Pittsburgh Seamless STEEL MECHANICAL TUBING

PITTSBURGH STEEL CO.
PITTSBURGH, PA.

B302

Pittsburgh Seamless

STEEL MECHANICAL TUBING

PITTSBURGH STEEL COMPANY

Pittsburgh, Pennsylvania

NEW YORK DETROIT CHICAGO ST. LOUIS HOUSTON

TULSA CHARLOTTE LOS ANGELES SAN FRANCISCO

Seamless for Safety

THE SUPREMACY OF SEAMLESS

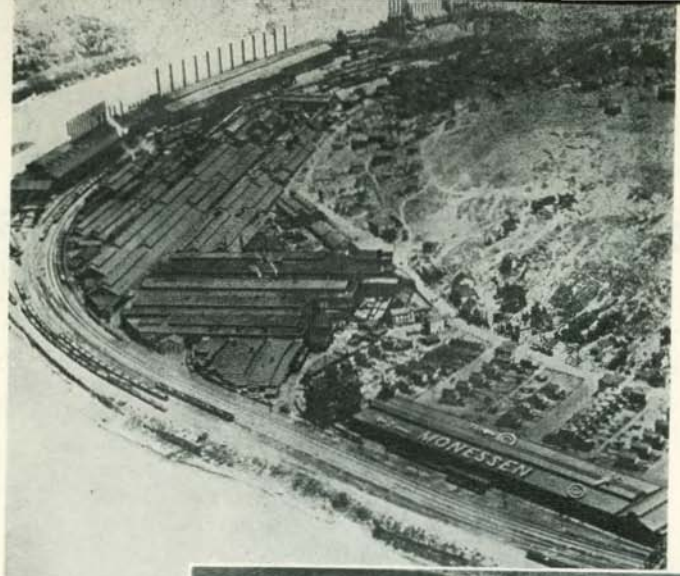
Seamless Steel Pipe and Tubes are pierced from solid billets of steel. This process is absolute assurance of homogeneous wall structure and uniform steel strength throughout. There are no seams, no welding processes to disturb the molecular structure of the metal, no points or zones of potential weakness. "Seamless" moreover can be made of steel of practically any desired strength and analysis.

The Seamless Tube is nature's own resource for light weight in relation to strength. Consider the stems of wheat, the bamboo, the bones of animals—maximum strength with minimum weight; all Seamless Tubes. There can be no compromise with perfection, and Seamless is the nearest approach to perfection in tubular steel products. Pittsburgh Seamless is the product of a pipe and tubing manufacturing organization that for more than thirty years has devoted its research and development to Seamless Steel Pipe and Tubes exclusively.

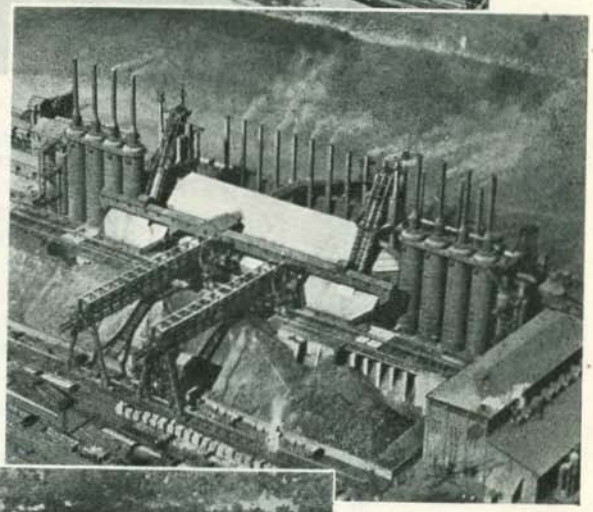
Although this volume is primarily a catalogue and data handbook for the finished products, we have included on the following pages a brief discussion of the steel making and seamless steel tube manufacturing processes in the belief that it will be interesting to many readers.

Note: For a complete list of products manufactured by Pittsburgh Steel Company, please see last page.

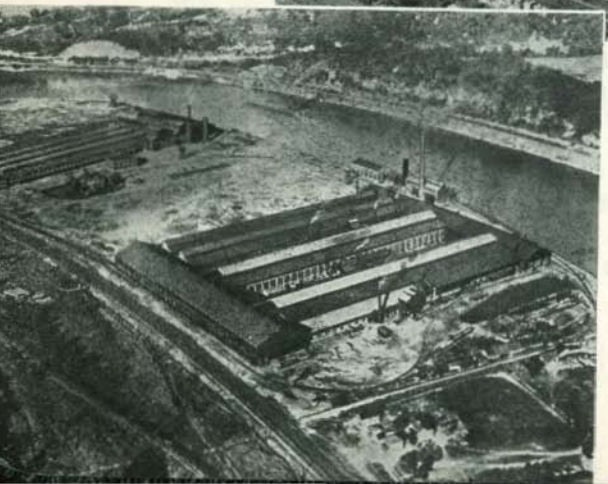
Seamless for Safety



Above: General view of Pittsburgh Steel Company's Monessen, Pennsylvania Works (Pittsburgh District), extending for more than a mile along the Monongahela River.



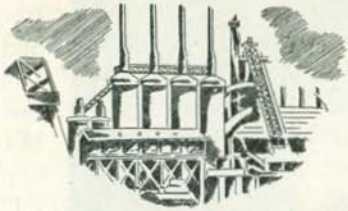
Center: A closeup of the huge blast furnaces.



Below: Allenport, Pennsylvania Works, a few miles up-river from the main plant at Monessen. Pittsburgh Seamless Steel Pipe and Tubes are the principal products of this mill.

In these plants Pittsburgh Steel and Wire Products are carried through all the stages of production, from the iron ore to finished material.

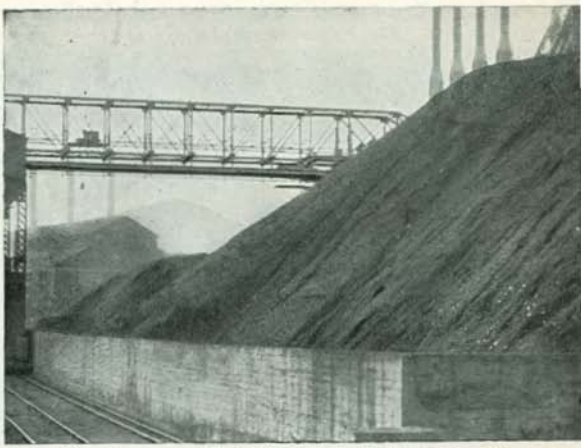
THE MANUFACTURE OF IRON and STEEL



MAKING IRON IN THE BLAST FURNACE

More than six tons of materials are charged into the pig-iron and steel-making furnaces to produce one ton of steel. Iron ore comes chiefly from Minnesota and Michigan. Limestone is quarried mostly in Pennsylvania, Ohio and Maryland. Coal, coming largely from the great Appalachian bituminous fields, is converted into steel-making coke. Dolomite, manganese, copper, aluminum and many other materials are also employed.

The necessary materials having been assembled, the first step in steel manufacture is the production of pig iron. Pig iron is made in 90-to 100-foot high



Ore storage yard at Pittsburgh Steel Company's Monessen works.

Pittsburgh Steel Company's Monessen Mine tipple on the Monongahela River. This is one of the Company's three mines in the Pittsburgh District.

Tapping a blast furnace. The stream at the right is slag. The long white stream is iron.

Iron not for immediate use is cast into pigs. The metal is poured from a ladle at the right.

blast furnaces into which are charged measured quantities of iron ore, coke (for fuel) and limestone (to separate the impurities from the iron). These materials are melted down under the intense heat of a pre-heated, oxygen-fed forced blast fire. Wastes and impurities from the ore combine to form a slag which separates from the molten iron, much as cream separates from milk, and is drawn from the furnace periodically. The remaining molten metal is then tapped out at the bottom of the furnace into large fire-brick-lined receptacles called "ladles." The time required for completing each blast furnace charge is about twelve hours. The capacity of Pittsburgh Steel Company's two blast furnaces is approximately 1,200 tons each 24-hour day.

If the molten pig iron is to be made promptly into steel it is taken in the ladles to a "hot metal mixer," or reservoir, where it is kept hot and drawn upon as required for charging into the steel-making furnaces. On the other hand, if the pig iron is to be stored for future use it is cast into small molds—or "pigs"— and cooled. These pigs weigh roughly 135 pounds each.

THE MANUFACTURE OF STEEL

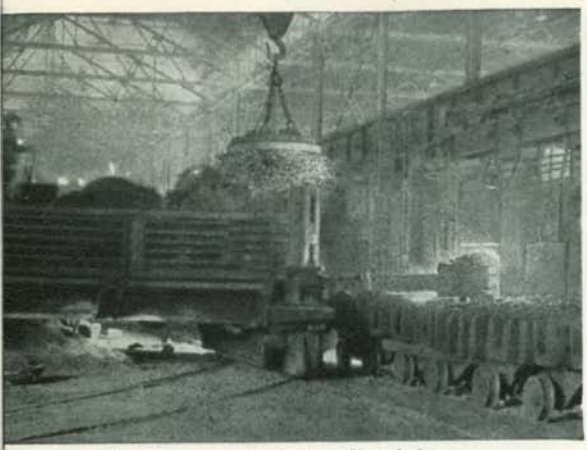
The next step is the further refining of pig iron, which in its crude state contains many impurities and an excess of such substances as carbon, silicon, manganese, phosphorus and sulphur. Also it lacks the toughness, ductility and tensile strength that come from repeated rolling, working and control of chemical content necessary to produce finished steel products.

In American steelmaking practice there are two chief methods of converting large tonnages of iron into steel—the *Acid Bessemer* process and the *Basic Open Hearth* process. *Acid* steel is steel that has been refined by oxidation alone, which removes carbon, silicon and manganese from the iron. *Basic* steel is steel that has been purified by oxidation plus the addition of a strong base, usually lime, to remove also phosphorus and sulphur. Although either *acid* or *basic* steel can be produced both by Bessemer and Open Hearth processes, the composition of iron ores available in the United States causes most American steels to be produced either by the *Acid Bessemer* or by the *Basic Open Hearth* process. Pittsburgh Steel Company employs only the Basic Open Hearth method.

Looking down the length of the open hearth building, Monessen Works. There are 12 furnaces here.

BASIC OPEN HEARTH STEEL

The Open Hearth furnace is a large rectangular bowl of 100-odd tons metal capacity, completely enclosed by brick walls of highly heat-resistant refractory brick. In making steel the pre-heated, dolomite lined bottom of this furnace is first covered with about



Charging scrap at an open hearth furnace.

Charging an open hearth furnace with molten iron.

Adding copper to a heat of steel in the open hearth.

21,000 pounds of limestone, which in turn is heated to a temperature of more than 3000° Fahrenheit.

Now comes the charging into the furnace of a fixed amount of selected scrap steel, which is subjected to full heat for about two hours, or until it is melted down to a thick liquid ready for admixture with hot iron from the blast furnace. Molten pig iron—about 50 tons of it—is then charged into the furnace where it mixes with the partly melted steel already there.

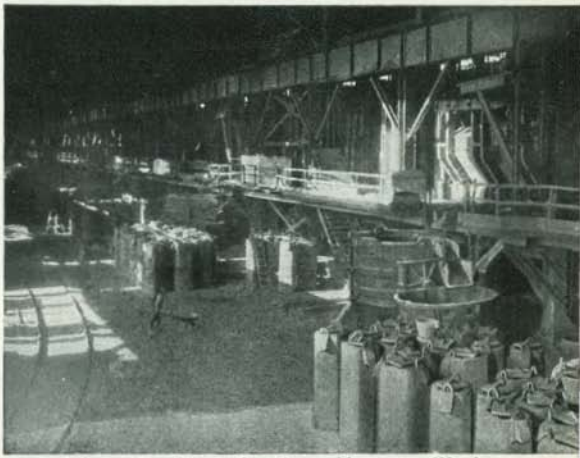
The heating in an open hearth furnace is done by combustion of pre-heated gas and pre-heated air forced into and through the furnace alternately from one side, then from the other. The residual heat in the burned gasses leaving the furnace is employed, by

this alternating process, for pre-heating the gas and air next entering the furnace.

With the charging completed the mass of metal inside the furnace undergoes a "lime boil" period for several hours, during which the limestone from the bottom of the furnace, calcined by the heat, moves slowly upward through and to the surface of the molten metal, purifying as it goes. When the calcined lime has reached the top, impurities from the iron have combined with it to form slag which floats on the surface.

Following the lime-boil period the heat is continued to the "working period," during which the greatest skill and experience are necessary to maintain

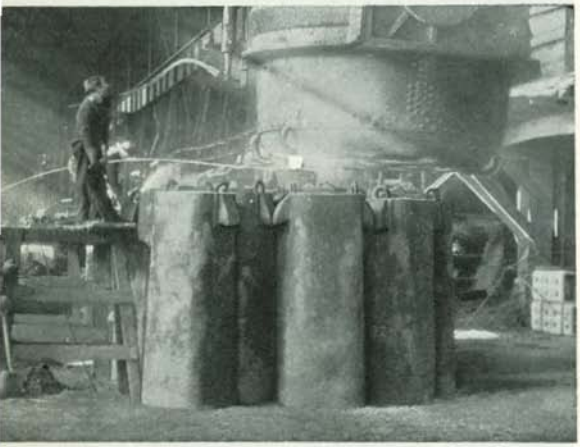
Taking a test spoonful of metal at the open hearth.



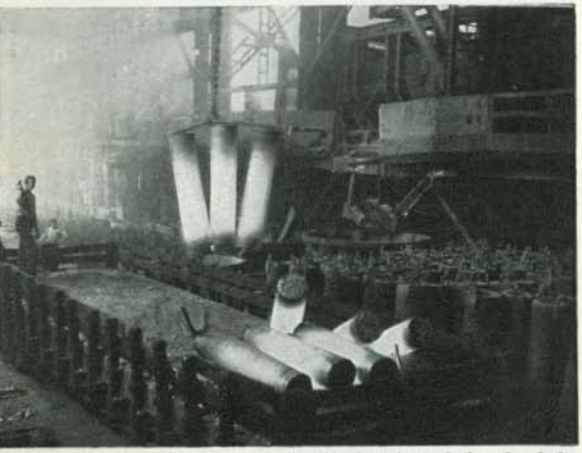
Open hearth pouring floor, Monessen Works.

Tapping an open hearth furnace. The small-ladle or "thimble" is for slag.

the proper temperatures and to control all of the other factors in accordance with the requirements of each individual heat. Throughout this period many samples of the metal are taken from the furnace for expert examination and laboratory analysis to make possible the necessary control of the "heat;" it is also during the "working period" that materials such as copper, manganese, nickel, etc., are added when desired. The period of time required for completing a "heat" of from 90 to 100 tons of Basic Open Hearth steel is approximately 11 hours.



Bottom-casting a heat of steel at the open hearth.



Stripped round ingots—still glowing hot—being loaded at Monessen Works for use up the river at Allenport.

POURING INGOTS

When the molten steel is tapped from the Open Hearth furnace it is received in a large fire-brick-lined ladle from which it is immediately cast into individual ingot molds producing ingots of approximately 3½ tons each, usually rectangular in cross section, but in some cases and for special purposes round in cross section.

Depending upon the character of steel being poured and the purpose for which it is destined, the ingots are either "top-poured"—that is, each ingot mold is filled directly from the ladle—or "bottom-cast," by which method

the steel is poured into a central piping "riser," flowing down, then out through a network of refractory piping, then up into a group of ingot molds—literally from the bottom.

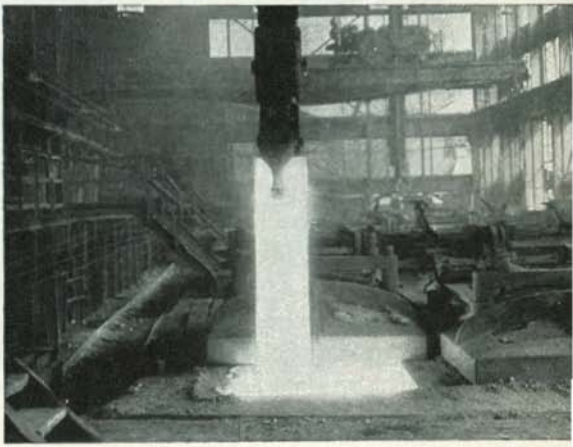
The steel is allowed to remain in the ingot molds until a considerable shell of the ingot solidifies, then the molds are stripped off and the ingots are removed to the "soaking pits."

ROLLING STEEL

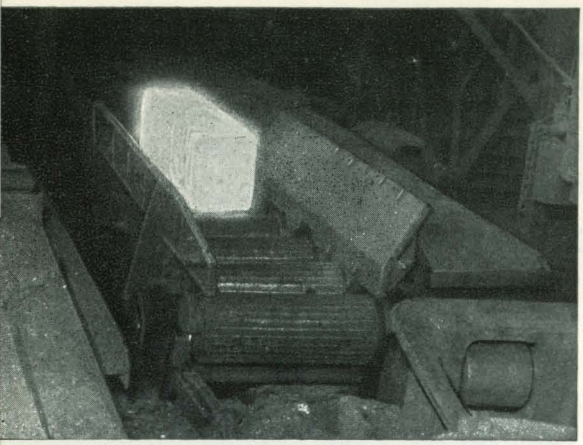
Omitting many details but touching upon some of the most important essential factors in the production of uniformly high quality steel, we now come to the point where, instead of by melting and pouring, the metal is carried further in preparation and refinement through controlled lower temperatures and rolling.

Soaking Ingots: Before an ingot can be successfully rolled its interior and exterior temperatures must be approximately the same overall, for temperature inequalities in the ingot would cause trouble in rolling, with consequent imperfections in the finished steel. Each ingot is therefore taken immediately after stripping to the "soaking pits." These soaking

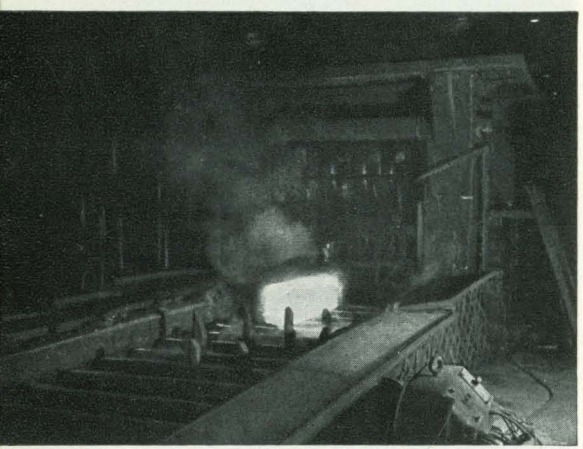
Looking down the blooming mill toward the soaking pits at the far end.



Ingot leaving a soaking pit at the blooming mill.



Ingot on conveyor to the blooming mill.



Ingot entering the second pass at the blooming mill.

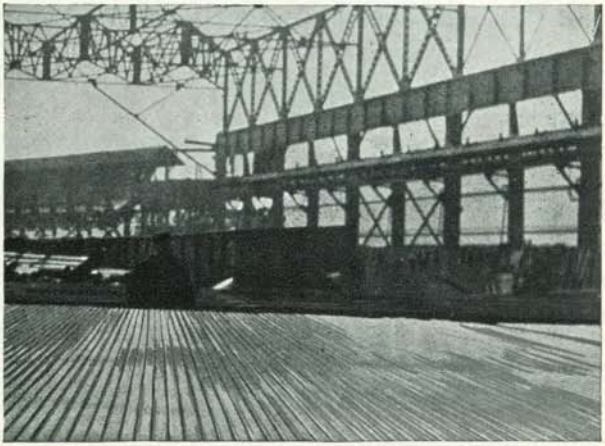
pits, located in the same building with the blooming mill, are comparatively small gas-fired pit furnaces, each accommodating about 20 tons of ingots. Here the ingots, standing on end, are allowed to "soak" in heat of about 2000°F., until they reach that temperature uniformly. They are then ready for rolling.

Blooming: The uniformly heated ingot is taken from the soaking pit directly to the "blooming" mill. Here it is rolled forward and backward through a series of "passes," each successively smaller than the preceding one, until the ingot—which was about 7 ft. long and 19 inches to 22 inches in its other dimensions—has been reduced to a "bloom" about 40 feet long by 7⅝ inches square.

After the rough ends are cropped from the bloom it proceeds directly to the billet mill, where by further rolling it is reduced to a billet about 4 inches square in cross section when destined for finished steel products other than seamless tubes, or rolled into a round billet from 2 inches to 6½ inches in diameter when destined to be finished into Seamless Steel Tubing.

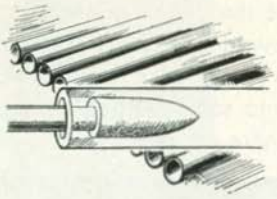
This covers in a very brief and sketchy way the production of what is termed "semi-finished" steel. As indicated, the metal ordinarily is kept hot throughout these processes. Now in billet form the steel is allowed to cool, is properly marked for identification and either stored for later use or taken to the finishing mills to be manufactured into some finished steel product. The products of immediate interest here are seamless steel pipe and tubes.

Billet mill at Monessen Works. Either round or oblong billets can be rolled here.



Billets on the cooling table at Monessen.

