging operation in which the metal is worked from the inside as well as the outside. The substantial amount of metal displacement, as the tube is pierced while spinning at a high RPM, results in a refined grain structure and uniform grain flow. At the same time, the steel fibers are given a slight spiral twist, which results in greater strength and ductility.

The tube making process includes four hot working operations:

1) The piercing of the billet, which produces a tube hollow at approximately .3 meters per second,
2) Elongating or plug mill rolling to establish the tube wall,
3) Rolling or sinking the tube to establish the approximate outer diameter and
4) Rounding and sizing the tube OD to decimal dimensions.

These operations are monitored to produce a tube with uniform properties from the surface through the wall and from one end to the other.

NOTE: The cost for parts produced from seamless tubing are very competitive due to the high rate of metal displacement when compared to other forging processes. Depending on final part configuration, seamless mechanical tubing is often the most economical method to manufacture steel components.



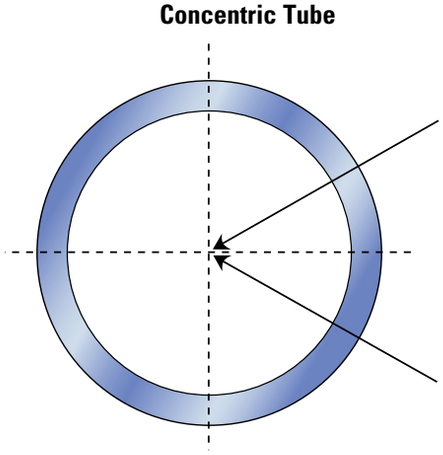
Tube Eccentricity

Seamless tubing is made by rotary piercing a solid round billet. In this rugged operation, it is rarely possible to center the hole exactly along the center line of the former billet OD. This characteristic is known as “eccentricity.” It is defined as the distance between the centers of the circles prescribed by the OD and ID. This eccentricity spirals through the tube and naturally occurs in all seamless tubing manufactured by rotary piercing.

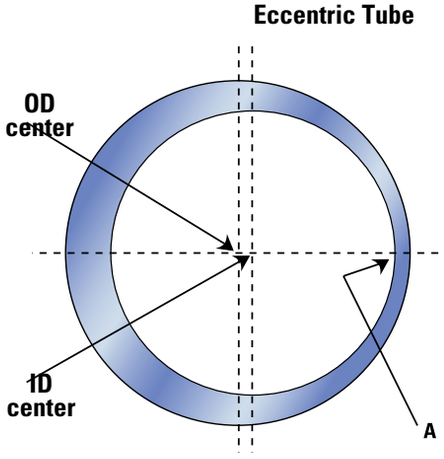
Only the wall thickness is affected by tube eccentricity. The theoretical or average wall thickness is reduced at any one point and the wall is increased by approximately an equal amount at the point directly opposite. This continuing effect is controlled by the manufacturing process, and is measured as a variation of the wall dimension with a plus or minus tolerance. This tolerance is customarily expressed as a percentage of the theoretical average wall.

This wall variation is one of several seamless tubing characteristics that influence the size of tube required to satisfactorily machine a part.

For assistance on how to design a tube size contact your Timken sales representative.



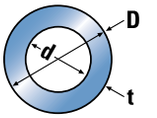
Tube cross section with center of OD and ID circles located at the same point. Wall thickness is the same at all points.



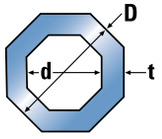
Tube cross section with center of OD and ID circles located at different points. Wall thickness light at A, heavy at opposite side.

Eccentricity in the diagram is greatly exaggerated. Maximum permissible eccentricity for most tubes is rarely apparent to the naked eye.

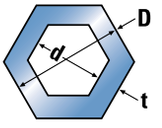
Seamless Steel Tubing Shapes



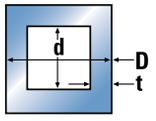
W = 10.68 (D - t) t
M = .02466 (D - t) t



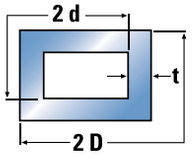
W = 11.27 (D - t) t
M = .02601 (D - t) t
eD = 1.027 D
ed = 1.027 d



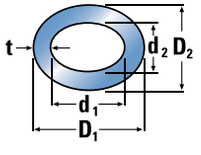
W = 11.78 (D - t) t
M = .02719 (D - t) t
eD = 1.050 D
ed = 1.050 d



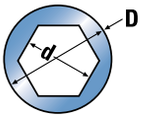
W = 13.60 (D - t) t
M = .03138 (D - t) t
eD = 1.128 D
ed = 1.128 d