SEAMLESS STEEL TUBES



Before we proceed with any description of the processes of manufacturing seamless pipe and tubes it may be well to define the terms *"Pipe," "Pressure Tubes"* and *"Tubing"* and to give some general information about specifications for each.

Pipe

In general, the term "pipe" is applied to:

Standard Wrought Pipe
(*Including Extra Strong and Double Extra Strong*)
Drive Pipe
Large O.D. Pipe
Casing
Drill Pipe
Line Pipe
Oil Well "Tubing"

Material in the above classifications is known and spoken of by its nominal inside diameter, from ⅛" to 12" inclusive. Above 12" nominal inside diameter it is referred to by its outside diameter. Exceptions to this commercial practice are Casing, Drill Pipe and Plain End Line Pipe, ordered in accordance with American Petroleum Institute's Specifications 5-A and 5-L.

It is important to remember that the outside diameter of pipe remains constant to the listed dimensions and that any pipe heavier than the standards listed will carry its extra wall thickness on the inside, with a consequent reduction of the inside diameter. Orders for commercial pipe above 12" nominal inside diameter should specify both the outside diameter and the wall thickness desired. Orders for commercial pipe 12" nominal inside diameter and smaller should designate both the nominal size and weight. Pipe ordered to American Petroleum Institute's Standards should be designated by its outside diameter and weight (with the exception of *Threaded and Coupled Line Pipe* and *Oil Well Tubing*, which are designated by their nominal inside diameters).

Pittsburgh Seamless Standard Pipe is usually furnished "Hot Finished," although in certain sizes and for certain purposes it may be ordered "Cold Drawn." Unless specifically ordered otherwise, Pittsburgh Seamless Standard Pipe will be manufactured and tested in accordance with A.S.T.M. Specification A-53 (Grade A) of latest issue.

Pressure Tubes

Pressure Tubes comprise the heat transfer "pipes" of steam boilers, superheaters, condensers, oil cracking stills, heat exchangers, etc. The term "Pressure Tubes" is generally applied to:

Boiler Tubes or Flues
Superheater Tubes or Flues
Cracking Still Tubes
Heat Exchanger Tubes
Condenser Tubes

This material is referred to by its outside diameter and gage (wall thickness). As in the case of "Pipe," when the wall thickness is increased the inside diameter is decreased. Commercial quality and dimensional tolerances are fully covered by specifications issued by the A.S.M.E., A.S.T.M. and A.A.S.M.T.C.

Commercial Boiler Tubes, including Superheater Tubes, Safe Ends and Arch Tubes, are usually ordered to "Minimum Wall" specifications; i.e., the wall thickness shall nowhere be less than that specified, but may exceed that thickness by a certain definite amount. Cracking Still, Heat Exchanger and Condenser Tubes are usually ordered to "Average Wall" specifications; i. e., the wall thickness may vary a definite amount either over or under the specified thickness. In some instances, however, these classes of tubes also are ordered to "Minimum Wall." Thus to avoid errors it is essential that orders clearly designate whether the wall thickness desired is "Minimum" or "Average."

Pittsburgh Seamless Pressure Tubes are manufactured "Hot Finished" in sizes down to 1½" O.D. Smaller sizes are usually available only in "Cold Drawn" quality.

Tubing

The term "Tubing" is generally applied to those tubular products which are used for structural purposes and to form certain parts

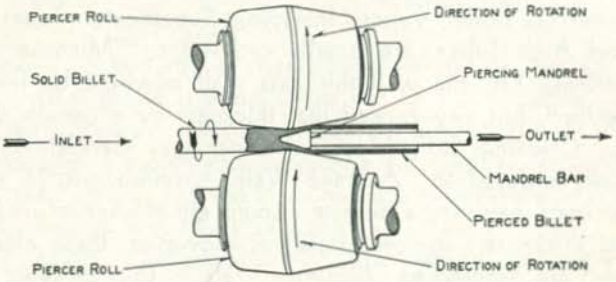
of machines. Such materials, usually referred to as Mechanical Tubing, generally require a greater degree of dimensional accuracy than either Pipe or Pressure Tubes.

Pittsburgh Seamless Mechanical Tubing is furnished either Hot Finished or Cold Drawn, as specified.

MANUFACTURE OF SEAMLESS STEEL TUBES

It is of course not possible within the limits of a few pages to enter into anything like an adequate description of the processes of seamless pipe and tube manufacture. Many vital features can be only lightly touched upon and many others must be omitted altogether. Since it is both interesting and useful, however, to know the essentials of seamless practice, we feel that even a very short description will be well worth while. Meanwhile we are always glad to give information in greater detail in response to specific inquiry, and in cases of special requirements our engineers are always available for consultation without obligation.

Piercing Billets



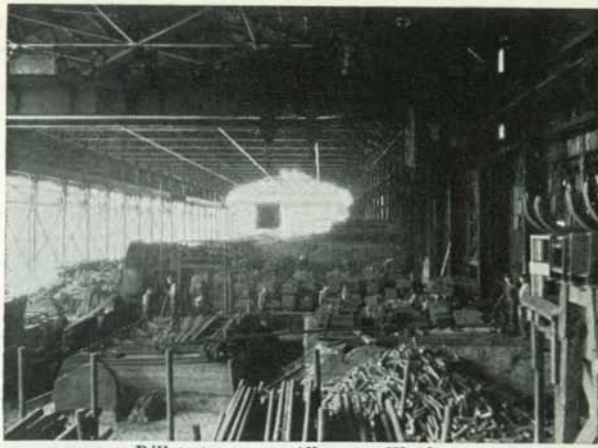
In our short discussion of the manufacture of iron and steel we left the steel in billet form, marked for identification. Having successfully passed careful inspection, the billet is now ready for the tube mill.

Over thirty years of experience in making seamless tubes have taught us many things. We know that it is not possible to get the best quality of product for each specific purpose for which seamless tubes are used by employing any one manufacturing process alone. Disregarding duplications of equipment to produce pipe and tubes in varying sizes by the same essential processes, Pittsburgh Steel Company is unique in that we use three totally different types of seamless

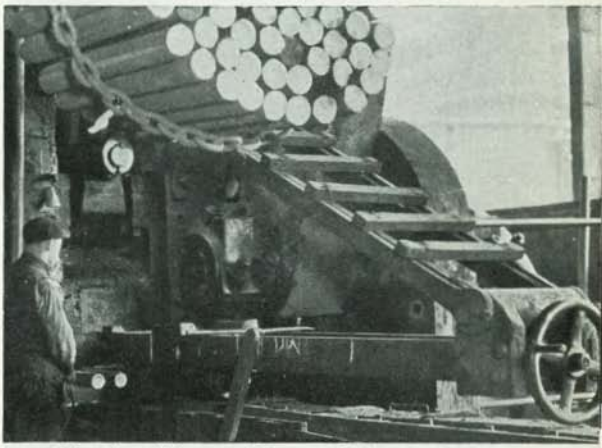
pipe and tube mills, each chosen to give certain very desirable basic qualities to the class of finished product it turns out. We make no welded pipe or tubes at all.

Mannesman Roll Piercing: The Mannesman piercing process is used exclusively to produce Pittsburgh Seamless Steel Tubes. These mills embody the principle of diagonal rolling and piercing. The comparatively heavy rolls — their diameters varying according to the size of the tube to be made—taper at an angle of 5 to 10 degrees toward each end from a flat central portion about 1" wide. These rolls are placed at their housings side by side, their axes slightly askew and inclined in opposite directions, but corresponding at their centers.

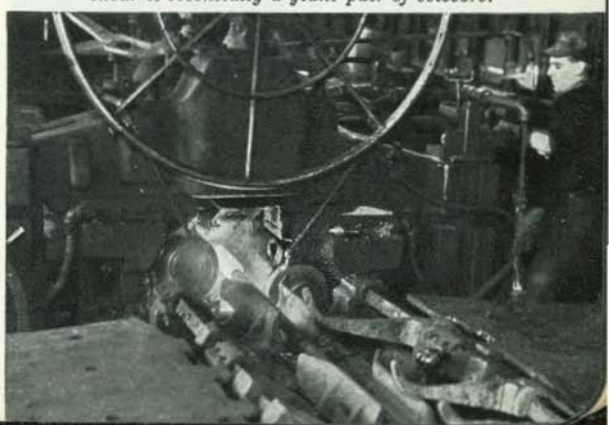
After being sheared to proper length the round billet is first heated, then con-



Billet storage at Allenport Works.



Shearing billets at Allenport Billet Yard. The shear is essentially a giant pair of scissors.



Piercing a tube blank at "Group H" mill, Allenport Works.

veyed to a trough on the entry side of the rolls. There it is pushed by a rod, actuated by a compressed air cylinder, into the opening between the rolls. In this space is a pointed mandrel or piercing point, supported by a water cooled rod from the delivery side of the rolls. The rolls cause the billet to revolve rapidly, pulling it and drawing it over the piercing point to make a hollow billet in the form of a rough, thick walled tube, ready for the rolling mill which follows and which will be described later.

Ejector bar pushing billet from furnace at the Elongator Mill.

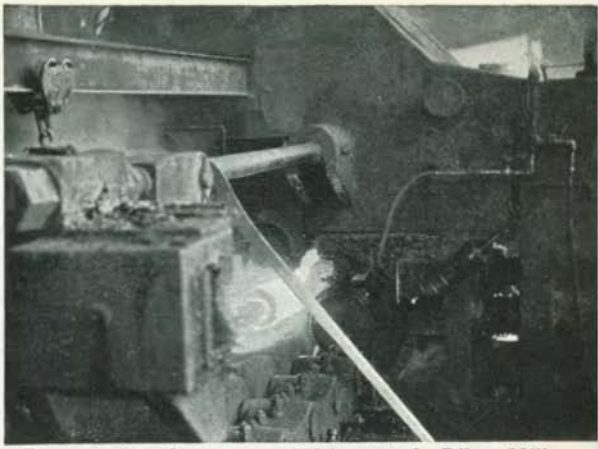
Piercing billet at the Elongator Mill. This is the outlet side of the mill.

Elongator Mill: The Elongator Mill — used to produce hot rolled tubes of smaller diameters and lighter walls than are practicable by ordinary processes — differs in important particulars as we come to the point of rolling after piercing. The piercing itself at this mill is essentially a repetition of the Mannesman principle already described, except that revolving discs are used as guides in addition to the rolls. More will be said of the Elongator Mill as we discuss rolling.

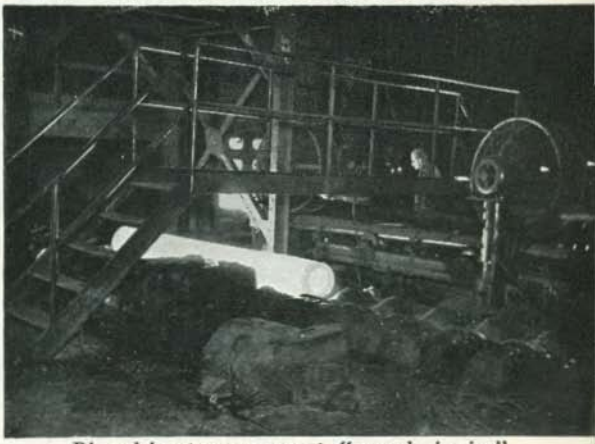
Pilger Mill: The Pilger process is used to make pipe and tubes of diameters larger than 6" for such purposes as oil country tubular

goods, boiler headers and pressure piping. Since this process is quite unusual, and since the Pilger Mill product has a number of features of great importance from the standpoint of usage in hard service, the Pilger Mill will be described in some detail when we reach the subject of rolling.

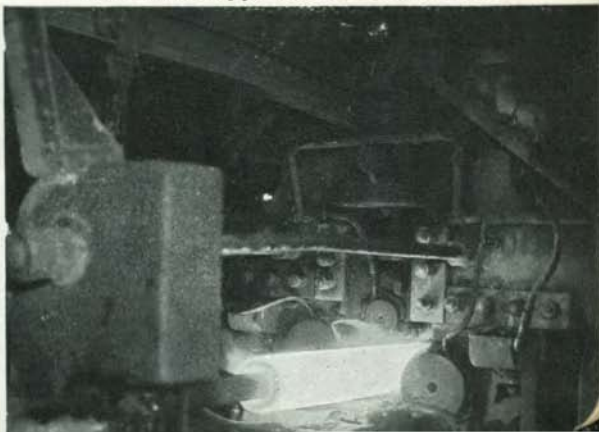
The chief feature of piercing at this mill is the size of the operation—entire round ingots being pierced by a Mannesman piercer of the same general type used for piercing small billets at the Mannesman mill already described. After this piercing the ingot is reheated, then passed through still another roll piercer in which the outside diameter of the blank remains unchanged while the wall thickness is reduced by use of a larger mandrel or plug. The hole in the blank is now thoroughly cleaned out with an air blast before the pierced ingot goes to the Pilger rolling mill.



First piercing of a two-ton solid ingot at the Pilger Mill.

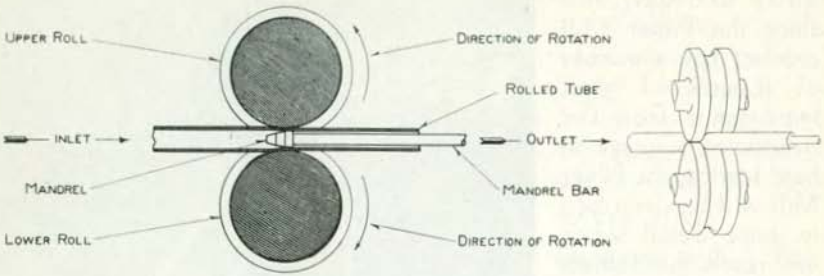


Pierced ingot on conveyor to "second-piercing" rolls. Reheating furnaces in the background.



"Second-piercing" an ingot at the Pilger Mill; outlet side.

ROLLING SEAMLESS TUBES



It is worth noting in passing that the operation of piercing solid steel is well calculated to demonstrate the fitness of the steel for pipe and tubes. The severity of the process will immediately bring to light any small defects in the piece which may have escaped detection in previous inspections, although of course sound metal is strengthened and refined by the rolling since it is being worked under closely pre-determined temperatures. Any billets or ingots that reveal imperfections during piercing are scrapped.

No matter by which of these similar processes the piercing of billets—or ingots—has been accomplished, we have a rough tubular blank of very heavy wall thickness and comparatively short length after the piercing. In order to finish the pipe or tube to smoothness, proper length and accurate dimensions it is necessary to send it now through a series of "refining" operations, each of which adds definitely to the quality characteristics of the finished product.

Although there are in the plants of Pittsburth Steel Company several seamless tube rolling mills designed to take the pipe and tube blanks turned out

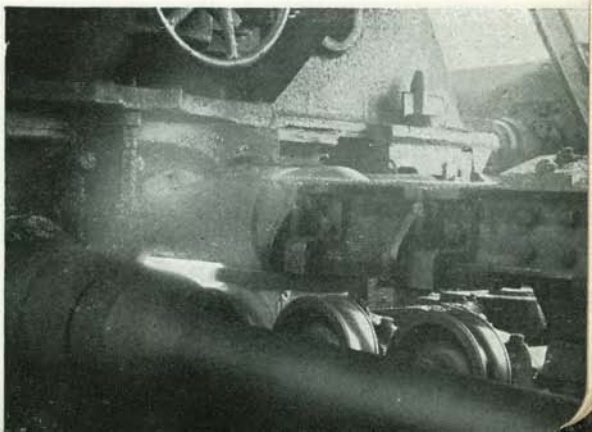
Rolling a tube after piercing. This tube is entering the final pass.

by the Mannesman, Elongator and Pilger mills, we shall concern ourselves here with only one of each of these mills.

Semi-Automatic Rolling Mill: Tube blanks go directly from the Mannesman piercer to the rolling mill, which comprises two long rolls, one above the other in the stand. Each of these rolls has a series of somewhat U-shaped grooves around its face, each groove progressively narrower and shallower than the preceding one. As the rolls are adjusted properly the grooves in both conjoin to make a series of approximately round "passes" through which the hot tube blank will be rolled successively until it reaches approximately the length, diameter and wall thickness of the required finished tube. Supported by a long rod at the rear of the mill—as at the piercing mill—is a mandrel or plug over which the tube will be rolled through each pass.

In rolling, one end of the almost white hot pierced billet—or tube blank—is introduced into the first and largest of the rolling mill passes. When the rolls seize it and force it through the pass the tube is elongated as the extremely thick walls are rolled down to more nearly normal size over the mandrel. Returning automatically from the rear of the mill the tube is given a 90° turn and introduced into the second pass, which furthers the action of reducing the outside diameter and wall thickness while lengthening the tube proportionately. The tube receives two or more successive rollings in the same way until it reaches proper size.

Elongator Mill: Pierced tube blanks go direct from the piercing mill to the Elongator Mill, just as in other seamless rolling processes. Instead of the two heavy, grooved rolls of the usual rolling mill type, the Elongator Mill has in effect four adjustable rolls—two parallel rolls inclined on their axes and two disc guides. The parallel or working rolls are mounted side by side in the stand; the

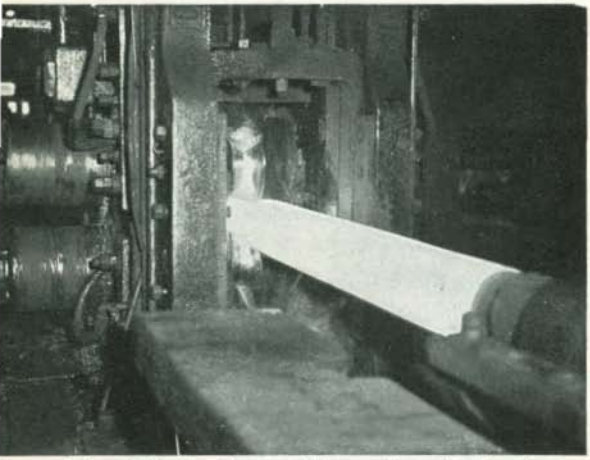


Rolling a tube at the Elongator Mill. This is the outlet side of the mill.

disc guides—their working faces grooved like rolls—are mounted one above the other and between the working rolls in such a way that the opening pass between the four rolling faces corresponds to the size and shape of the finished tube to be made.

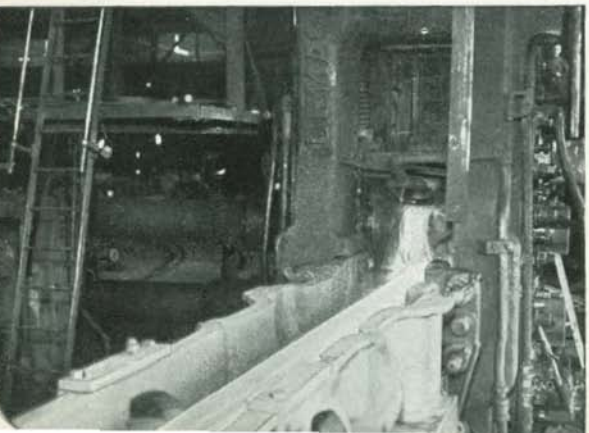
When it comes from the piercing mill the hot pierced billet is transferred to a rack beside the Elongator rolls, where a long, round, smooth mandrel bar is immediately inserted into it. The blank with its mandrel bar is then introduced into the Elongator rolls, where as the tube is rolled its inside walls are smoothed over the round mandrel bar, the wall thickness being reduced uniformly and the exterior smoothly finished.

The chief advantages of this method of making seamless tubes are the remarkably concentric walls and the smooth inside and outside finish it gives the tubes without cold drawing. The latter feature is of considerable importance in much boiler and power piping, while in the mechanical tubing field concentricity — with its resulting balance — is most desirable.



Pierced ingot entering Pilger rolls. As the pipe is forged and rolled the plunger table automatically moves forward.

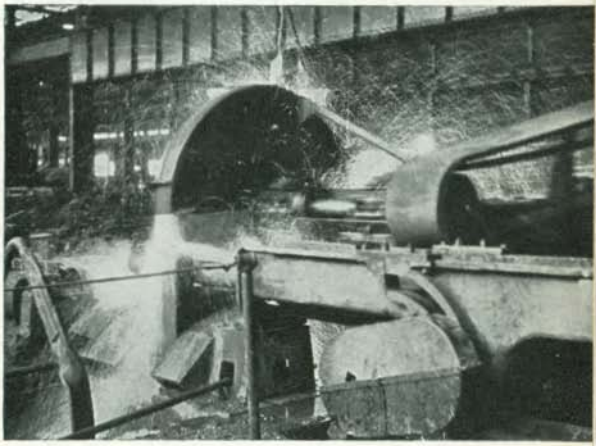
Pilger Mill: From the so-called "second piercing" of the ingot at the Pilger Mill the hot pierced blank is delivered to an electric buggy, thoroughly cleaned out by an air blast and taken to the Pilger rolls.



Pilger rolls, outlet side. Pipe leaving here goes—after cropping—to the normalizing furnace.

The Pilger pipe rolling mills, of which there are two at Pittsburgh Steel Company's Allenport Works, are so unique as to merit rather detailed description. In considering the merits of the Pilger process it should be remembered that the more hot steel is worked and forged the tougher it becomes. Therein lie the advantages of forged steel. The Pilger process of making seamless pipe is essentially a combination forging-rolling process. Such products as Oil Country Tubular Goods and Pressure Piping may in actual use quite often require the extra margin of safety this unusual process produces.

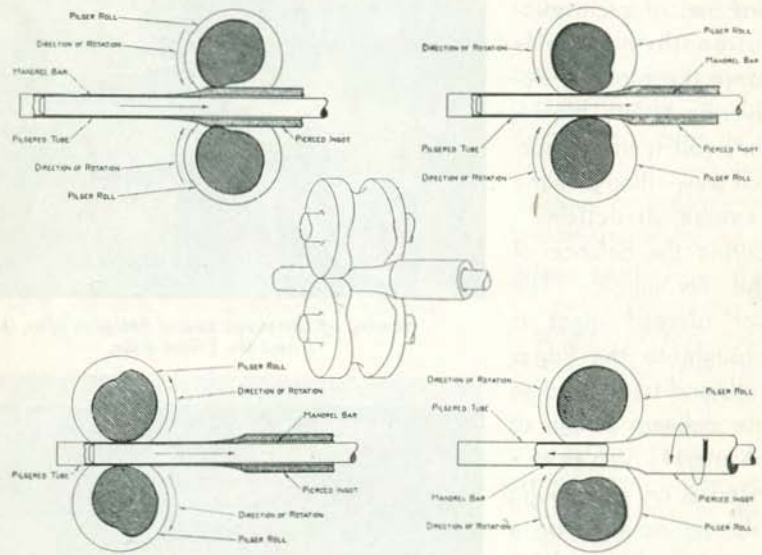
Pilger rolls are placed one above the other in the mill stand with parallel axes, much as are the rolls in an ordinary rolling mill. The big difference between ordinary rolls and Pilger rolls, however, is in the *shape* of the Pilger rolls, which have *eccentric passes* designed in such a way that while during the first part of each revolution they actually forge the pipe by delivering severe blows, they roll it in the normal way—though in the reverse direction—during the balance of the revolution. The hot pierced ingot is brought to the Pilger rolls and transferred to the delivery trough of the mill where a mandrel on a hydraulic plunger mounted on a large movable table is



Sawing off the rough end of hot pipe after it leaves the Pilger rolls.

General view of Pilger Mill building at Allenport Works

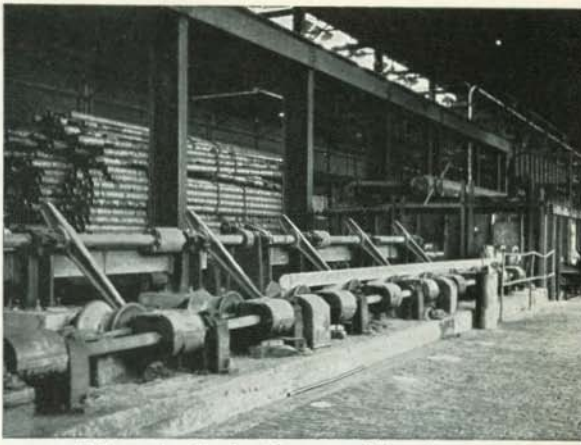
inserted into and through the blank until its forward end projects into the space between the rolls. As the rolls revolve the blank is forced between the rolls where their surfaces are cut away, then struck a heavy blow in the sharply narrowing throat. As the pass continues to narrow the pipe is seized and rolled. Since the direction of roll movement is against the pipe, however, rather than with it as in customary practice, the forged and rolled end of the pipe is thrown backward to the limit allowed by the hydraulic mandrel upon which it is supported. At the same time the mandrel and pipe are mechanically rotated 90°, again the pipe is carried forward into the rolls, struck a hard blow, rolled out and thrown back. This action is repeated many times during Pilgering of a length of pipe until every square inch of the pipe has been both forged and rolled. The pipe emerges from the rolls slightly oversize in diameter, but of proper wall thickness. Rough ends are sawed off while the pipe is still almost cherry red, after which it is conveyed to the normalizing furnace.



Normalizing

The normalizing furnace at the Pilger Mill is a gas-fired furnace, so arranged that the pipe to be normalized is conveyed on specially designed water-cooled rolls through an opening in one end. The

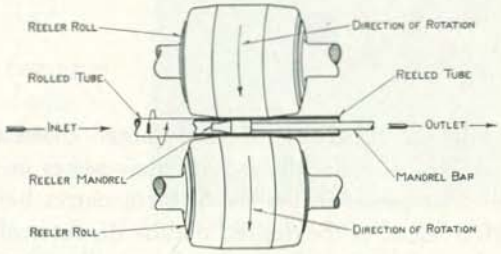
pipe is gradually heated to the proper normalizing temperature as it rolls across the floor or hearth to the opposite side, where it is picked up by a second set of conveyor rolls, passed out of the furnace and thence on to further finishing operations to be described.



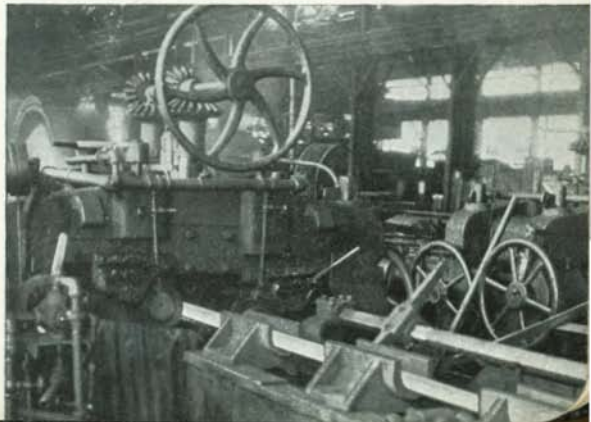
Pilger pipe leaving the normalizing furnace.

By this normalizing operation, under close temperature control, all work strains are relieved and the grain structure of the steel restored to its ideal condition. This assures that each length of pipe has the same uniformity of structure throughout.

REELING SEAMLESS TUBES



As tubes come from the rolling mills previously described they are slightly oval shaped, oversize and not perfectly smooth. To correct these conditions it is necessary to put

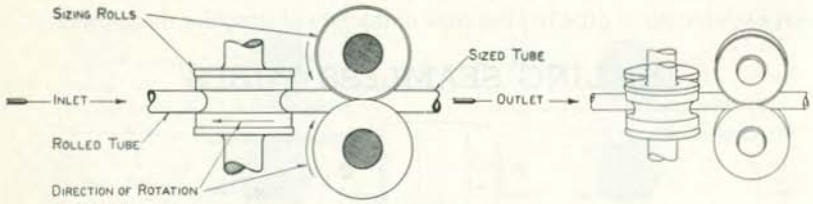


One of the reeling mills at Allenport Works.

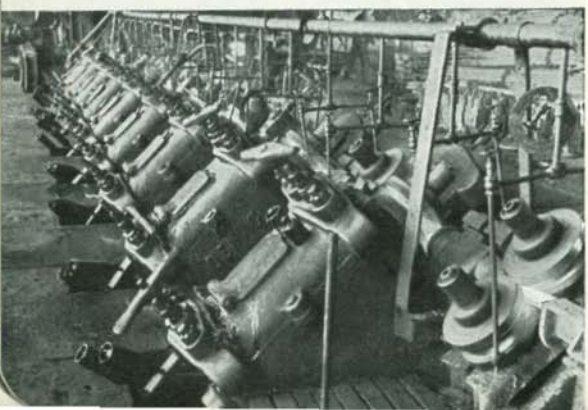
them through three finishing operations, the first of which is "reeling."

The reeling mill consists of two short heavy rolls mounted side by side with their axes inclined slightly toward the horizontal. The rolls thus cross each other at their centers. Each roll is adjustable laterally so that the pass between them may be varied by thousandths of an inch. A plug is supported on a mandrel bar at the back of the rolls as at the rolling mill. In operation a tube, still retaining enough of its original billet heat to make it a cherry red, is introduced into the reeling mill where it is seized, forced between the swiftly revolving rolls, over the mandrel plug and out of the mill. The tube is now perfectly round, practically straight and highly burnished. It is still slightly oversize, however—a condition which will be remedied in the "sizing" operation.

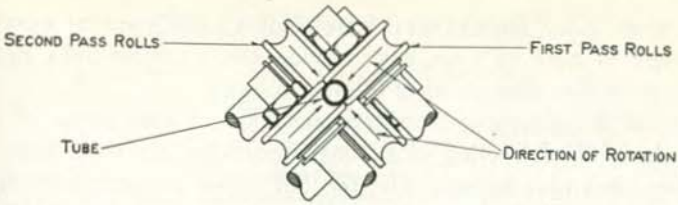
SIZING SEAMLESS TUBES



The sizing mill for tubes of 3" and larger diameters employs horizontal and vertical rolls, all set with their passes in a horizontal line with all other passes in the stand, these passes being grooved to form a perfect round of the desired outside diameter of the finished tube. The tube is introduced into the sizing mill—this time without a mandrel—which draws it slowly through, compressing the slightly oversize walls to give the tube its specified outside diameter.

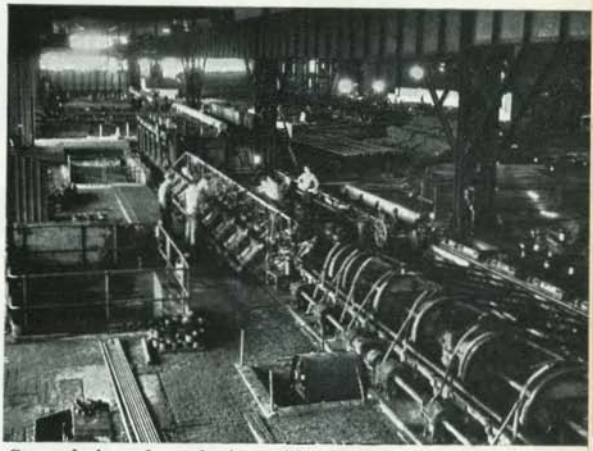


Following the reeling operation tubes are usually reheated before they are run through the reducing rolls.



Sinking: Tubes of smaller than 3" outside diameter are reheated and finished by a "sinking" process which is similar to the sizing operation except that each of the 18 stands of rolls in the sinking mill presents a slightly smaller pass to the hot tube as it comes through the mill. By this process it is possible to produce hot rolled tubes as small as 1½" O.D.

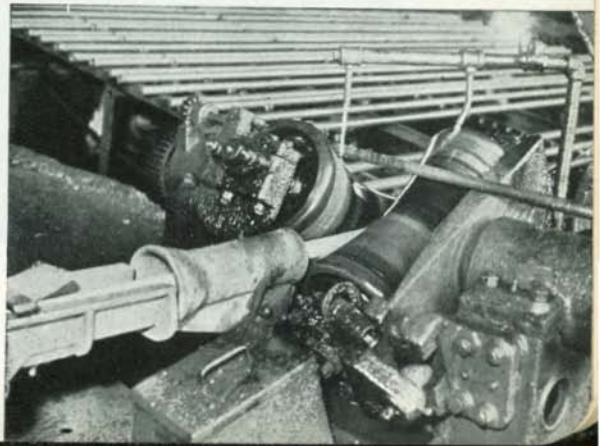
While these finishing operations of sizing and sinking have their counterparts in the Pilger and Elongator mills respectively, these operations will not be detailed here because of their essential similarity to what has already been described.



General view of a reducing mill layout at Allenport Works.

Straightening Seamless Tubes

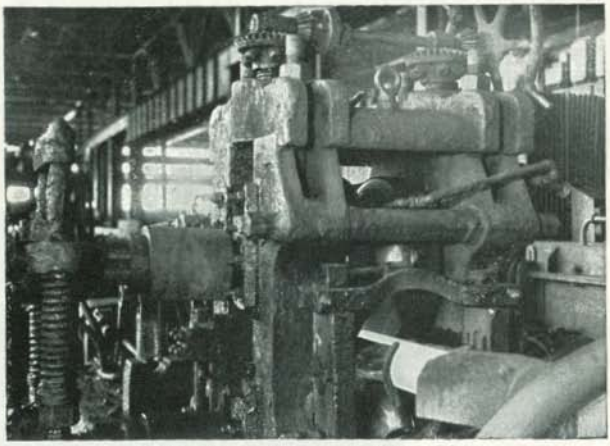
In order to get completely straight pipe and tubes we run all seamless materials, by whatever processes produced, through straightening mills of which there are a number of different types at Pittsburgh Steel Company's Allenport and



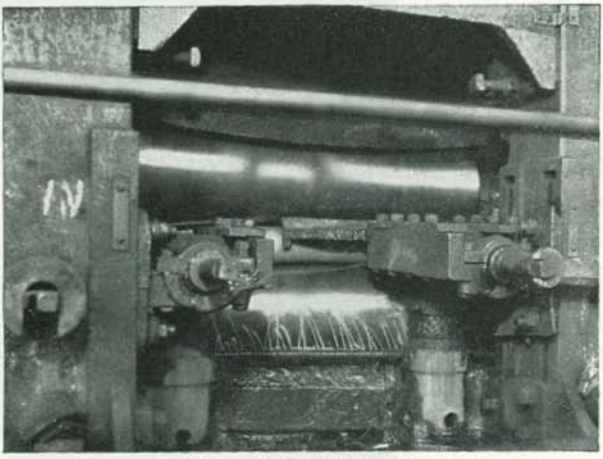
Tube being finished in cross rolls. Cooling table in the background.

Monessen mills. Each of these straighteners is designed for a particular type of pipe or tube, each turning out a commercially straight product within close limits of tolerance.

After straightening, crop ends are cut from each piece of pipe or tube and—following close final inspection for size, gage and surface, and tests for strength—the hot rolled product is ready for preparation and shipment.

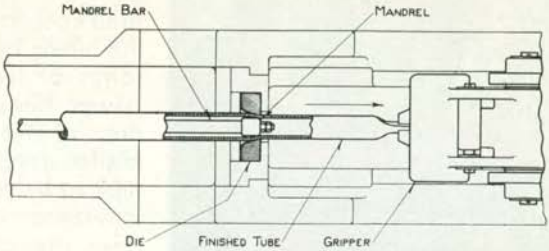


Sizing large pipe at the Pilger Mill.



Pipe in cross-rolls at the Pilger Mill. Next step is the cooling table.

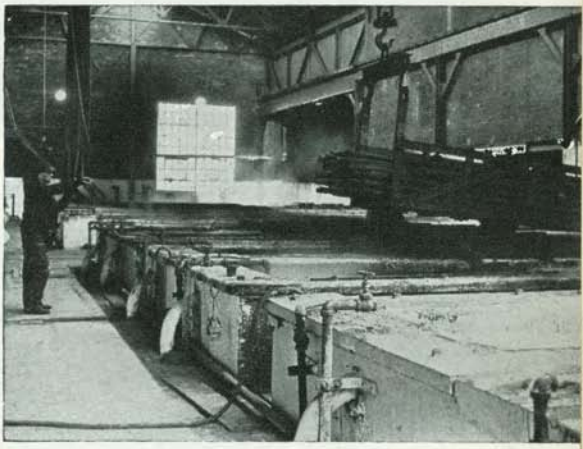
COLD DRAWN TUBING



In general when tubing is cold drawn after hot rolling the cold drawing is done to produce lighter walls and to secure a greater degree of accuracy in all dimensions than would be possible by hot finishing. Cold drawing also produces a bright finish on the exterior of tubing and imparts increased strength and stiffness through modification of the grain structure of the steel. It is necessary to relieve this stiffness after each cold draw pass by controlled annealing, which restores the normal grain structure.

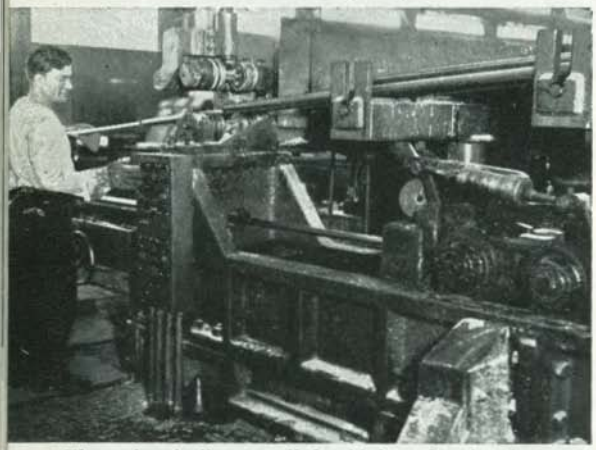
Cold drawing begins where hot finish-

Pointing for the cold-draw dies.

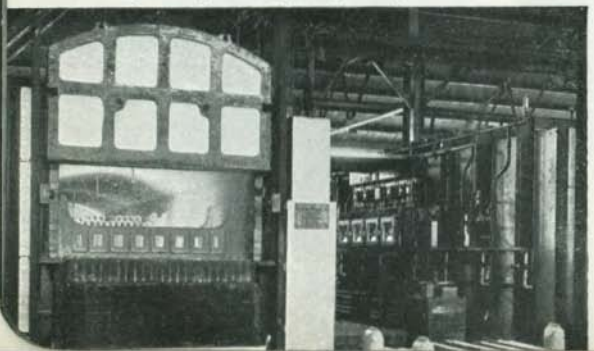


Pickling tubes in preparation for cold drawing. Note the pointed ends.

Cold drawing large-size pipe for extreme accuracy. The pipe is pulled very slowly but with great force through the die opening.



These electrically-controlled cold-draw benches feed the material a piece at a time and perform the entire cold drawing operation with little more than button-pushing on the part of the operator.



ing ends—after the sizing mill. The process itself consists of pulling the tubing by drawing-tongs of tremendous power through round dies of the required smaller sizes. First the tube to be cold drawn is swaged—or pointed—at the end which must start through the die. Next it is pickled in acid for removal of all traces of rolling mill scale, then washed and dried. It is then treated inside and out with a liquid mixture of flour and tallow or other suitable lubricant. When this lubricant has dried the tube is ready for the drawing.

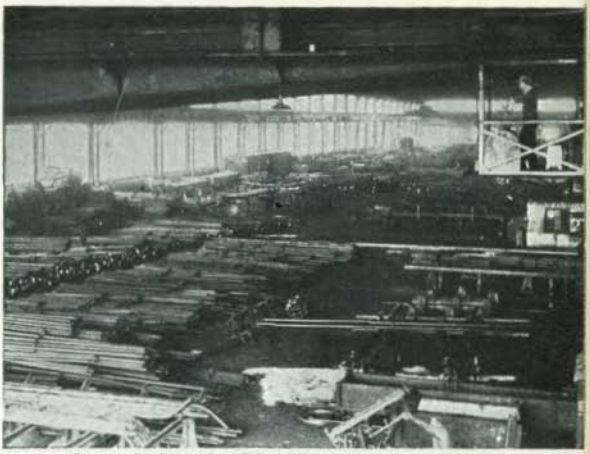
There are two chief processes of cold drawing—the "pulling" process and the "sinking" process. In "pulling" the pointed end of the tube is inserted through the die and gripped on the other side by the drawing tongs. At the same time a mandrel, attached to the end of a long rod, is pushed into the tube from the open end all the way

These automatic annealing furnaces at Allenport Works are the very latest word in scientific heat control methods.

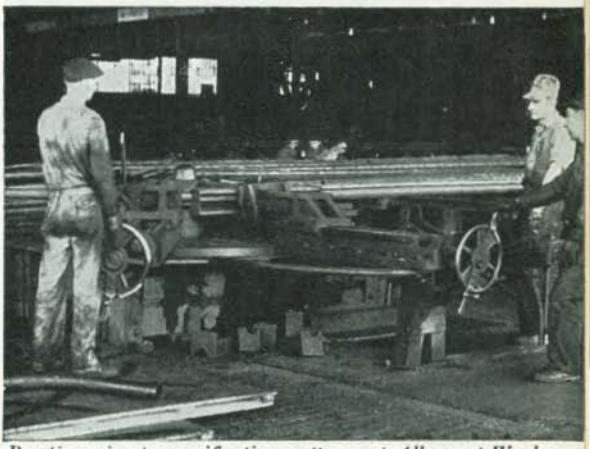
down to the die. When the drawing tongs are engaged with the endless chain of the drawbench and start pulling the tube through the die, the mandrel on the inside of the tube centers itself in the die opening, where it remains until the entire tube is drawn over it. In this way wall thickness is closely controlled.

The "sinking" process — used for very heavy walled tubing and for inside diameters of ½" or less—is practically the same as the pulling process, with the exception that no mandrel is used. This process obviously does not permit altogether accurate control of wall thickness.

In some cases one cold draw pass is sufficient to finish a tube to size, but usually it is necessary to give it two or even six or eight — and in some cases as high as twenty —passes through dies

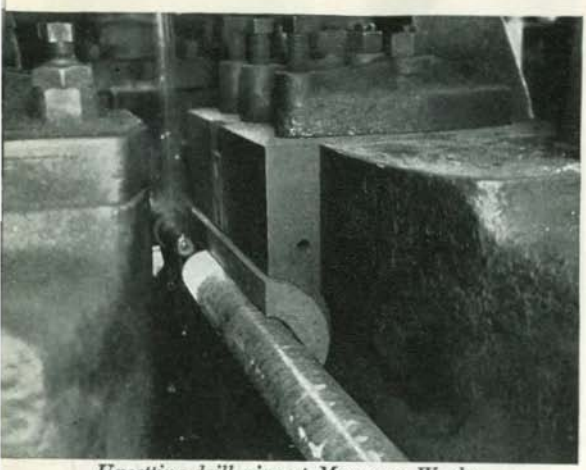


General view of a Finishing Department bay at Allenport Works.