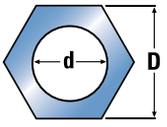
W = 13.60 (D - t) t
M = .03138 (D - t) t
eD = 1.128 D
ed = 1.128 d



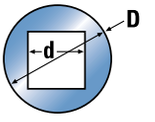
W = 5.34 ($D_1 + D_2 - 2t$) t
M = .01233 ($D_1 + D_2 - 2t$) t
eD = $\frac{D_1 + D_2}{2}$
ed = $\frac{d_1 + d_2}{2}$



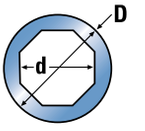
W = 10.68 (D - et) et
M = .02466 (D - et) et
et = $\frac{D - 1.050\ d}{2}$
ed = 1.050 d



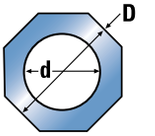
W = 10.68 (eD - et) et
M = .02466 (eD - et) et
et = $\frac{1.050\ D - d}{2}$
eD = 1.050 D



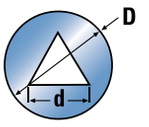
W = 10.68 (D - et) et
M = .02466 (D - et) et
et = $\frac{D - 1.128\ d}{2}$
ed = 1.128 d



W = 10.68 (D - et) et
M = .02466 (D - et) et
et = $\frac{D - 1.027\ d}{2}$
ed = 1.027 d



W = 10.68 (eD - et) et
M = .02466 (eD - et) et
et = $\frac{1.027\ D - d}{2}$
eD = 1.027 D



W = 10.68 (D - et) et
M = .02466 (D - et) et
et = $\frac{D - .7425\ d}{2}$
ed = .7425 d

legend

W = Weight in pounds per foot
M = Mass in kilograms per meter
D = Outside diameter or distance across flats in inches (or millimeters)
d = Inside diameter or distance across flats in inches (or millimeters)
t = Wall thickness in inches (or millimeters)
eD = Equivalent round outside diameter in inches (or millimeters)
ed = Equivalent round inside diameter in inches (or millimeters)
et = Equivalent wall thickness in inches (or millimeters)
D_1 = Major outside diameter of oval tube in inches (or millimeters)
d_1 = Major inside diameter of oval tube in inches (or millimeters)
D_2 = Minor outside diameter of oval tube in inches (or millimeters)
d_2 = Minor inside diameter of oval tube in inches (or millimeters)

We welcome your inquiries regarding any seamless steel tubing need. To get the fastest service and most value from your call, consider the following questions and be prepared to discuss your needs with your Timken customer care representative, call 1-866-2846536 or visit www.timken.com/products/alloysteel.

What Grade And Quality Do You Need?

The Timken Company produces more than 300 types of steel in quality levels including:
• Commercial • Electric Furnace • Bearing • Aircraft
• Parapremium • Consumable Electrode Vacuum Remelt (CEVM)

Which Finish Is Best For You?

You can choose from:
• Hot Rolled • Cold Drawn • Rotorolled • Rough Turned

Does Your Order Require Thermal Treatment?

We offer the following heat treatments or combinations thereof:
• Annealed • Tempered • Stress Relieved • Normalized
• Quenched and Tempered

What Tube Size Do You Need?

If you're not sure, we can calculate a size based on the size of your finished part and your machining parameters. (See GTS listed in glossary of term, page 11)

What Quantity Do You Need?

A minimum order is 10,000 pounds (4,545 kilograms), except for CEVM or polyethylene commodity products, which have a minimum order quantity of 5,000 pounds (2,270 kilograms). For foot weight over 100 pounds per foot, the minimum order is 20,000 pounds.

What Lengths Are Most Appropriate?

You can order random lengths, multiples or lengths cut to your specifications.

Do You Have Certain Specifications That Must Be Met?

All our steel is made to order, so we can meet your specifications, whether they are ASTM (American Society for Testing and Materials), AMS (Aerospace Material Specifications), MILS (Military Specifications) or any other specification.

What Is The Machining Sequence?

Is the part chucked on the OD or ID? Is it chucked at one or both ends?

What Type Of Cleanup Of OD And ID Do You Need?

• "Full cleanup" is the removal of all surface imperfections (seams, decarb, scale, etc.).
(See the warranty information on your order acknowledgement sheet).
• "Bright metal cleanup" is the removal of the as-supplied surface, but not necessarily

For information on sizes, grades and other value-added services, call 1-866-284-6536, Fax 330-471-7032 or visit our website at www.timken.com/products/alloysteel.

TIMKEN

Where You Turn

Bearings • Steel • Precision Components
Lubrication • Seals • Remanufacture and
Repair • Industrial Services

www.timken.com

2.5M 06-07-29 Order No. 4033