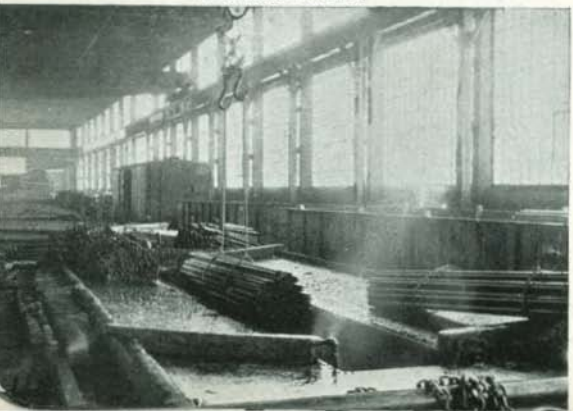
Bending pipe to specification patterns at Allenport Works

Heat-treating automobile axle housings at Monessen. This is the inlet side of one of the special electrically controlled furnaces at this mill.



Upsetting drill pipe at Monessen Works.

General view of the Specialty Department at Monessen Works.



of decreasing diameters before the required size is reached. After each pass the tube must be annealed, then cleaned, lubricated and dried before the next pass.

Annealing: When a tube has been cold drawn to finished size it may or may not be annealed, depending upon the use for which it is intended. Boiler tubes, for example, must be full-annealed to bring the grain structure to "dead soft" condition. Various classes of mechanical tubing are annealed at various temperatures, all according to what physical characteristics it may be desired to produce for the service for which the tubing is intended.

After annealing the cold drawn tube is straightened, cut to length, inspected inside and out, tested and — providing no further processing operations have been specified— prepared for shipment.

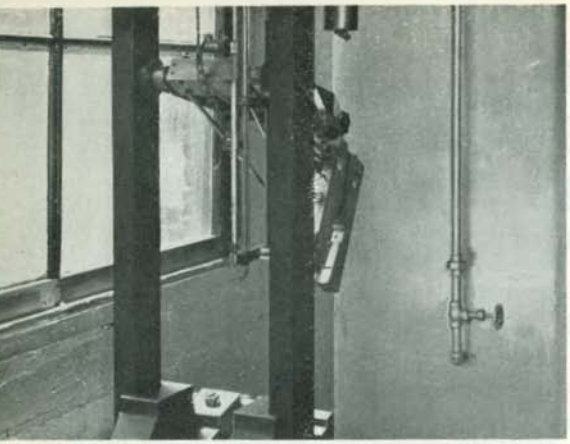
Oiling tubes to combat rust during shipment and storage. Oil Country material is treated by special cleaning and coating equipment.

INSPECTION, TESTING and FINISHING of PITTSBURGH SEAMLESS MECHANICAL TUBING

Inspection: It has already been indicated that the manufacture of Pittsburgh Seamless Pipe and Tubes is attended by close inspection all the way from the blast furnaces to the time the finished product is loaded for shipment. A typical illustration of the thoroughness of this "inspection-control" of manufacture in Pittsburgh Steel Company's mills is the fact that the so-called Controlled Steels of today are products of the same sort of close inspection-control adopted by this Company more than ten years ago. Many of the highly publicized new steel cleaners and deoxidizers were, in fact, developed in Pittsburgh Steel Company's open hearths—principally because our control methods here have long had the reputation of being among the most accurate and complete in the entire Industry.

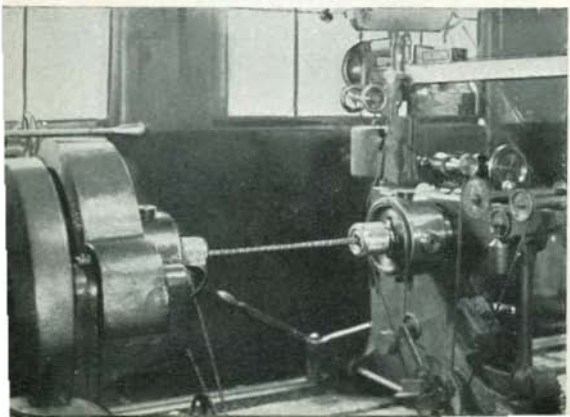
Pittsburgh Steel Company's ordinary research and testing facilities are distributed at strategic points throughout the mills. This is a corner of one laboratory at Monessen Works; microscopic examination in inset.

Without going into further detail about inspection, we do feel it of great significance to emphasize that inspection alone is not depended upon in these plants to achieve uniformity of product



Samples cut from the walls of pipe and tubing are subjected to impact tests on this Charpy tester.

The tensile test. This machine is capable of exerting a 250,000-pound pulling stress.

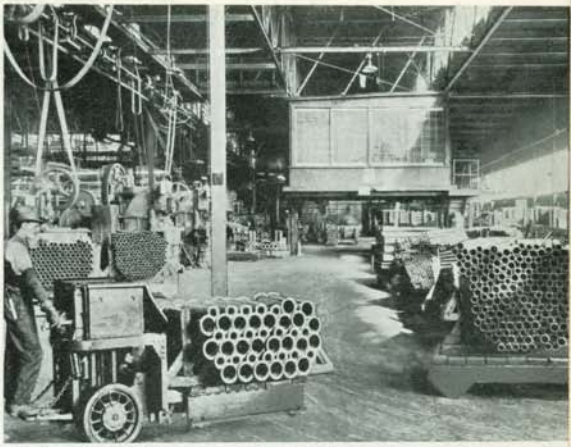


Torsion-testing to destruction a length of mechanical tubing.

through simple rejection of visibly irregular material. It is an unusually close co-ordination of inspection, operating and metallurgical departments that gives the inspection-control we consider so vitally important in prevention of irregularities in the finished product.

Tests: Depending upon the specific use to which any particular lot of Pittsburgh Seamless Mechanical Tubing is to be put, the entire lot will be subjected before shipment to one or a variety of tests to determine the tubing's concentricity, accuracy to diameters and wall thickness, hardness, temper, tensile strength, resistance to torsion, behaviour under impact and all other characteristics that seem to have any bearing upon the performance to be expected from the tubing in its intended service. This is in addition to the routine care exercised all the way

from the blast furnace. Such close control of Pittsburgh Seamless quality and Pittsburgh Seamless uniformity may well be expected to show up in your own plant, not only as reduced machining costs and handling time but in a more dependable finished product as well. Pittsburgh Seamless Mechanical Tubing is an engineers' product for an engineer's demands.



Mechanical tubes are expanded, flanged, upset, tapered, bent and otherwise formed to any required specifications in this Specialty Department, Monessen Works.

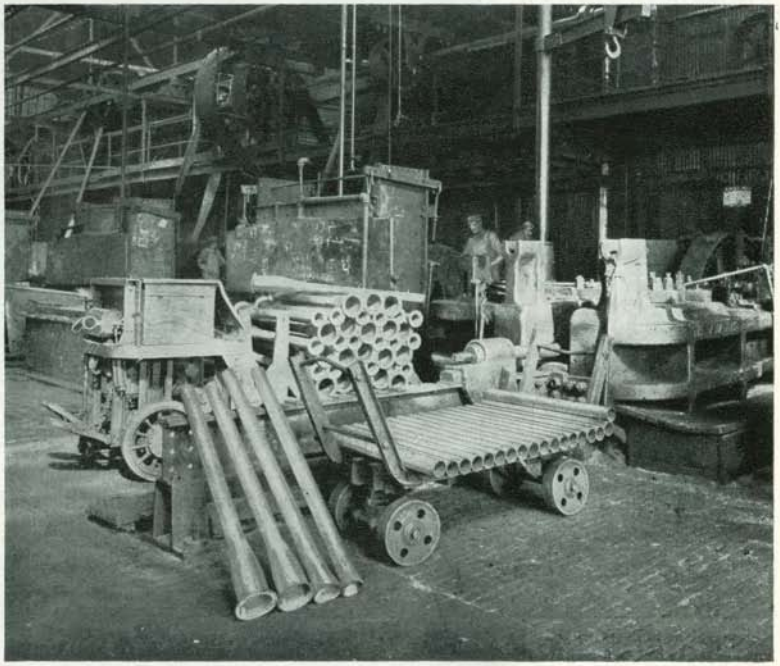
Upsetting mechanical tubing in the Specialty Department, Monessen Works.

Finishing: Broadly speaking, we consider "finishing" operations on Pittsburgh Seamless Mechanical Tubing to include — on order — forming or heat treating (or both) in addition to the mere preparation of material for shipment. We have complete equipment for all standard and many special forming operation, as well as modern electrically-controlled heat treating furnaces for producing material to the exacting specifications of automotive parts and specially stressed tubing. In short, Pittsburgh Seamless Mechanical Tubing is available in almost any steel, formed to almost any specifications and heat treated whenever heat treating is indicated. You have at your disposal at this one plant either all of these services or as few of

Tapering mechanical tubing at Monessen Works

them as you may choose to specify. "Pittsburgh Seamless" is both a quality of tubing and a rounded type of service.

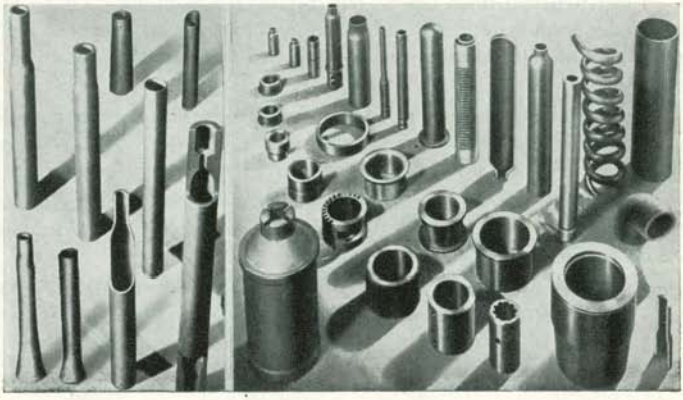
All finishing operations completed and all tests and final inspections passed, the finished Pittsburgh Seamless Mechanical Tubing is oiled to prevent rust (unless otherwise specified—see Page M-6—) and boxed or otherwise packed for shipment.



USES of PITTSBURGH SEAMLESS MECHANICAL TUBING

The great strength of the seamless steel tube, coupled with its relative lightness, makes it the ideal material for load-bearing machine parts—either working or "dead"—whose stresses are great, but whose weight must be held at a minimum. The modern automobile, the airplane and the streamlined train have many such parts. Drive shafts, axles and housings and frame members are typical examples of the application of Pittsburgh Seamless Mechanical Tubing in such usage.

Fully as important as these more spectacular uses of the lightness and strength of seamless, however, is the growing use of Pittsburgh Seamless Mechanical Tubing for the manufacture of hundreds of small machine parts—from ball bearing races to ring gears and piston pins. Many former users of solid stock for small parts have discovered a two-way reason for shifting to seamless. First: machining costs can be lowered surprisingly often and surprisingly far. Second: they get strength with minimum weight. Either of these important possibilities may make it worth while to check over your production to see where Pittsburgh Seamless can replace solid stock or forgings to your marked advantage.



INFORMATION

TO ACCOMPANY INQUIRIES AND ORDERS FOR SEAMLESS STEEL MECHANICAL TUBING

The importance of selecting tubing of the proper size, anneal and analysis for a particular purpose cannot be over-emphasized. The purchaser should always specify on his order or inquiry the particular grade of steel and finish required; also, where possible, the manner in which the tubes are to be used. If sufficient information accompanies the order or inquiry, difficulties will be avoided and complaints minimized.

If tubes are to be machined by the purchaser, the "finished dimensions" (O.D.; I.D.; Length) should be given on the order, together with the manner of chucking and sequence of machining operations. Unless the manner of chucking is stated, it is assumed that the tube will be chucked true to O.D.

When tubes are to be formed cold (Swaged, Expanded, Tapered, or Upset), give details of the nature of the forming and sketches covering such forming, together with a description of operations. Such data is also essential when tubes are to be forged or formed hot.

If the purchaser intends to polish or grind the tubing before using, that fact should be stated and the extent of the grinding given.

If tubes are to be plated, heat treated, case-hardened or welded, that fact should be stated in each case.

Medium and soft annealed tubes will be scaled to a certain extent. If such scale is objectionable it can be removed by pickling at the mill upon order.

Orders for tubing to be used for pump cylinders should state definitely whether purchaser intends to finish the inside surface to suit his needs, and to what dimensions, so that sufficient stock can be left in the tube to insure cleaning up. If pump cylinder finish is desired from the mill the order should plainly so indicate, since this type of finish involves special tools and operations for which an extra must be charged.

Orders for tubing which is to telescope over or inside another part should state whether the fit is loose, sliding or driving, and the length of fit. Allowance must be made for the usual variations in diameters and in straightness.

In the case of material ordered to special dimensional accuracy or surface finish it is essential that the order state whether the outside or inside diameter is the most important.

If the presence of oil is objectionable that fact should be noted. Mechanical tubing is shipped oiled to prevent rust unless otherwise ordered.

GRADES OF STEEL

USED IN THE MANUFACTURE OF PITTSBURGH SEAMLESS STEEL MECHANICAL TUBING

CARBON STEELS

S.A.E. No.	Carbon Range	Manganese Range	Phosphorus Max.	Sulphur Max.	Nickel Range	Chromium Range
1010	.05–.15	.30– .60	.045	.055	.....	.....
1015	.10–.20	.30– .60	.045	.055	.....	.....
X-1015	.10–.20	.70–1.00	.045	.055	.....	.....
1020	.15–.25	.30– .60	.045	.055	.....	.....
X-1020	.15–.25	.70–1.00	.045	.055	.....	.....
1025	.20–.30	.30– .60	.045	.055	.....	.....
X-1025	.20–.30	.70–1.00	.045	.055	.....	.....
1030	.25–.35	.60– .90	.045	.055	.....	.....
1035	.30–.40	.60– .90	.045	.055	.....	.....
1040	.35–.45	.60– .90	.045	.055	.....	.....
X-1040	.35–.45	.40– .70	.045	.055	.....	.....
1045	.40–.50	.60– .90	.045	.055	.....	.....
X-1045	.40–.50	.40– .70	.045	.055	.....	.....
1050	.45–.55	.60– .90	.045	.055	.....	.....
X-1050	.45–.55	.40– .70	.045	.055	.....	.....
1055	.50–.60	.60– .90	.040	.055	.....	.....
X-1055	.50–.60	.90–1.20	.040	.055	.....	.....
X-1315	.10–.20	1.30–1.60	.045	Range .075–.15	.....	.....

NICKEL STEELS*

2015	.10–.20	.30– .60	.040	.050	.40– .60	.....
2115	.10–.20	.30– .60	.040	.050	1.25–1.75	.....
2315	.10–.20	.30– .60	.040	.050	3.25–3.75	.....
2320	.15–.25	.30– .60	.040	.050	3.25–3.75	.....
2330	.25–.35	.50– .80	.040	.050	3.25–3.75	.....
2335	.30–.40	.50– .80	.040	.050	3.25–3.75	.....
2340	.35–.45	.60– .90	.040	.050	3.25–3.75	.....
2345	.40–.50	.60– .90	.040	.050	3.25–3.75	.....
2350	.45–.55	.60– .90	.040	.050	3.25–3.75	.....
2515	.10–.20	.30– .60	.040	.050	4.75–5.25	.....

NICKEL CHROMIUM STEELS*

3115	.10–.20	.30– .60	.040	.050	1.00–1.50	.45–.75
3120	.15–.25	.30– .60	.040	.050	1.00–1.50	.45–.75
3125	.20–.30	.50– .80	.040	.050	1.00–1.50	.45–.75
3130	.25–.35	.50– .80	.040	.050	1.00–1.50	.45–.75
3135	.30–.40	.50– .80	.040	.050	1.00–1.50	.45–.75
3140	.35–.45	.60– .90	.040	.050	1.00–1.50	.45–.75
X-3140	.35–.45	.60– .90	.040	.050	1.00–1.50	.60–.90
3145	.40–.50	.60– .90	.040	.050	1.00–1.50	.45–.75
3150	.45–.55	.60– .90	.040	.050	1.00–1.50	.45–.75

(*)See note, Page M-8.

(Continued on the following page)

GRADES OF STEEL

USED IN THE MANUFACTURE OF PITTSBURGH SEAMLESS STEEL MECHANICAL TUBING (Continued)

NICKEL CHROMIUM STEELS (Continued)

S.A.E. No.	Carbon Range	Manganese Range	Phosphorus Max.	Sulphur Max.	Nickel Range	Chromium Range
3215	.10–.20	.30–.60	.040	.050	1.50–2.00	.90–1.25
3220	.15–.25	.30–.60	.040	.050	1.50–2.00	.90–1.25
3230	.25–.35	.30–.60	.040	.050	1.50–2.00	.90–1.25
3240	.35–.45	.30–.60	.040	.050	1.50–2.00	.90–1.25
3245	.40–.50	.30–.60	.040	.050	1.50–2.00	.90–1.25
3250	.45–.55	.30–.60	.040	.050	1.50–2.00	.90–1.25
3312	Max. .17	.30–.60	.040	.050	3.25–3.75	1.25–1.75
3325	.20–.30	.30–.60	.040	.050	3.25–3.75	1.25–1.75
3335	.30–.40	.30–.60	.040	.050	3.25–3.75	1.25–1.75
3340	.35–.45	.30–.60	.040	.050	3.25–3.75	1.25–1.75
3415	.10–.20	.30–.60	.040	.050	2.75–3.25	.60– .95
3435	.30–.40	.30–.60	.040	.050	2.75–3.25	.60– .95
3450	.45–.55	.30–.60	.040	.050	2.75–3.25	.60– .95

MOLYBDENUM STEELS*

S.A.E. No.	Carbon Range	Manganese Range	Phosphorus Max.	Sulphur Max.	Nickel Range	Chromium Range	Molybdenum Range
4130	.25– .35	.50–.80	.040	.050	.....	.50– .80	.15–.25
X-4130	.25– .35	.40–.60	.040	.050	.....	.80–1.10	.15–.25
4135	.30– .40	.60–.90	.040	.050	.....	.80–1.10	.15–.25
4140	.35– .45	.60–.90	.040	.050	.....	.80–1.10	.15–.25
4150	.45– .55	.60–.90	.040	.050	.....	.80–1.10	.15–.25
4615	.10– .20	.40–.70	.040	.050	1.65–2.00	.....	.20–.30

CHROMIUM STEELS*

5120	.15– .25	.30–.60	.040	.050	.....	.60– .90	.....
5140	.35– .45	.60–.90	.040	.050	.....	.80–1.10	.....
5150	.45– .55	.60–.90	.040	.050	.....	.80–1.10	.....
52100	.95–1.10	.20–.50	.030	.035	.....	1.20–1.50	.....

CHROMIUM VANADIUM STEELS*

S.A.E. No.	Carbon Range	Manganese Range	Phosphorus Max.	Sulphur Max.	Chromium Range	Vanadium	
						Min.	Desired
6115	.10–.20	.30–.60	.040	.050	.80–1.10	.15	.18
6120	.15–.25	.30–.60	.040	.050	.80–1.10	.15	.18
6125	.20–.30	.60–.90	.040	.050	.80–1.10	.15	.18
6130	.25–.35	.60–.90	.040	.050	.80–1.10	.15	.18
6135	.30–.40	.60–.90	.040	.050	.80–1.10	.15	.18
6140	.35–.45	.60–.90	.040	.050	.80–1.10	.15	.18
6145	.40–.50	.60–.90	.040	.050	.80–1.10	.15	.18
6150	.45–.55	.60–.90	.040	.050	.80–1.10	.15	.18

*Silicon range of all S.A.E. basic open hearth alloy steels shall be 0.15–0.30. For electric and acid open hearth alloy steels, the silicon content shall be 0.15 minimum.

While tubing in practically all these grades can be supplied, steels 1015, X-1020, 1025, 1035, 1045, 2330, X-4130, and 4135 are standard and can be furnished in usual sizes and quantities promptly on order. Regular cold drawn mechanical tubing is furnished in analysis corresponding generally to S.A.E. 1015 unless otherwise specified.

CHARACTERISTICS OF ANNEALS

1. Unannealed. Surface bright and free from scale. Has maximum strength but slight ductility. The machining qualities are good, but unannealed tubing is unsuitable for cold forming operations. Ordinarily used where material is desired with smooth finish or maximum strength without regard to ductility.

2. Finish Anneal (940°F.). Dull surface and practically free from scale. Has good machineability. Mechanical tubing is always furnished in this anneal unless otherwise specified. Usually used where good finish and free machining qualities are essential. Will be found stiff and with only moderate ductility. Should not be subjected to severe cold forming operations.

3. Medium Anneal (1100°F.). Surface dull and somewhat scaled. Machines easily and possesses considerable softness, with relatively good tensile strength. Capable of standing a fair amount of cold forming. Scale, if objectionable, can be removed with a pickling operation, which will not alter the physical properties derived from this anneal.

4. Soft Anneal (1350°F.). Soft annealed tubes are considerably scaled, but this scale can be removed by a pickling operation. Such tubes are ideal for cold forming operations. However, on account of their extreme softness, tubes of this anneal cannot be held as closely to dimensions as the stiffer anneals and a greater degree of ovality will be encountered. Likewise, machineability is not so good as in the stiffer anneals.

PHYSICAL PROPERTIES

OF COLD DRAWN SEAMLESS STEEL TUBING

The table on the following page covers tubing of various types of steel after normal cold draw passes and annealing at the temperatures shown. These figures represent values for tubing of usual sizes and wall thicknesses. They do not apply to unusual sizes, gages or specifications—for several reasons:

1. Physical properties of cold drawn tubes will vary according to the varying degrees of cold work performed in producing the tubes.

2. Annealing of cold drawn tubes changes the physical properties. The amount of these changes will vary with the degree of cold work the tube has received.

3. Greater proportion of change, with increased proportionate strength, will be found in light wall tubes than in tubes with heavy walls, due to the fact that the latter cannot be given the same degree of cold work as the light wall tubes. For the same reason, large tubes with relatively heavy walls will not show the same increase in strength as small tubes.

MINIMUM VALUES

Type of Steel	Annealing Temperature	Yield Point	Ultimate Strength	% Elong. in 2 Ins.	Brinell	Rockwell B.
S.A.E. 1010	Unannealed	55,000	59,000	19	120	66
	Finish (940°F)	45,000	53,000	30	107	59
	Medium (1100°F)	30,000	45,000	48	90	48
	Soft (1350°F)	25,000	44,000	55	87	46
S.A.E. 1015	Unannealed	60,000	64,000	16	128	70
	Finish (940°F)	49,000	58,000	27	117	66
	Medium (1100°F)	32,000	49,000	44	99	54
	Soft (1350°F)	28,000	47,000	50	94	50
S.A.E. 1020	Unannealed	65,000	68,000	13	136	73
	Finish (940°F)	53,000	64,000	23	126	71
	Medium (1100°F)	35,000	53,000	40	107	59
	Soft (1350°F)	32,000	50,000	45	100	55
S.A.E. 1025	Unannealed	68,000	73,000	10	146	78
	Finish (940°F)	56,000	69,000	19	136	77
	Medium (1100°F)	38,000	56,000	37	113	64
	Soft (1350°F)	35,000	53,000	41	107	59
S.A.E. 1030	Unannealed	70,000	78,000	8	158	83
	Finish (940°F)	60,000	75,000	18	148	81
	Medium (1100°F)	43,000	61,000	33	121	68
	Soft (1350°F)	38,000	57,000	37	115	64
S.A.E. 1035	Unannealed	73,000	85,000	6	177	88
	Finish (940°F)	65,000	81,000	16	160	85
	Medium (1100°F)	48,000	66,000	29	130	73
	Soft (1350°F)	43,000	61,000	34	121	68
S.A.E. 1040	Unannealed	78,000	90,000	5	183	91
	Finish (940°F)	70,000	85,000	14	170	88
	Medium (1100°F)	51,000	70,000	27	137	77
	Soft (1350°F)	46,000	65,000	31	130	72
S.A.E. 1045	Unannealed	80,000	95,000	4	197	93
	Finish (940°F)	75,000	89,000	12	182	90
	Medium (1100°F)	55,000	75,000	25	143	80
	Soft (1350°F)	50,000	68,000	28	136	75
S.A.E. 1050	Unannealed	85,000	100,000	3	212	95
	Finish (940°F)	80,000	93,000	10	194	92
	Medium (1100°F)	60,000	80,000	23	158	83
	Soft (1350°F)	53,000	73,000	25	144	79
S.A.E. X-1315	Unannealed	85,000	90,000	8	185	90
	Finish (940°F)	75,000	86,070	15	175	87
	Medium (1100°F)	43,000	60,000	38	135	76
	Soft (1350°F)	35,000	55,000	40	125	69
S.A.E. X-4130	Unannealed	95,000	100,000	9	212	95
	Finish (940°F)	90,000	95,000	12	197	93
	Medium (1100°F)	75,000	85,000	20	170	87
	Soft (1350°F)	40,000	70,000	25	130	75

MINIMUM VALUES (Continued)

Type of Steel	Annealing Temperature	Yield Point	Ultimate Strength	% Elong. in 2 Ins.	Brinell	Rockwell B.
S.A.E. 4135	Unannealed	100,000	105,000	8	235	99
	Finish (940°F)	95,000	100,000	10	218	95
	Medium (1100°F)	80,000	90,000	18	185	90
	Soft (1350°F)	45,000	73,000	23	148	79
S.A.E. 4140	Unannealed	105,000	112,000	7	255	102
	Finish (940°F)	100,000	110,000	9	238	99
	Medium (1100°F)	90,000	95,000	15	197	93
	Soft (1350°F)	51,000	75,000	20	166	84
S.A.E. 4145	Unannealed	115,000	120,000	6	276	103
	Finish (940°F)	110,000	115,000	8	260	102
	Medium (1100°F)	95,000	102,000	14	215	95
	Soft (1350°F)	60,000	84,000	19	186	87

S.A.E. Alloy steels are usually heat treated by the user to develop the best possible physical properties. The physical properties for alloy steels listed are those obtaining after annealing as shown.

Since it is impracticable to list a complete table of the physical properties of cold drawn tubing, this table should be used only for sizes not over 4" O.D., and for wall thicknesses not over $\frac{3}{8}$" nor under $\frac{1}{32}$".

PHYSICAL PROPERTIES OF

HOT FINISHED SEAMLESS STEEL TUBING

It has already been noted that the physical properties of hot finished seamless steel tubing depend largely upon the wall thickness. Light wall tubing will cool faster from the finishing temperatures than will heavy wall tubing. This comparatively rapid air cooling has an appreciable hardening effect and consequently light wall tubing will have greater strength with less ductility than will heavier wall tubing of the same analysis.

The following table shows the physical properties of hot finished seamless steel tubing of various wall thicknesses made from the most commonly used carbon steels.

MINIMA

Spec.	Wall Thickness in Inches	Yield Point Pounds per Square Inch	Ultimate Strength Pounds per Square Inch	Elongation		Reduction in Area Per Cent.
				Per Cent in 2 Ins.	Per Cent in 8 Ins.	
S.A.E. 1015	.109 to .148	40,000	55,000	44	24	37
	.148 to .203	37,000	50,000	45	25	40
	.203 to .300	33,000	48,000	48	26	42
	.300 to .500	30,000	47,000	50	27	43
S.A.E. 1025	.109 to .148	45,000	58,000	40	21	31
	.148 to .203	39,000	54,000	41	22	34
	.203 to .300	35,000	52,000	44	24	35
	.300 to .500	32,000	50,000	45	25	37
S.A.E. 1035	.109 to .148	48,000	65,000	37	20	25
	.148 to .203	43,000	62,000	38	21	28
	.203 to .300	37,000	60,000	40	22	29
	.300 to .500	34,000	58,000	42	23	32

DEFINITIONS OF TRADE TERMS

USED IN CONNECTION WITH DIMENSIONS OF SEAMLESS STEEL MECHANICAL TUBING

1. Tolerances: Since in all manufactured articles more or less variation exists in the dimensional values, it is necessary to establish limits or tolerances beyond which these dimensional variations must not go. A seamless tube section consists of three dimensions—Outside Diameter, Inside Diameter and Wall Thickness (or Gage). All of these dimensions will vary independently.

2. O.D.: Outside Diameter. Specified in inches and fractions of an inch, or in inches and decimals of an inch, to three places.

3. I.D.: Inside Diameter. Specified in the same terms as the O.D.

4. Wall: Wall Thickness or Gage. Specified in either fractions of an inch, decimals of an inch or by a "Wire Gage" number. In the United States the standard wire gage used for tubing is the "Birmingham" iron wire gage, designated "B.W.G."

5. Nominal: The theoretical or stated value of the O.D., I.D. or Wall dimension as specified by the customer.

6. Maximum and Minimum: The dimensions obtaining after applying the proper tolerances to the nominal dimensions.

7. Mean: The average or working dimension between Maximum and Minimum dimensions.

8. Average: Those dimensions obtained by averaging a number of measurements on a tube.

9. Minimum Wall: A tube whose wall thickness is not permitted to fall below the specified measurement.

10. Average Wall: A tube whose wall thickness is permitted to range over or under the specified wall measurement within certain defined tolerances.

11. Wall Variation and Eccentricity: In piercing a seamless tube it is not possible to maintain the centers of the O.D. and I.D. circles consistently at the same point. This naturally results in a wall variation, commonly called eccentricity. In other words, as the centers of the O.D. and I.D. differ from each other, the wall thickness will be greater on one side of the tube and lesser on the opposite side; therefore any tolerances for wall thickness must be plus and minus. Experience has proved that the degree of eccentricity is dependent on the thickness of the wall produced; thus the limits or tolerances of wall variation should be expressed in terms of percentage of the thickness specified. This is shown clearly in the diagram on the following page, M13, Figure 1. Here it will be noted that eccentricity alone does not affect the average wall of the tube, consequently does not alter the weight per foot. However, while wall variations are principally due to eccentricity, contributing factors are variations in the O.D. and I.D. When these occur the weight per foot can be affected.

The wall tolerance for cold drawn tubing, due to eccentricity, can be commercially maintained at plus and minus 10 per cent, and for hot finished tubing plus and minus 12½ per cent.

Since O.D. and I.D. variations will also affect the wall variations it should be understood that specified wall tolerances are intended to include variations in average wall from tube to tube and also eccentricity in the individual tubes.

Of course all tubes will not show the extreme dimensional variations permitted. It will be found that most of the tubes in any one lot will check very closely to the specified size and show little eccentricity.

12. O.D. and I.D. Variations: From the description of the various processes of manufacture of seamless tubing in the preceding pages it will be seen that Hot Finished tubes are finished to their final dimensions through grooves in the rolls and over mandrels of appropriate size to produce the desired O.D., I.D. and Wall Thickness. Cold Drawn tubes, beginning where the hot working ends, are finished by being drawn cold through dies and over mandrels.

In general, variations in the O.D. and I.D. dimensions of hot finished tubes are considerably greater than in cold drawn tubing because hot steel must be worked on equipment that is more rugged and less susceptible to delicate adjustment than that which can be used for cold working. The tendency of steel worked at high temperatures, particularly in the case of a hollow section like a tube, is to vary about equally plus and minus in its O.D. and I.D. dimensions, therefore in tooling up to roll hot finished tubes it is necessary to aim at a mean diameter about half way between maximum and minimum in order to insure that the finished dimensions will not run under those specified. Since the O.D. and I.D. variations of cold drawn tubing are largely due to the wear on dies and mandrels, which can be observed and checked closely, such variations can be held to a minimum.

Pittsburgh Steel Company follows the standard practice of generally holding O.D. tolerances all plus and I.D. tolerances all minus. This assures sufficient stock to clean up in machining operations.

Tables of standard commercial tolerances are given on Pages M19 to M22.

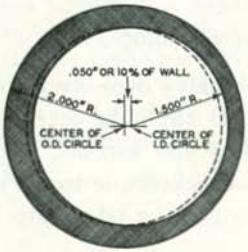


Figure 1

Dotted Circle indicates I. D. Circle of Concentric Tube

Illustrating the maximum permissible difference in wall thickness

of a seamless tube section caused by a shifting of the centers of the O.D. and I.D. circles, termed eccentricity. While very few seamless tubes will be found to have this extreme eccentricity, it is deemed advisable in the interests of better understanding between the manufacturer and the purchaser to illustrate the cause and effect.

It should be noted that if the wall in one place is reduced, due to eccentricity, there will be a corresponding increase in the thickness on the opposite side of the tube. This fact should be kept in mind when calculating the amount of material to be removed by machining so that the proper dimensions of the stock tube can be arrived at.

For this example we have used a 4" O.D. x ½" (.500") wall seamless tube. Since the nominal wall is .500", the maximum allowable tolerances for eccentricity between the O.D. and I.D. circles will be 10 per cent of .500" or .050". In other words, the total difference in wall thickness, due to eccentricity, will be twice the amount that the O.D. and I.D. circles are eccentric.

Eccentricity affects only the wall of the tube—not the O.D. or I.D.

MACHINING OF

SEAMLESS STEEL MECHANICAL TUBING

Selection of a tube size from which it is desired to machine a finished part requires consideration of three main factors:

1. Make sure that if all dimensions vary to the extreme limits permitted by that size there will still be ample stock to insure that the part will clean up in machining.

2. The method of chucking is of utmost importance. If the tube is chucked true to the O.D. circle the eccentricity will appear on the inside and must be taken into account in cleaning up the inside diameter. If the tube is chucked true to the I.D. circle the reverse is true and the eccentricity must be taken into account on the outside diameter.

3. The amount of stock to be removed by any one tool cut should be known and due allowance made for this amount in the dimensions of the tube.

Selecting the Proper Size of Cold Drawn Tubing: Since cold drawn tubes are normally * worked through a die and over a mandrel, simultaneously, the tendency is, as those tools wear, for the outside diameter variation to be *over* the nominal size and for the inside diameter variation to be *under*. Thus in figuring on machining a cold drawn tube it should be remembered that the nominal O.D. is also the minimum O.D., while the nominal I.D. is the maximum I.D.

*Note: In certain cases tubes cannot be successfully drawn over a mandrel, therefore the I.D. cannot be accurately controlled and wider tolerances are essential. Three such cases are:

1. Tubes with a wall ¾" or heavier.
2. Tubes with I.D. less than 60 per cent of the O.D.
3. Tubes with I.D. less than ½".

Following are typical examples of selecting the proper cold drawn tube size to produce a machined part—it being desired to machine both the O.D. and I.D. to produce a concentric bushing 2.500" O.D. x 1.500" I.D., the minimum depth of the cut on both O.D. and I.D. to be .020".

CASE A

TUBING TO BE FIRST CHUCKED TRUE TO THE O.D. and I.D. bored, then chucked on I.D. and O.D. turned.

2.500"—finished O.D. of tube.
1.500"—finished I.D. of tube.
2/1.000"
.500"—finished wall of tube.
plus .020"—minimum depth cut on O.D.
plus .020"—minimum depth cut on I.D.
.540"—minimum permissible wall in stock tubing.

In the table of tolerances for cold drawn tubing on Page M19 it is seen that the wall variation for this size tube is plus and minus 10 per cent of the nominal wall. Since .540" is the minimum wall allowable in the stock tubing to be used, the stock tubing ordered must have a nominal wall thickness which will give .540" when the 10 per cent for tolerance is deducted.

Hence, $\frac{.540"}{.90}$ = .600"—nominal wall of stock tubing to be used.

After the tube has been made concentric by boring the I.D., the O.D. is turned by chucking on the I.D.

2.500"—O.D. finished tube.
plus .040"—twice minimum cut on O.D.
2.540"—minimum O.D. of stock tube.

From the table on Page M19 it is seen that the minimum O.D. is the nominal O.D. Hence the proper size stock tubing to be ordered under these conditions is:

2.540" O.D. x .600" wall.

CASE B

TUBING TO BE FIRST CHUCKED TRUE TO I.D. and O.D. turned; then chucked on O.D. and I.D. bored.

2.500"—finished O.D. of tube.
1.500"—finished I.D. of tube.
2/1.000"
.500"—finished wall of tube.
plus .020"—minimum depth cut on O.D.
plus .020"—minimum depth cut on I.D.
.540"—minimum permissible wall in stock tubing.

As in the first case the minimum wall is 90 per cent of the nominal wall.

Hence, $\frac{.540"}{.90}$ = .600"—nominal wall of stock tubing.

After the tube has been made concentric by turning the O.D., the I.D. is bored by chucking on the O.D.

1.500"—finished I.D. of tube.
minus .040"—twice minimum cut on I.D.
1.460"—maximum I.D. of stock tubing.

Again from the table on Page M19 it is seen that for this size tube the maximum I.D. is also the nominal I.D., hence:

1.460"—nominal I.D.
plus 1.200"—twice nominal wall.
2.660"—nominal O.D.

Accordingly the proper size stock tubing to order under these conditions is:

2.660" O.D. x .600" wall.

From these two examples it is seen that the Wall Thickness of the stock tube is the same in both cases but the O.D. and I.D. vary, depending upon the sequence of the chucking operations. If the tubing to be machined falls in one of the classes covered by the footnotes to the tables on Pages M19-20, calculate the stock sizes in the same manner, using the O.D., I.D. and Wall tolerances given in the footnotes.

If tubing is to be machined by the customer on both the O.D. and I.D. and nothing is stated on the order or inquiry regarding the sequence of the machining operations, it will be assumed that the tubing is first chucked true to the O.D.

Selecting the Proper Size of Hot Finished Tubing: For reasons already noted, necessarily greater O.D., I.D. and Wall Thickness tolerances are required for hot finished tubing than for cold drawn. It should be remembered that in hot finished tubing the tendency of the diameters to vary from the desired dimensions is about equal in both diameters,

consequently the *mean* O.D. and I.D. are the measurements aimed for. It naturally follows, then, that in working to a mean O.D. and I.D. the mean wall is the desired wall, and is the measurement used in calculating the wall tolerance of 12½ per cent. The following example will illustrate this:

It is desired to produce a hot finished tube 3" O.D. x ½" wall, or 2" I.D. From the table on Page M22 it will be seen that for this size of tubing

The nominal O.D. may vary minus .000", plus .062"
The nominal I.D. may vary plus .000", minus .062"

Minimum O.D.	=	3.000"
Maximum O.D.	=	3.062"
		2/6.062"
Mean O.D.		3.031

Likewise for the I.D.

Maximum I.D.	=	2.000"
Minimum I.D.	=	1.938"
		2/3.938"
Mean I.D.		1.969"

By subtracting the mean I.D. from the mean O.D. and dividing by 2, we find a mean Wall of .531". Since the wall tolerance of 12½ per cent on hot finished tubing is taken on the mean wall, in this case the limits of wall thickness are .597 to .465.

Following are typical examples of selecting the proper hot finished tube size to produce a machined part, it being desired to produce a concentric bushing 3.500" O.D. x 2.500" I.D. with a minimum cut of .020" on both O.D. and I.D.

CASE A

TUBING TO BE FIRST CHUCKED TRUE TO O.D. and I.D. bored; then chucked on I.D. and O.D. turned.

	3.500"—finished O.D. of tube.
	2.500"—finished I.D. of tube.
	2/1.000"
	.500"—finished wall of tube.
plus	.020"—minimum depth of cut on O.D.
plus	.020"—minimum depth of cut on I.D.
	.540"—minimum permissible wall in stock tubing.

In the table of tolerances for hot finished mechanical tubing on Page M22 it is seen that the wall variation for this size tube is plus and minus 12½ per cent of the mean wall. Since .540" is the minimum wall permissible in the stock tubing to be used, the stock tubing ordered must have a mean wall thickness which will give .540" when the 12½ per cent for tolerance is deducted.

Hence, $\frac{.540''}{.875''}$ = .617″—mean wall of stock tubing.

After the tube has been made concentric by boring the I.D., the O.D. is turned by chucking on the I.D.

3.500″—O.D. finished tube.
plus .040″—twice minimum cut on O.D.
3.540″—minimum O.D. of stock tubing.

From the table on Page M22 it is seen that the minimum O.D. is the nominal O.D. Hence, the proper size hot finished mechanical tubing to be ordered under these conditions is:

3.540″ O.D. x .617″ Mean Wall.

In this case it is important to specify "mean wall," otherwise the order will be executed on the assumption that it is the nominal wall.

CASE B

TUBING TO BE FIRST CHUCKED TRUE TO I.D. and O.D. turned; then chucked on the O.D. and I.D. bored.

3.500″—finished O.D. of tube.
2.500″—finished I.D. of tube.
2/1.000″
.500″—finished wall of tube.
plus .020″—minimum depth of cut on O.D.
plus .020″—minimum depth of cut on I.D.
.540″—minimum permissible wall in stock tubing.

As in the first case the minimum wall is 87½ per cent of the mean wall.

Hence, $\frac{.540''}{.875''}$ = .617″ mean wall of stock tubing.

2.500″—finished I.D. of tube.
minus .040″—twice minimum cut.
2.460″—maximum and nominal I.D. of stock tube.
minus .062″—tolerance on I.D. table on Page M22.
2.398″—minimum I.D. of stock tube.
plus .031″—one-half tolerance on I.D.
2.429″—mean I.D. of stock tube.

2.429″—mean I.D. of stock tube.
plus 1.234″—twice mean wall.
3.663″—mean O.D. of stock tubing.
minus .031″—one-half O.D. tolerance.
3.632″—nominal O.D. of stock tube.

Hence, proper size tube to order is:

3.632″ O.D. x .617″ MEAN wall.

As in Case A, the customer should specify "mean wall."

TOLERANCES

ROUND SEAMLESS MECHANICAL TUBING

COLD DRAWN

PERMISSIBLE VARIATIONS IN THE OUTSIDE AND INSIDE DIAMETERS AND WALL THICKNESSES

The letters a, b and c in the table below refer to Notes on the following page M-20

Group	Size O. D., Inches	PERMISSIBLE VARIATIONS FROM					
		Outside Diameter Inches		Inside Diameter Inches		Wall Thickness Percent	
		Over	Under	Over	Under	Over	Under
1	3/16 to 1/2, excl.	0.004	0	a, b	a, b	a, b	a, b
2	1/2 to 1 1/2, excl.	0.005c	0c	0a, b	0.005a, b	10a, b	10a, b
3	1 1/2 to 3 1/2, excl.	0.010c	0c	0a	0.010a	10a	10a
4	3 1/2 to 5 1/2, excl.	0.015c	0c	0.005a	0.015a	10a	10a
5	5 1/2 to 8, excl. when wall is less than 5% of O. D.	0.030c	0.030c	0.035c	0.035c	10	10
6	5 1/2 to 8, excl. when wall is from 5% to 7.5% of O. D.	0.020	0.020	0.025	0.025	10	10
7	5 1/2 to 8, excl. when wall is over 7.5% of O. D.	0.030	0	0.015a	0.030a	10a	10a
8	8 to 10 3/4 incl. when wall is less than 5% of O. D.	0.045c	0.045c	0.050c	0.050c	10	10
9	8 to 10 3/4, incl., when wall is from 5% to 7.5% of O. D.	0.035	0.035	0.040	0.040	10	10
10	8 to 10 3/4, incl., when wall is over 7.5% of O. D.	0.045	0	0.015a	0.040a	10a	10a

Please refer to **Explanatory Notes** to above Table as shown on the following pages M20 and M21

(See page M20)

PERMISSIBLE VARIATIONS IN THE DIAMETERS AND WALL THICKNESSES OF ROUND SEAMLESS COLD DRAWN MECHANICAL TUBING

The following notes refer to TABLE shown on the previous page.

(a) For tubes with inside diameter less than 50 percent of outside diameter or with wall thickness more than 25 percent of outside diameter, or with wall thickness over 1¼ inches, or weighing more than 90 lb. per ft. which cannot be successfully drawn over a mandrel, the inside diameter may vary over or under by an amount equal to 10 percent of the wall thickness. The wall thickness may vary 12½% over or under that specified.

(b) For tubes with inside diameter less than ½ inch (or less than ⅝ inches when the wall thickness is more than 20 percent of the outside diameter), which cannot be successfully drawn over a mandrel, the wall thickness may vary 15 percent over or under that specified and the inside diameter will be governed by the outside diameter and wall thickness variations.

(c) Tubing having a wall thickness less than 3% of the outside diameter cannot be straightened properly without a certain amount of distortion. Consequently such tubes while having an average outside diameter and inside diameter within the tolerances shown in Table on Page M 19, will require an ovality tolerance of ½ percent over or under the nominal outside diameter and inside diameter, this being in addition to the tolerances indicated in the table on Page M 19.

EXPLANATORY NOTES TO TABLE SHOWN ON PAGE M 19

The outside and inside diameters and wall thickness tolerances APPLY ONLY TO NOMINAL SIZES and to UNANNEALED AND FINISHED ANNEALED TUBING.

Tubing having relatively heavy or light wall in relation to the outside diameter is covered by special tolerances, reference to which is made in the notes above.

Finished and unannealed tubing constitute the bulk of COLD DRAWN MECHANICAL TUBING. Tubes which have been given a softer anneal are apt to possess more or less ovality or out-of-roundness, due to warping in annealing, or to the subsequent straightening operations. The higher temperature used in making the softer anneals, with the attendant increase in scale also affects the accuracy of diameter. Therefore, medium or soft annealed tubes will not be as close to size as the table indicates.

PERMISSIBLE VARIATIONS IN THE DIAMETERS AND WALL THICKNESSES OF ROUND SEAMLESS COLD DRAWN MECHANICAL TUBING

Tolerances are applicable only to two dimensions (length excepted). Thus, if outside diameter and wall thickness are specified, the theoretical inside diameter may not conform to published tolerances. If outside diameter and inside diameter are specified, the wall thickness may not conform to published tolerances except that the mean or average wall thickness (taking into account the permissible outside diameter and inside diameter tolerances) will not vary more than indicated under Permissible Variations in Wall Thickness, Table on Page M 19.

EXAMPLE

If a cold-drawn tube is specified to be 1.500 inches O.D. and 1.250 inches I.D., the theoretical wall thickness might be expected to be held to a variation of 10 percent over or under, or within the limits of 0.1125 to 0.1375 inches.

However, a nominal O.D. of 1.500 inches may vary between 1.500 inches and 1.510 inches (average 1.505 inches) and the I.D. may vary between 1.240 inches and 1.250 inches (average 1.245 inches), resulting in an average or mean wall thickness of 0.130 inch instead of 0.125 inch. Consequently the wall thickness may vary 10 percent over or under from the mean of 0.130 inch, or within the limits of 0.117 to 0.143 inch.

Therefore, if the three dimensions O.D., I.D. and wall thickness are specified, it would be impracticable to meet all three of the tolerances specified for them. If, in the above case, all three of the dimensions were specified, a wall thickness tolerance of 0.1125 to 0.1375 inch would be required, which is obviously inconsistent with the actual average wall thickness resulting from standard O.D. and I.D. tolerances.

Standard tolerances on commercially exact lengths are:

Tubes cut 4′ and shorter	Plus $\frac{1}{16}$″	Minus .000″
Over 4′ to 10′, inclusive	Plus $\frac{3}{32}$″	Minus .000″
Over 10′	Plus $\frac{1}{8}$″	Minus .000″

TOLERANCES

ROUND SEAMLESS MECHANICAL TUBING

HOT FINISHED

PERMISSIBLE VARIATIONS IN THE OUTSIDE AND INSIDE DIAMETERS AND WALL THICKNESSES

Group	Size Outside Diameter in Inches	Ratio of Wall Thickness to Outside Diameter, Percent	PERMISSIBLE VARIATIONS FROM					
			Outside Diameter, Inches		Inside Diameter, Inches		Wall Thickness, Percent	
			Over	Under	Over	Under	Over	Under
1	Under 3	All wall thicknesses	1/64	0	0	1/32a	12.5b	12.5b
2a	3 to 5½, excl.	All wall thicknesses	1/32	0	0	1/64a	12.5b	12.5b
2b	5½ to 10¾, incl.	7½ or over	1/32	0	0	1/64a	12.5b	12.5b
3	5½ to 8, excl.	Under 5	1/64	1/64	..	..	12.5c	12.5c
4	5½ to 8, excl.	5 to 7½, excl.	1/32	1/32	..	..	12.5c	12.5c
5	8 to 10¾, incl.	Under 3	1/32	1/32	..	..	12.5c	12.5c
6	8 to 10¾, incl.	5 to 7½, excl.	1/64	1/64	..	..	12.5c	12.5c

(a) Permissible variations from inside diameters apply only to tubes having an inside diameter not less than 75% of the outside diameter.

(b) Mean Wall Thickness.

(c) Wall Thickness as ordered.

NOTE: The recognized standard range of sizes of hot-finished tubes is 1½ inch to 10¾ inches outside diameter. The wall thickness cannot be less than 0.095 inch (No. 13 B.W.G.) and must be 3 percent or more of the outside diameter. For sizes under 1½ inches or over 10¾ inches outside diameter the permissible variations are a matter of agreement between the purchaser and the manufacturer.

Standard tolerances on commercially exact lengths are:
(See Maximum Length Tables, Pages M24–M29)

Tubes cut 4′ and shorter	Plus 1/16″	Minus .000″
Over 4′ to 10′, inclusive	Plus 3/32″	Minus .000″
Over 10′	Plus 1/8″	Minus .000″

FORMED AND HEAT TREATED

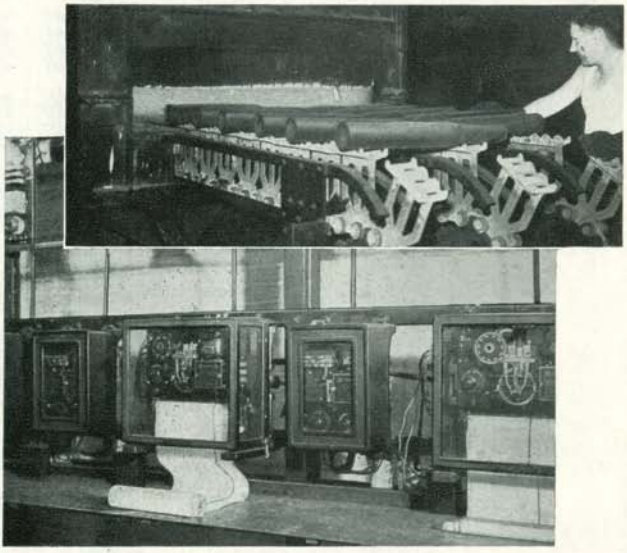
SEAMLESS STEEL MECHANICAL TUBING

Pittsburgh Steel Company has specialized for many years in forming seamless tubing for the automotive and other industries. We have much special equipment of our own design for upsetting, swaging, expanding, tapering, flanging, spinning and bending Pittsburgh Seamless material to meet your requirements with a minimum of manufacturing operations in your own plant.

In addition to this equipment for hot and cold forming operations we also have modern electrically-controlled heat treating furnaces that enable us to offer a complete mechanical tube service—flexible to your specifications from the blast furnace to the finished tubes.

It is needless to cite the many advantages of using seamless steel tubing instead of solid forgings for formed parts. Where light weight, extra strength and easy machineability are important considerations, seamless tubing is ideal.

Our engineers, always at your service, will be glad to assist in any problem you may have involving the application of formed tubing.



Automobile axle housings leaving a heat treating furnace. Inset: Heat treating temperatures are controlled within very narrow limits by electric recorders and automatic control switches.

ROUND HOT FINISHED

SEAMLESS STEEL MECHANICAL TUBING

Maximum finished lengths in feet.

Wall Thickness		OUTSIDE DIAMETER										
B.W.G. Fraction of Inch	Decimal Equivalent	1½"	1.660"	1¾"	1⅞"	2"	2¼"	2½"	2¾"	2⅞"	3"	3¼"
No. 12	.109"	.....	.....	.....	26′	26′	24′	22′	22′	.....	.....	.....
No. 11	.120"	20′	26′	26′	26′	26′	26′	27′	26′	25′	25′	39′
No. 10	.134"	22′	31′	31′	27′	26′	27′	27′	26′	25′	30′	40′
No. 9	.148"	24′	31′	31′	28′	26′	27′	27′	26′	25′	30′	42′
No. 8	.165"	24′	31′	31′	28′	27′	27′	27′	26′	25′	30′	45′
No. 7	.180"	24′	31′	31′	28′	28′	27′	27′	26′	25′	30′	45′
No. 6	.203"	24′	31′	31′	28′	28′	27′	27′	26′	25′	30′	45′
No. 5	.220"	.....	.....	.....	.....	27′	25′	27′	26′	25′	30′	44′
No. 4	.238"	.....	.....	.....	.....	26′	24′	27′	26′	25′	30′	40′
¼"	.250"	.....	.....	.....	.....	26′	23′	27′	26′	25′	30′	38′
9/32"	.281"	.....	.....	.....	.....	24′	22′	25′	24′	25′	28′	31′
5/16"	.313"	.....	.....	.....	.....	22′	22′	24′	24′	24′	26′	31′

Wall Thickness		OUTSIDE DIAMETER									
B.W.G. or Fraction of Inch	Decimal Equivalent	3½"	4"	4¼"	4½"	4¾"	5"	5¼"	5½"	5¾"	6"	6¼"
No. 11	.120"	35′	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
No. 10	.134"	38′	30′	30′	30′	25′	25′	.....	.....	.....	.....	.....
No. 9	.148"	40′	36′	30′	30′	30′	30′	30′	30′	30′	.....	.....
No. 8	.165"	43′	38′	38′	38′	35′	30′	30′	30′	30′	30′	.....
No. 7	.180"	45′	40′	40′	40′	35′	35′	35′	30′	30′	30′	30′
No. 6	.203"	45′	45′	45′	45′	45′	40′	40′	40′	40′	40′	40′
No. 5	.220"	45′	45′	45′	45′	45′	40′	40′	40′	40′	40′	40′
No. 4	.238"	45′	45′	45′	45′	45′	45′	45′	45′	40′	40′	40′
¼"	.250"	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	40′
9/32"	.281"	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′
5/16"	.313"	40′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′
11/32"	.344"	36′	44′	42′	45′	45′	45′	45′	45′	45′	44′	42′
3/8"	.375"	34′	42′	39′	45′	44′	45′	45′	45′	43′	40′	39′
13/32"	.406"	32′	37′	36′	44′	42′	45′	44′	41′	39′	35′	34′
7/16"	.438"	29′	36′	34′	41′	38′	43′	41′	38′	37′	34′	33′
15/32"	.469"	.....	34′	32′	38′	36′	40′	38′	36′	34′	33′	32′
½"	.500"	.....	32′	30′	36′	34′	38′	35′	34′	31′	35′	34′
17/32"	.531"	.....	29′	29′	34′	32′	36′	33′	31′	29′	33′	32′
9/16"	.563"	.....	26′	27′	33′	30′	34′	32′	29′	28′	31′	30′
19/32"	.594"	.....	26′	25′	30′	29′	32′	30′	29′	27′	30′	28′
5/8"	.625"	.....	26′	24′	29′	28′	31′	29′	32′	30′	29′	27′
21/32"	.656"	.....	.....	.....	28′	26′	29′	28′	30′	29′	27′	26′
11/16"	.688"	.....	.....	.....	27′	25′	28′	27′	29′	28′	26′	25′
23/32"	.719"	.....	.....	.....	26′	24′	27′	25′	28′	27′	25′	24′
¾"	.750"	.....	.....	.....	25′	23′	26′	24′	27′	26′	24′	23′
25/32"	.781"	.....	.....	.....	.....	.....	25′	23′	26′	25′	23′	22′
13/16"	.813"	.....	.....	.....	.....	.....	25′	22′	25′	24′	22′	21′
27/32"	.844"	.....	.....	.....	.....	.....	24′	22′	24′	23′	21′	21′
⅞"	.875"	.....	.....	.....	.....	.....	23′	21′	23′	22′	21′	20′
15/16"	.938"	.....	.....	.....	.....	.....	.....	.....	22′	21′	20′	19′
1"	1.000"	.....	.....	.....	.....	.....	.....	.....	21′	20′	19′	18′

These Maximum Lengths apply only to Regular Carbon Steels—Maximum Lengths for Special Chemical Analyses on Application.

ROUND HOT FINISHED SEAMLESS STEEL MECHANICAL TUBING (Continued)

Maximum finished lengths in feet.

Wall Thickness		OUTSIDE DIAMETER										
B.W.G. or Fraction of Inch	Decimal Equivalent	6½"	6⅝"	7"	7¼"	7⅜"	7½"	7⅝"	7¾"	8"	8⅛"	8¼"
No. 6	.203"	40′	40′	.....	.....	.....	.....	.....	.....	.....	.....	.....
No. 5	.220"	40′	40′	.....	.....	.....	.....	.....	.....	.....	.....	.....
No. 4	.238"	40′	40′	.....	.....	.....	.....	.....	.....	.....	.....	.....
¼"	.250"	40′	40′	.....	.....	.....	.....	.....	.....	.....	.....	.....
9/32"	.281"	45′	45′	43′	43′	43′	43′	43′	43′	43′	43′	43′
5/16"	.313"	44′	43′	43′	43′	43′	43′	43′	43′	43′	43′	43′
11/32"	.344"	40′	43′	.....	.....	.....	.....	.....	.....	.....	.....	.....
⅜"	.375"	37′	43′	43′	43′	43′	43′	43′	43′	43′	43′	43′
13/32"	.406"	34′	43′	.....	.....	.....	.....	.....	.....	.....	.....	.....
7/16"	.438"	32′	43′	43′	43′	43′	43′	43′	43′	43′	43′	43′
15/32"	.469"	30′	43′	.....	.....	.....	.....	.....	.....	.....	.....	.....
½"	.500"	32′	43′	43′	43′	43′	43′	43′	43′	43′	43′	43′
17/32"	.531"	30′	43′	.....	.....	.....	.....	.....	.....	.....	.....	.....
9/16"	.563"	29′	43′	43′	43′	43′	43′	42′	42′	42′	42′	42′
19/32"	.594"	27′	43′	.....	.....	.....	.....	.....	.....	.....	.....	.....
⅝"	.625"	26′	43′	43′	41′	41′	41′	40′	40′	40′	40′	40′
21/32"	.656"	25′	41′	.....	.....	.....	.....	.....	.....	.....	.....	.....
11/16"	.688"	24′	41′	40′	40′	40′	40′	36′	36′	36′	36′	36′
23/32"	.719"	23′	41′	.....	.....	.....	.....	.....	.....	.....	.....	.....
¾"	.750"	22′	40′	37′	36′	36′	36′	33′	33′	33′	33′	33′
25/32"	.781"	21′	35′	.....	.....	.....	.....	.....	.....	.....	.....	.....
13/16"	.813"	20′	35′	35′	34′	34′	34′	31′	31′	31′	30′	30′
27/32"	.844"	19′	30′	.....	.....	.....	.....	.....	.....	.....	.....	.....
⅞"	.875"	19′	30′	31′	31′	31′	31′	29′	29′	29′	28′	28′
15/16"	.938"	18′	17′	30′	30′	30′	29′	28′	28′	26′	25′	25′
1"	1.000"	17′	16′	29′	29′	29′	28′	27′	27′	25′	24′	24′
1⅛"	1.125"	.....	.....	.....	27′	27′	26′	24′	24′	22′	20′	20′
1¼"	1.250"	.....	.....	.....	.....	.....	23′	22′	22′	20′	19′	19′
1⅜"	1.375"	.....	.....	.....	.....	.....	.....	.....	20′	18′	18′	18′
1½"	1.500"	.....	.....	.....	.....	.....	.....	.....	.....	17′	16′	16′
1⅝"	1.625"	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15′

Wall Thickness		OUTSIDE DIAMETER										
Fraction of Inch	Decimal Equivalent	8½"	8⅝"	8¾"	9"	9¼"	9½"	9⅝"	9¾"	10"	10¼"	10½"
9/32"	.281"	43′	43′	43′	43′	43′	43′	43′	43′	43′	.....	.....
5/16"	.313"	43′	43′	43′	43′	43′	43′	43′	43′	43′	43′	43′
⅜"	.375"	43′	43′	43′	43′	43′	43′	43′	43′	43′	43′	43′
7/16"	.438"	43′	43′	43′	43′	43′	43′	43′	43′	43′	43′	43′
½"	.500"	43′	43′	43′	43′	43′	43′	43′	43′	43′	43′	43′
9/16"	.563"	42′	43′	43′	42′	42′	42′	42′	42′	42′	42′	42′
⅝"	.625"	43′	43′	43′	40′	40′	40′	39′	39′	39′	39′	39′
11/16"	.688"	39′	39′	39′	39′	39′	39′	36′	36′	36′	36′	36′
¾"	.750"	38′	38′	38′	38′	38′	38′	32′	32′	32′	32′	32′
13/16"	.813"	34′	34′	34′	34′	34′	33′	32′	32′	32′	32′	32′
⅞"	.875"	33′	33′	32′	32′	32′	32′	31′	31′	31′	31′	31′
15/16"	.938"	32′	32′	31′	31′	31′	31′	30′	30′	30′	30′	30′
1"	1.000"	31′	31′	27′	27′	27′	27′	29′	29′	29′	29′	29′
1⅛"	1.125"	26′	26′	24′	24′	24′	24′	26′	26′	26′	26′	26′
1¼"	1.250"	23′	23′	22′	22′	22′	22′	24′	24′	24′	24′	24′
1⅜"	1.375"	22′	20′	20′	20′	20′	20′	22′	22′	22′	22′	22′
1½"	1.500"	20′	19′	19′	19′	19′	19′	20′	20′	20′	20′	20′
1⅝"	1.625"	19′	19′	19′	19′	19′	19′	18′	18′	18′	18′	18′
1¾"	1.750"	17′	17′	17′	17′	17′	17′	17′	17′	17′	17′	17′
2"	2.000"	.....	15′	15′	15′	15′	15′	15′	15′	15′	15′	15′

These Maximum Lengths apply only to Regular Carbon Steels—Maximum Lengths for Special Chemical Analyses on Application.

ROUND HOT FINISHED SEAMLESS STEEL MECHANICAL TUBING (Continued)

Maximum finished lengths in feet.

Wall Thickness		OUTSIDE DIAMETER										
Fraction of Inch	Decimal Equivalent	10⅝"	10¾"	10⅞"	11"	11¼"	11½"	11¾"	12"	12¼"	12½"	12⅝"
5/16"	.313"	43′	43′	43′	43′	.....	.....	.....	.....	.....	.....	.....
3/8"	.375"	43′	43′	43′	43′	43′	43′	43′	43′	43′	43′	43′
7/16"	.438"	43′	43′	43′	43′	43′	43′	42′	42′	42′	42′	42′
1/2"	.500"	43′	43′	43′	43′	43′	43′	41′	41′	41′	40′	40′
9/16"	.563"	42′	43′	43′	43′	43′	43′	40′	40′	40′	40′	40′
5/8"	.625"	39′	41′	41′	41′	41′	40′	39′	39′	39′	39′	38′
11/16"	.688"	36′	40′	40′	40′	40′	40′	38′	38′	38′	38′	38′
3/4"	.750"	32′	39′	39′	39′	39′	37′	36′	36′	36′	35′	35′
13/16"	.813"	32′	37′	37′	37′	37′	36′	34′	34′	34′	34′	34′
7/8"	.875"	31′	35′	35′	35′	35′	33′	32′	32′	31′	31′	30′
15/16"	.938"	30′	33′	33′	33′	33′	32′	30′	30′	30′	30′	29′
1"	1.000"	29′	31′	31′	31′	31′	29′	28′	28′	28′	27′	27′
1 1/16"	1.125"	26′	27′	27′	27′	27′	26′	25′	25′	25′	24′	24′
1 1/4"	1.250"	24′	25′	25′	25′	25′	24′	23′	23′	23′	22′	22′
1 3/8"	1.375"	22′	23′	23′	23′	23′	23′	22′	22′	21′	21′	20′
1 1/2"	1.500"	20′	21′	21′	21′	21′	21′	20′	20′	19′	19′	18′
1 5/8"	1.625"	18′	19′	19′	19′	19′	19′	19′	19′	18′	18′	17′
1 3/4"	1.750"	17′	18′	18′	18′	18′	18′	18′	18′	18′	17′	16′
2"	2.000"	15′	16′	16′	16′	16′	16′	16′	16′	15′	15′	14′

Wall Thickness		OUTSIDE DIAMETER										
Fraction of Inch	Decimal Equivalent	12¾"	12⅞"	13"	13¼"	13⅜"	13½"	13¾"	14"	14¼"	14⅜"	
3/8"	.375"	43′	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
7/16"	.438"	43′	43′	43′	43′	43′	43′	.....	.....	.....	.....	.....
1/2"	.500"	40′	40′	41′	41′	42′	42′	42′	.....	.....	.....	.....
9/16"	.563"	40′	40′	40′	40′	40′	40′	40′	.....	.....	.....	.....
5/8"	.625"	38′	38′	38′	38′	38′	38′	38′	35′	.....	.....	.....
11/16"	.688"	38′	37′	37′	36′	36′	36′	36′	33′	.....	.....	.....
3/4"	.750"	34′	34′	34′	33′	32′	32′	32′	32′	32′	.....	.....
13/16"	.813"	34′	34′	34′	33′	31′	31′	31′	30′	30′	.....	.....
7/8"	.875"	30′	30′	30′	30′	30′	30′	30′	28′	28′	26′	.....
15/16"	.938"	29′	29′	29′	28′	28′	27′	27′	26′	26′	24′	.....
1"	1.000"	27′	27′	27′	27′	27′	26′	25′	24′	24′	23′	.....
1 1/8"	1.125"	24′	24′	24′	24′	24′	23′	23′	22′	22′	21′	.....
1 1/4"	1.250"	22′	22′	22′	21′	21′	21′	21′	19′	19′	19′	.....
1 3/8"	1.375"	20′	20′	20′	20′	19′	19′	19′	18′	18′	17′	.....
1 1/2"	1.500"	18′	18′	18′	18′	18′	17′	17′	17′	16′	16′	.....
1 5/8"	1.625"	17′	17′	17′	16′	16′	16′	16′	15′	15′	14′	.....
1 3/4"	1.750"	16′	16′	16′	15′	15′	15′	15′	14′	14′	13′	.....
2"	2.000"	14′	14′	14′	13′	13′	13′	13′	12′	12′	12′	.....
2 1/8"	2.125"	.....	.....	.....	.....	12′	11′	11′	10′	10′	10′	.....
2 1/4"	2.250"	.....	.....	.....	.....	11′	10′	10′	9′	9′	9′	.....
2 3/8"	2.375"	.....	.....	.....	.....	10′	9′	9′	8′	8′	8′	.....
2 1/2"	2.500"	.....	.....	.....	.....	10′	9′	9′	8′	8′	8′	.....

These Maximum Lengths apply only to Regular Carbon Steels—Maximum Lengths for Special Chemical Analyses on Application.

COLD DRAWN

SEAMLESS STEEL MECHANICAL TUBING

Maximum finished lengths in feet.

Wall Thickness		OUTSIDE DIAMETER											
B.W.G. Fraction of Inch	Decimal Equivalent	½"	9/16"	5/8"	11/16"	¾"	7/8"	1"	1 1/8"	1 ¼"	1 3/8"	1 ½"	1 5/8"
No. 22	.028"	22′	22′	22′	22′	22′	22′	22′	22′	22′	22′	22′	20′
No. 21	.032"	22′	22′	22′	22′	22′	22′	22′	22′	22′	22′	22′	20′
No. 20	.035"	22′	22′	22′	22′	22′	22′	22′	22′	22′	22′	22′	22′
No. 19	.042"	22′	22′	22′	22′	22′	22′	22′	22′	22′	22′	22′	22′
No. 18	.049"	22′	22′	22′	22′	22′	22′	25′	25′	25′	25′	25′	25′
No. 17	.058"	22′	22′	22′	22′	22′	25′	30′	30′	30′	30′	30′	30′
No. 16	.065"	25′	27′	27′	27′	27′	27′	30′	30′	30′	30′	32′	32′
No. 15	.072"	25′	27′	27′	27′	27′	27′	30′	30′	30′	30′	32′	32′
No. 14	.083"	25′	27′	27′	27′	27′	27′	30′	30′	30′	30′	32′	32′
No. 13	.095"	25′	27′	27′	27′	30′	35′	40′	40′	40′	40′	40′	45′
No. 12	.109"	25′	27′	27′	30′	35′	40′	45′	45′	45′	45′	45′	45′
No. 11	.120"	25′	27′	27′	30′	35′	40′	45′	45′	45′	45′	45′	45′
No. 10	.134"	25′	27′	27′	30′	35′	40′	45′	45′	45′	45′	45′	45′
No. 9	.148"	25′	27′	27′	30′	35′	40′	45′	45′	45′	45′	45′	45′
No. 8	.165"	25′	27′	27′	30′	35′	40′	45′	45′	45′	45′	45′	45′
No. 7	.180"	25′	27′	27′	30′	35′	40′	45′	45′	45′	45′	45′	45′
No. 6	.203"	.....	.....	27′	30′	35′	40′	45′	45′	45′	45′	45′	45′
No. 5	.220"	.....	.....	27′	30′	35′	40′	45′	45′	45′	45′	45′	45′
No. 4	.238"	.....	.....	.....	30′	35′	40′	45′	45′	45′	45′	45′	45′
No. 3	.259"	.....	.....	.....	.....	.....	35′	40′	40′	40′	40′	40′	45′
No. 2	.284"	.....	.....	.....	.....	.....	30′	35′	35′	35′	35′	35′	35′
No. 1	.300"	.....	.....	.....	.....	.....	.....	35′	35′	35′	35′	35′	35′
No. 0	.340"	.....	.....	.....	.....	.....	.....	30′	30′	30′	30′	35′	35′
3/8"	.375"	.....	.....	.....	.....	.....	.....	30′	30′	30′	30′	30′	35′
7/16"	.438"	.....	.....	.....	.....	.....	.....	.....	.....	30′	30′	30′	30′
½"	.500"	.....	.....	.....	.....	.....	.....	.....	.....	.....	30′	30′	30′
9/16"	.563"	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	30′

Wall Thickness		OUTSIDE DIAMETER											
B.W.G.	Decimal Equivalent	1 ¾"	1 7/8"	2"	2 1/8"	2 ¼"	2 3/8"	2 ½"	2 ¾"	3"	3 ¼"	3 ½"	3 ¾"
No. 20	.035"	22′	22′	22′	20′	20′	.....	.....	.....	.....	.....	.....	.....
No. 19	.042"	22′	22′	22′	20′	20′	20′	.....	.....	.....	.....	.....	.....
No. 18	.049"	25′	24′	23′	21′	20′	20′	20′	20′	20′	20′	20′	.....
No. 17	.058"	30′	25′	24′	23′	22′	22′	22′	22′	22′	22′	22′	.....
No. 16	.065"	32′	30′	30′	30′	30′	30′	30′	30′	30′	25′	25′	25′
No. 15	.072"	32′	30′	30′	30′	30′	30′	30′	30′	30′	25′	25′	25′
No. 14	.083"	32′	32′	32′	32′	32′	32′	30′	30′	30′	28′	28′	28′
No. 13	.095"	45′	45′	45′	45′	45′	45′	32′	32′	32′	30′	30′	30′
No. 12	.109"	45′	45′	45′	45′	45′	45′	40′	40′	40′	40′	40′	40′
No. 11	.120"	45′	45′	45′	45′	45′	45′	40′	40′	40′	40′	40′	40′
No. 10	.134"	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′
No. 9	.148"	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′
No. 8	.165"	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′
No. 7	.180"	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′
No. 6	.203"	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′
No. 5	.220"	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′

These Maximum Lengths apply only to Regular Carbon Steels—Maximum Lengths for Special Chemical Analyses on Application. In many instances, by means of Special Setups, it is possible to manufacture Cold Drawn Tubing to Longer Lengths than shown. When Longer Lengths are required, the matter should be referred to the Mill

COLD DRAWN SEAMLESS STEEL MECHANICAL TUBING (Continued)

Maximum finished lengths in feet.

Wall Thickness		OUTSIDE DIAMETER											
B.W.G. Fraction of Inch	Decimal Equivalent	1¾"	1⅞"	2"	2⅛"	2¼"	2⅜"	2½"	2¾"	3"	3¼"	3½"	3¾"
No. 4	.238"	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′
No. 3	.259"	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′
No. 2	.284"	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′
No. 1	.300"	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′
No. 0	.340"	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′
3/8"	.375"	40′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′
7/16"	.438"	35′	40′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′
1/2"	.500"	35′	40′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′
9/16"	.563"	35′	40′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′
5/8"	.625"	.....	40′	40′	40′	40′	40′	40′	40′	40′	40′	40′	40′
11/16"	.688"	.....	.....	.....	35′	35′	35′	35′	35′	35′	35′	35′	35′
3/4"	.750"	.....	.....	.....	.....	.....	.....	30′	30′	30′	30′	30′	30′
13/16"	.813"	.....	.....	.....	.....	.....	.....	30′	30′	30′	30′	30′	30′
7/8"	.875"	.....	.....	.....	.....	.....	.....	.....	.....	25′	25′	25′	25′
15/16"	.938"	.....	.....	.....	.....	.....	.....	.....	.....	20′	20′	20′	20′
1"	1.000"	.....	.....	.....	.....	.....	.....	.....	.....	20′	20′	20′	20′
1 1/16"	1.063"	.....	.....	.....	.....	.....	.....	.....	.....	.....	20′	20′	20′

Wall Thickness		OUTSIDE DIAMETER										
B.W.G. Fraction of Inch	Decimal Equivalent	4"	4¼"	4½"	4¾"	5"	5¼"	5½"	5¾"	6"	6¼"	6½"
No. 16	.065"	25′	25′	25′	25′	25′	.....	.....	.....	.....	.....	.....
No. 15	.072"	25′	25′	25′	25′	25′	.....	.....	.....	.....	.....	.....
No. 14	.083"	25′	25′	25′	25′	25′	.....	.....	.....	.....	.....	.....
No. 13	.095"	30′	30′	30′	30′	30′	30′	30′	.....	.....	.....	.....
No. 12	.109"	40′	40′	40′	40′	40′	40′	40′	40′	40′	.....	.....
No. 11	.120"	40′	40′	40′	40′	40′	40′	40′	40′	40′	40′	40′
No. 10	.134"	45′	45′	45′	45′	40′	40′	40′	40′	40′	40′	40′
No. 9	.148"	45′	45′	45′	45′	42′	42′	42′	42′	42′	42′	42′
No. 8	.165"	45′	45′	45′	45′	45′	45′	42′	42′	42′	42′	42′
No. 7	.180"	45′	45′	45′	45′	45′	45′	45′	45′	42′	42′	42′
No. 6	.203"	45′	45′	45′	45′	45′	45′	45′	45′	42′	42′	42′
No. 5	.220"	45′	45′	45′	45′	45′	45′	45′	45′	42′	42′	42′
No. 4	.238"	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′
No. 3	.259"	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′
No. 2	.284"	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′
No. 1	.300"	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′
No. 0	.340"	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′
3/8"	.375"	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′
7/16"	.438"	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′
1/2"	.500"	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′
9/16"	.563"	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′	45′
5/8"	.625"	40′	40′	40′	40′	40′	40′	40′	40′	40′	40′	40′
11/16"	.688"	35′	35′	35′	35′	35′	35′	35′	40′	40′	40′	40′
3/4"	.750"	30′	30′	30′	30′	35′	35′	35′	35′	35′	35′	35′
13/16"	.813"	30′	30′	30′	30′	30′	30′	30′	30′	30′	30′	30′
7/8"	.875"	30′	30′	30′	30′	30′	30′	30′	30′	30′	30′	30′
15/16"	.938"	25′	25′	28′	28′	28′	28′	28′	28′	28′	28′	28′
1"	1.000"	22′	22′	22′	22′	26′	26′	26′	26′	26′	26′	26′
1 1/16"	1.063"	20′	20′	20′	20′	25′	25′	25′	25′	25′	25′	25′
1 1/8"	1.125"	20′	20′	20′	20′	22′	22′	22′	22′	22′	22′	22′
1 3/16"	1.188"	.....	.....	.....	.....	22′	22′	22′	22′	22′	22′	22′
1 1/4"	1.250"	.....	.....	.....	.....	20′	20′	20′	20′	20′	20′	20′

These Maximum Lengths apply only to Regular Carbon Steels—Maximum Lengths for Special Chemical Analyses on Application. In many instances, by means of Special Setups, it is possible to manufacture Cold Drawn Tubing to Longer Lengths than shown. When Longer Lengths are required, the matter should be referred to the Mill.

COLD DRAWN SEAMLESS STEEL MECHANICAL TUBING (Continued)

Maximum finished lengths in feet.

Wall Thickness		OUTSIDE DIAMETER										
B.W.G. Fraction of Inch	Decimal Equivalent	6¾"	7"	7¼"	7½"	7¾"	8"	8¼"	8½"	8¾"	9"	9¼"
No. 11	.120"	40′	40′	40′	.....	.....	.....	.....	.....	.....	.....	.....
No. 10	.134"	40′	40′	40′	40′	40′	40′	.....	.....	.....	.....	.....
No. 9	.148"	42′	42′	42′	42′	42′	42′	42′	42′	42′	.....	.....
No. 8	.165"	42′	42′	42′	42′	42′	42′	42′	42′	42′	.....	.....
No. 7	.180"	42′	42′	42′	42′	42′	42′	42′	42′	42′	42′	.....
No. 6	.203"	42′	42′	42′	42′	42′	42′	42′	42′	42′	42′	42′
No. 5	.220"	42′	42′	42′	42′	42′	42′	42′	42′	42′	42′	42′
No. 4	.238"	45′	45′	45′	45′	45′	45′	42′	42′	42′	42′	42′
No. 3	.259"	45′	45′	45′	45′	45′	45′	42′	41′	41′	41′	41′
No. 2	.284"	45′	45′	45′	45′	45′	45′	40′	40′	40′	40′	40′
No. 1	.300"	45′	45′	45′	45′	45′	45′	40′	40′	40′	40′	39′
No. 0	.340"	45′	45′	45′	45′	45′	45′	40′	40′	40′	40′	38′
3/8"	.375"	45′	45′	45′	45′	45′	45′	40′	40′	40′	40′	37′
7/16"	.438"	45′	45′	45′	45′	45′	40′	40′	40′	40′	40′	36′
1/2"	.500"	45′	45′	45′	45′	40′	40′	40′	40′	40′	40′	35′
9/16"	.563"	45′	45′	45′	45′	40′	40′	40′	40′	40′	37′	34′
5/8"	.625"	40′	40′	40′	40′	40′	40′	40′	40′	40′	35′	33′
11/16"	.688"	40′	40′	40′	40′	40′	40′	40′	40′	40′	34′	32′
3/4"	.750"	35′	35′	35′	35′	35′	35′	35′	35′	35′	33′	31′
13/16"	.813"	30′	30′	30′	30′	30′	30′	30′	30′	30′	30′	30′
7/8"	.875"	30′	30′	30′	30′	30′	30′	30′	30′	30′	30′	28′
15/16"	.938"	28′	28′	28′	28′	28′	28′	28′	28′	28′	28′	27′
1"	1.000"	26′	26′	26′	26′	26′	26′	26′	26′	26′	26′	26′
1 1/16"	1.063"	25′	25′	25′	25′	25′	25′	25′	25′	25′	25′	25′
1 1/8"	1.125"	22′	22′	22′	22′	22′	22′	23′	24′	24′	24′	24′
1 3/16"	1.188"	22′	22′	22′	22′	22′	22′	22′	22′	22′	21′	21′
1 1/4"	1.250"	20′	20′	20′	20′	20′	20′	20′	20′	20′	.....	.....

Wall Thickness		OUTSIDE DIAMETER									
B.W.G. Fraction of Inch	Decimal Equivalent	9½"	9¾"	10"	10¼"	10½"	10¾"	11"	11¼"	11½"	11¾"	12"
No. 5	.220"	42′	42′	41′	.....	.....	.....	.....	.....	.....	.....	.....
No. 4	.238"	41′	41′	40′	39′	39′	.....	.....	.....	.....	.....	.....
No. 3	.259"	40′	40′	39′	38′	38′	36′	35′	34′	32′	31′	30′
No. 2	.284"	39′	39′	38′	37′	37′	35′	34′	33′	31′	30′	29′
No. 1	.300"	38′	38′	37′	36′	36′	34′	33′	32′	30′	29′	28′
No. 0	.340"	37′	37′	36′	35′	35′	33′	32′	31′	29′	28′	27′
3/8"	.375"	36′	36′	35′	34′	34′	32′	31′	30′	28′	27′	26′
7/16"	.438"	35′	35′	34′	33′	33′	31′	30′	29′	27′	26′	25′
1/2"	.500"	34′	34′	33′	32′	32′	30′	29′	28′	26′	25′	24′
9/16"	.563"	33′	33′	32′	31′	31′	29′	28′	27′	25′	24′	23′
5/8"	.625"	32′	32′	31′	30′	30′	28′	27′	26′	24′	23′	22′
11/16"	.688"	31′	31′	30′	29′	29′	27′	26′	25′	23′	22′	21′
3/4"	.750"	30′	30′	29′	28′	28′	26′	25′	24′	22′	21′	20′
13/16"	.813"	29′	29′	28′	27′	27′	25′	24′	23′	21′	20′	.....
7/8"	.875"	28′	28′	27′	26′	26′	24′	23′	22′	20′	.....	.....
15/16"	.938"	27′	27′	26′	25′	25′	23′	22′	21′	.....	.....	.....
1"	1.000"	26′	26′	25′	24′	24′	22′	21′	.....	.....	.....	.....
1 1/16"	1.063"	25′	25′	24′	23′	23′	21′	.....	.....	.....	.....	.....
1 1/8"	1.125"	24′	24′	23′	22′	22′	.....	.....	.....	.....	.....	.....
1 3/16"	1.188"	21′	21′	20′	.....	.....	.....	.....	.....	.....	.....	.....

These Maximum Lengths apply only to Regular Carbon Steels—Maximum Lengths for Special Chemical Analyses on Application. In many instances, by means of Special Setups, it is possible to manufacture Cold Drawn Tubing to Longer Lengths than shown. When Longer Lengths are required, the matter should be referred to the Mill.

MASTER WEIGHT TABLES

FOR ROUND SEAMLESS STEEL MECHANICAL TUBING

EXPLANATION

The weights shown in the following tables are the theoretical weights per lineal foot of average wall round seamless steel tubing, hot finished or cold drawn, and are based on one cubic inch of steel weighing .2833 pounds.

In determining these weights the following formula was used:

$$W = 10.68\,(D - t)\,t$$

where

W = Weight in pounds per foot (carried to 4 digits)
D = Outside Diameter in inches (to 3 decimal places)
t = Wall Thickness in inches (to 3 decimal places)

All weights are carried to 4 digits only, the fifth digit being carried forward if five (5) or over, or dropped if under five (5).

Outside diameters and wall thicknesses are carried to 3 decimal places, the fourth decimal being carried forward if five (5) or over, or dropped if under five (5).

ROUND

SEAMLESS STEEL MECHANICAL TUBING

Weight in pounds per foot.

Wall Thickness		OUTSIDE DIAMETER IN INCHES								
B.W.G. or Fraction	Decimal Equivalent	1/16" .063	3/32" .094	1/8" .125	3/16" .188	1/4" .250	5/16" .313	3/8" .375	7/16" .438	1/2" .500
No. 36	.004"	.0025	.0038	.0052	.0079	.0105	.0132	.0158	.0185	.0212
No. 35	.005"	.0031	.0048	.0064	.0098	.0131	.0164	.0198	.0231	.0264
No. 34	.007"	.0042	.0065	.0088	.0135	.0182	.0229	.0275	.0322	.0369
No. 33	.008"	.0047	.0073	.0100	.0154	.0207	.0261	.0314	.0367	.0420
No. 32	.009"	.0052	.0082	.0111	.0172	.0232	.0292	.0352	.0412	.0472
No. 31	.010"	.0057	.0090	.0123	.0190	.0256	.0324	.0390	.0457	.0523
No. 30	.012"	.0065	.0105	.0145	.0226	.0305	.0386	.0465	.0546	.0625
No. 29	.013"	.0069	.0112	.0156	.0243	.0329	.0417	.0503	.0590	.0676
No. 28	.014"	.0073	.0120	.0166	.0260	.0353	.0447	.0540	.0634	.0727
No. 27 or 1/64"	.016"	.0080	.0133	.0186	.0294	.0400	.0508	.0613	.0721	.0827
No. 26	.018"	.0087	.0146	.0206	.0327	.0446	.0567	.0686	.0807	.0927
No. 25	.020"	.0092	.0158	.0224	.0359	.0491	.0626	.0758	.0893	.1025
No. 24	.022"	.0096	.0169	.0242	.0390	.0536	.0684	.0829	.0977	.1123
No. 23	.025"	.....	.0184	.0267	.0435	.0601	.0769	.0935	.1103	.1268
No. 22	.028"	.....	.0197	.0290	.0478	.0664	.0852	.1038	.1226	.1411
1/32"	.031"	.....	.0209	.0311	.0520	.0725	.0934	.1139	.1347	.1553
No. 21	.032"	.....	.0212	.0318	.0533	.0745	.0960	.1172	.1388	.1599

ROUND SEAMLESS STEEL MECHANICAL TUBING (Continued)

Weight in pounds per foot.

Wall Thickness		OUTSIDE DIAMETER IN INCHES								
B.W.G. or Fraction	Decimal Equivalent	1/16" .063	3/32" .094	1/8" .125	5/32" .188	1/4" .250	5/16" .313	3/8" .375	7/16" .438	1/2" .500
No. 20	.035"	.....	.0221	.0336	.0572	.0804	.1039	.1271	.1506	.1738
No. 19	.042"	.....	.0233	.0372	.0655	.0933	.1216	.1494	.1776	.2054
3/64"	.047"	.....	.....	.0392	.0708	.1019	.1335	.1646	.1963	.2274
No. 18	.049"	.....	.....	.0398	.0727	.1052	.1382	.1706	.2036	.2360
No. 17	.058"	.....	.....	.0415	.0805	.1189	.1580	.1964	.2354	.2738
1/16"	.063"	.....	.....	.....	.0841	.1258	.1682	.2099	.2523	.2940
No. 16	.065"	.....	.....	.....	.0854	.1284	.1722	.2152	.2589	.3020
No. 15	.072"	.....	.....	.....	.....	.1369	.1853	.2330	.2814	.3291
5/64"	.078"	.....	.....	.....	.....	.1433	.1958	.2474	.2999	.3515
No. 14	.083"	.....	.....	.....	.....	.1480	.2039	.2588	.3147	.3696
3/32"	.094"	.....	.....	.....	.....	.1566	.2199	.2821	.3453	.4076
No. 13	.095"	.....	.....	.....	.....	.1573	.2212	.2841	.3480	.4109
No. 12 or 7/64"	.109"	.....	.....	.....	.....	.....	.2375	.3097	.3830	.4552
No. 11	.120"	.....	.....	.....	.....	.....	.2473	.3268	.4075	.4870
1/8"	.125"	.....	.....	.....	.....	.....	.2510	.3338	.4179	.5006
No. 10	.134"	.....	.....	.....	.....	.....	.2562	.3449	.4351	.5238
9/64"	.141"	.....	.....	.....	.....	.....	.....	.3524	.4472	.5406
No. 9	.148"	.....	.....	.....	.....	.....	.....	.3588	.4584	.5564
5/32"	.156"	.....	.....	.....	.....	.....	.....	.3649	.4698	.5731
No. 8	.165"	.....	.....	.....	.....	.....	.....	.....	.4811	.5903
11/64"	.172"	.....	.....	.....	.....	.....	.....	.....	.4886	.6025
No. 7	.180"	.....	.....	.....	.....	.....	.....	.....	.....	.6152
3/16"	.188"	.....	.....	.....	.....	.....	.....	.....	.....	.6264

Wall Thickness		OUTSIDE DIAMETER IN INCHES								
B.W.G. or Fraction	Decimal Equivalent	9/16" .563	5/8" .625	11/16" .688	3/4" .750	13/16" .813	7/8" .875	15/16" .938	1" 1.000	1 1/16" 1.063
No. 36	.004"	.0239	.0265	.....	.....	.....	.....	.....	.....	.....
No. 35	.005"	.0298	.0331	.0365	.0398	.0431	.....	.....	.....	.....
No. 34	.007"	.0416	.0462	.0509	.0555	.0603	.0649	.0696	.....	.....
No. 33	.008"	.0474	.0527	.0581	.0634	.0688	.0741	.0795	.0848	.0901
No. 32	.009"	.0533	.0592	.0653	.0712	.0773	.0832	.0893	.0953	.1013
No. 31	.010"	.0591	.0657	.0724	.0790	.0858	.0924	.0991	.1057	.1125
No. 30	.012"	.0706	.0786	.0866	.0946	.1027	.1106	.1187	.1266	.1347
No. 29	.013"	.0764	.0850	.0937	.1023	.1111	.1197	.1284	.1370	.1458
No. 28	.014"	.0821	.0914	.1008	.1100	.1195	.1287	.1382	.1474	.1568
No. 27 or 1/64"	.016"	.0935	.1041	.1148	.1254	.1362	.1468	.1576	.1681	.1789
No. 26	.018"	.1048	.1167	.1288	.1407	.1528	.1647	.1769	.1888	.2009
No. 25	.020"	.1160	.1292	.1427	.1559	.1694	.1826	.1961	.2093	.2228
No. 24	.022"	.1271	.1417	.1565	.1711	.1859	.2004	.2152	.2298	.2446
No. 23	.025"	.1436	.1602	.1770	.1936	.2104	.2270	.2438	.2603	.2771
No. 22	.028"	.1600	.1785	.1974	.2159	.2347	.2533	.2721	.2907	.3095
1/32"	.031"	.1761	.1967	.2175	.2380	.2589	.2794	.3003	.3208	.3417
No. 21	.032"	.1815	.2027	.2242	.2454	.2669	.2881	.3096	.3308	.3524
No. 20	.035"	.1974	.2205	.2441	.2673	.2908	.3140	.3375	.3607	.3843
No. 19	.042"	.2337	.2615	.2898	.3176	.3458	.3737	.4019	.4297	.4580
3/64"	.047"	.2590	.2901	.3218	.3529	.3845	.4156	.4472	.4784	.5100
No. 18	.049"	.2690	.3014	.3344	.3668	.3998	.4323	.4652	.4977	.5306
No. 17	.058"	.3128	.3512	.3902	.4287	.4677	.5061	.5451	.5835	.6225
1/16"	.063"	.3364	.3781	.4205	.4622	.5046	.5463	.5887	.6305	.6728
No. 16	.065"	.3457	.3888	.4325	.4755	.5193	.5623	.6060	.6491	.6928
No. 15	.072"	.3776	.4252	.4737	.5214	.5698	.6175	.6659	.7136	.7620
5/64"	.078"	.4040	.4557	.5082	.5598	.6123	.6639	.7164	.7681	.8205
No. 14	.083"	.4255	.4805	.5363	.5913	.6471	.7021	.7579	.8129	.8687
3/32"	.094"	.4708	.5331	.5963	.6586	.7218	.7841	.8473	.9096	.9728
No. 13	.095"	.4748	.5377	.6017	.6646	.7285	.7914	.8553	.9182	.9821
No. 12 or 7/64"	.109"	.5285	.6007	.6740	.7462	.8195	.8917	.9651	1.037	1.111
No. 11	.120"	.5677	.6472	.7279	.8074	.8881	.9676	1.048	1.128	1.209
1/8"	.125"	.5847	.6675	.7516	.8344	.9185	1.001	1.085	1.168	1.252
No. 10	.134"	.6140	.7027	.7928	.8816	.9717	1.060	1.151	1.239	1.330
9/64"	.141"	.6355	.7288	.8237	.9171	1.012	1.105	1.200	1.294	1.388

ROUND SEAMLESS STEEL MECHANICAL TUBING (Continued)

Weight in pounds per foot.

Wall Thickness		OUTSIDE DIAMETER IN INCHES								
B.W.G. or Fraction	Decimal Equivalent	5/16" .563	5/8" .625	11/16" .688	3/4" .750	13/16" .813	7/8" .875	15/16" .938	1" 1.000	1 1/16" 1.063
No. 9	.148"	.6560	.7540	.8535	.9515	1.051	1.149	1.249	1.347	1.446
5/32"	.156"	.6781	.7814	.8864	.9897	1.095	1.198	1.303	1.406	1.511
No. 8	.165"	.7014	.8106	.9216	1.031	1.142	1.251	1.362	1.471	1.582
11/64"	.172"	.7183	.8321	.9479	1.062	1.177	1.291	1.407	1.521	1.637
No. 7	.180"	.7363	.8555	.9766	1.096	1.217	1.336	1.457	1.576	1.697
3/16"	.188"	.7529	.8774	1.004	1.128	1.255	1.379	1.506	1.630	1.757
No. 6 or 13/64"	.203"	.....	.9149	1.051	1.186	1.323	1.457	1.594	1.728	1.865
7/32"	.219"	.....	.9496	1.097	1.242	1.389	1.534	1.682	1.827	1.974
No. 5	.220"	.....	.....	.....	1.245	1.393	1.539	1.687	1.833	1.981
No. 4	.238"	.....	.....	.....	1.301	1.462	1.619	1.779	1.937	2.097
1/4"	.250"	.....	.....	.....	1.335	1.503	1.669	1.837	2.003	2.171
No. 3	.259"	.....	.....	.....	.....	.....	1.704	1.878	2.050	2.224
9/32"	.281"	.....	.....	.....	.....	.....	1.783	1.972	2.158	2.347
No. 2	.284"	.....	.....	.....	.....	.....	1.793	1.984	2.172	2.363
No. 1	.300"	.....	.....	.....	.....	.....	1.842	2.044	2.243	2.445
5/16"	.313"	.....	.....	.....	.....	.....	1.879	2.089	2.297	2.507
11/32"	.344"	.....	.....	.....	.....	.....	.....	.....	2.410	2.642
3/8"	.375"	.....	.....	.....	.....	.....	.....	.....	2.503	2.755

Wall Thickness		OUTSIDE DIAMETER IN INCHES								
B.W.G. or Fraction	Decimal Equivalent	1 1/8" 1.125	1 3/16" 1.188	1 1/4" 1.250	1 5/16" 1.313	1 3/8" 1.375	1 7/16" 1.438	1 1/2" 1.500	1 9/16" 1.563	1 5/8" 1.625
No. 32	.009"	.1073	.1133	.....	.....	.....	.....	.....	.....	.....
No. 31	.010"	.1191	.1258	.1324	.1392	.....	.....	.....	.....	.....
No. 30	.012"	.1426	.1507	.1587	.1667	.1747	.1828	.....	.....	.....
No. 29	.013"	.1544	.1631	.1717	.1805	.1891	.1978	.....	.....	.....
No. 28	.014"	.1661	.1755	.1848	.1942	.2035	.2129	.2222	.2316	.....
No. 27 or 1/64"	.016"	.1895	.2003	.2109	.2216	.2322	.2430	.2536	.2644	.....
No. 26	.018"	.2128	.2249	.2368	.2490	.2609	.2730	.2849	.2970	.3089
No. 25	.020"	.2360	.2495	.2627	.2762	.2894	.3029	.3161	.3296	.3428
No. 24	.022"	.2592	.2740	.2885	.3033	.3179	.3327	.3473	.3621	.3766
No. 23	.025"	.2937	.3105	.3271	.3439	.3605	.3773	.3938	.4106	.4272
No. 22	.028"	.3280	.3469	.3654	.3843	.4028	.4216	.4402	.4590	.4776
1/32"	.031"	.3622	.3831	.4036	.4244	.4450	.4658	.4864	.5072	.5277
No. 21	.032"	.3735	.3951	.4163	.4378	.4590	.4805	.5017	.5232	.5444
No. 20	.035"	.4074	.4310	.4542	.4777	.5009	.5244	.5476	.5712	.5943
No. 19	.042"	.4858	.5140	.5419	.5701	.5979	.6262	.6540	.6823	.7101
3/64"	.047"	.5411	.5727	.6039	.6355	.6666	.6982	.7293	.7610	.7921
No. 18	.049"	.5631	.5961	.6285	.6615	.6939	.7269	.7593	.7923	.8248
No. 17	.058"	.6609	.7000	.7384	.7774	.8158	.8548	.8932	.9323	.9707
1/16"	.063"	.7146	.7569	.7987	.8411	.8828	.9252	.9669	1.009	1.051
No. 16	.065"	.7359	.7796	.8226	.8664	.9094	.9531	.9962	1.040	1.083
No. 15	.072"	.8097	.8582	.9058	.9543	1.002	1.050	1.098	1.147	1.194
5/64"	.078"	.8722	.9247	.9763	1.029	1.080	1.133	1.185	1.237	1.289
No. 14	.083"	.9237	.9795	1.034	1.090	1.145	1.201	1.256	1.312	1.367
3/32"	.094"	1.035	1.098	1.161	1.224	1.286	1.349	1.412	1.475	1.537
No. 13	.095"	1.045	1.109	1.172	1.236	1.299	1.363	1.426	1.489	1.552
No. 12 or 7/64"	.109"	1.183	1.256	1.328	1.402	1.474	1.547	1.619	1.693	1.765
No. 11	.120"	1.288	1.369	1.448	1.529	1.608	1.689	1.769	1.849	1.929
1/8"	.125"	1.335	1.419	1.502	1.586	1.669	1.753	1.836	1.920	2.003
No. 10	.134"	1.418	1.508	1.597	1.687	1.776	1.866	1.955	2.045	2.134
9/64"	.141"	1.482	1.577	1.670	1.765	1.858	1.953	2.046	2.141	2.235
No. 9	.148"	1.544	1.644	1.742	1.841	1.939	2.039	2.137	2.237	2.335
5/32"	.156"	1.614	1.719	1.823	1.928	2.031	2.136	2.239	2.344	2.447
No. 8	.165"	1.692	1.803	1.912	2.023	2.132	2.243	2.353	2.464	2.573
11/64"	.172"	1.751	1.866	1.980	2.096	2.210	2.326	2.439	2.555	2.669
No. 7	.180"	1.817	1.938	2.057	2.178	2.297	2.418	2.538	2.659	2.778
3/16"	.188"	1.881	2.008	2.132	2.259	2.383	2.510	2.634	2.761	2.885
No. 6 or 13/64"	.203"	1.999	2.136	2.270	2.407	2.541	2.678	2.812	2.949	3.083
7/32"	.219"	2.119	2.266	2.411	2.559	2.704	2.851	2.996	3.144	3.289

ROUND SEAMLESS STEEL MECHANICAL TUBING (Continued)

Weight in pounds per foot.

Wall Thickness		OUTSIDE DIAMETER IN INCHES								
B.W.G. or Fraction	Decimal Equivalent	1 1/8"	1 3/16"	1 1/4"	1 5/16"	1 3/8"	1 7/16"	1 1/2"	1 9/16"	1 5/8"
		1.125	1.188	1.250	1.313	1.375	1.438	1.500	1.563	1.625
No. 5	.220"	2.126	2.274	2.420	2.568	2.714	2.862	3.007	3.156	3.301
No. 4	.238"	2.255	2.415	2.572	2.732	2.890	3.050	3.208	3.368	3.526
1/4"	.250"	2.336	2.504	2.670	2.838	3.004	3.172	3.338	3.506	3.671
No. 3	.259"	2.395	2.570	2.741	2.915	3.087	3.261	3.433	3.607	3.779
9/32"	.281"	2.533	2.722	2.908	3.097	3.283	3.472	3.658	3.847	4.033
No. 2	.284"	2.551	2.742	2.930	3.121	3.309	3.500	3.688	3.879	4.067
No. 1	.300"	2.643	2.845	3.044	3.246	3.444	3.646	3.845	4.047	4.245
5/16"	.313"	2.714	2.925	3.132	3.343	3.550	3.761	3.968	4.179	4.386
11/32"	.344"	2.869	3.101	3.329	3.560	3.788	4.019	4.247	4.479	4.706
3/8"	.375"	3.004	3.256	3.504	3.757	4.005	4.257	4.506	4.758	5.006
7/16"	.438"	.....	3.508	3.798	4.093	4.383	4.678	4.968	5.263	5.553
1/2"	.500"	.....	.....	4.005	4.341	4.673	5.009	5.340	5.676	6.008
9/16"	.563"	.....	.....	.....	.....	4.882	5.261	5.634	6.013	6.386
5/8"	.625"	.....	.....	.....	.....	.....	.....	.....	6.261.	6.675

Wall Thickness		OUTSIDE DIAMETER IN INCHES								
B.W.G. or Fraction	Decimal Equivalent	1 11/16"	1 3/4"	1 13/16"	1 7/8"	1 15/16"	2"	2 1/16"	2 1/8"	2 3/16"
		1.688	1.750	1.813	1.875	1.938	2.000	2.063	2.125	2.188
No. 26	.018"	.3210	.....	.....	.....	.....	.....	.....	.....	.....
No. 25	.020"	.3563	.....	.....	.....	.....	.....	.....	.....	.....
No. 24	.022"	.3914	.4060	.4208	.4354	.4502	.4648	.....	.....	.....
No. 23	.025"	.4440	.4606	.4774	.4940	.5108	.5273	.....	.....	.....
No. 22	.028"	.4964	.5149	.5338	.5523	.5712	.5897	.6085	.6271	.6459
1/32"	.031"	.5486	.5691	.5900	.6105	.6314	.6519	.6728	.6933	.7141
No. 21	.032"	.5660	.5871	.6087	.6299	.6514	.6726	.6941	.7153	.7368
No. 20	.035"	.6179	.6411	.6646	.6878	.7113	.7345	.7581	.7812	.8048
No. 19	.042"	.7383	.7661	.7944	.8222	.8505	.8783	.9065	.9344	.9626
3/64"	.047"	.8237	.8548	.8865	.9176	.9492	.9803	1.012	1.043	1.075
No. 18	.049"	.8577	.8902	.9231	.9556	.9886	1.021	1.054	1.086	1.119
No. 17	.058"	1.010	1.048	1.087	1.126	1.165	1.203	1.242	1.280	1.319
1/16"	.063"	1.093	1.135	1.177	1.219	1.262	1.303	1.346	1.387	1.430
No. 16	.065"	1.127	1.170	1.213	1.257	1.300	1.343	1.387	1.430	1.474
No. 15	.072"	1.243	1.290	1.339	1.386	1.435	1.483	1.531	1.579	1.627
5/64"	.078"	1.341	1.393	1.445	1.497	1.549	1.601	1.654	1.705	1.758
No. 14	.083"	1.423	1.478	1.534	1.589	1.644	1.699	1.755	1.810	1.866
3/32"	.094"	1.600	1.662	1.726	1.788	1.851	1.913	1.977	2.039	2.102
No. 13	.095"	1.616	1.679	1.743	1.806	1.870	1.933	1.997	2.060	2.124
No. 12 or 7/64"	.109"	1.838	1.910	1.984	2.056	2.129	2.201	2.275	2.347	2.420
No. 11	.120"	2.010	2.089	2.170	2.249	2.330	2.409	2.490	2.570	2.650
1/8"	.125"	2.087	2.169	2.253	2.336	2.420	2.503	2.587	2.670	2.754
No. 10	.134"	2.224	2.313	2.403	2.492	2.582	2.670	2.761	2.849	2.940
9/64"	.141"	2.330	2.423	2.518	2.611	2.706	2.799	2.894	2.988	3.083
No. 9	.148"	2.434	2.532	2.632	2.730	2.829	2.927	3.027	3.125	3.225
5/32"	.156"	2.552	2.656	2.761	2.864	2.969	3.072	3.177	3.281	3.385
No. 8	.165"	2.684	2.793	2.904	3.013	3.124	3.234	3.345	3.454	3.565
11/64"	.172"	2.785	2.899	3.014	3.128	3.244	3.358	3.474	3.588	3.703
No. 7	.180"	2.899	3.018	3.139	3.258	3.380	3.499	3.620	3.739	3.860
3/16"	.188"	3.012	3.136	3.263	3.387	3.514	3.638	3.765	3.889	4.016
No. 6 or 13/64"	.203"	3.220	3.354	3.491	3.625	3.762	3.896	4.033	4.167	4.304
7/32"	.219"	3.436	3.581	3.728	3.873	4.021	4.166	4.313	4.458	4.605
No. 5	.220"	3.449	3.595	3.743	3.889	4.037	4.182	4.330	4.476	4.624
No. 4	.238"	3.686	3.843	4.003	4.161	4.321	4.479	4.639	4.796	4.957
1/4"	.250"	3.839	4.005	4.173	4.339	4.507	4.673	4.841	5.006	5.174
No. 3	.259"	3.953	4.124	4.299	4.470	4.644	4.816	4.990	5.162	5.336
9/32"	.281"	4.223	4.409	4.598	4.784	4.973	5.159	5.348	5.534	5.723
No. 2	.284"	4.259	4.447	4.638	4.826	5.017	5.205	5.396	5.584	5.775
No. 1	.300"	4.447	4.646	4.848	5.046	5.248	5.447	5.649	5.847	6.049
5/16"	.313"	4.596	4.804	5.014	5.222	5.432	5.639	5.850	6.057	6.268
11/32"	.344"	4.938	5.166	5.397	5.625	5.856	6.084	6.315	6.543	6.775
3/8"	.375"	5.259	5.507	5.759	6.008	6.260	6.508	6.760	7.009	7.261
7/16"	.438"	5.847	6.137	6.432	6.722	7.017	7.307	7.601	7.892	8.186

ROUND SEAMLESS STEEL MECHANICAL TUBING (Continued)

Weight in pounds per foot.

Wall Thickness		OUTSIDE DIAMETER IN INCHES								
B.W.G. or Fraction	Decimal Equivalent	1 11/16"	1 3/4"	1 13/16"	1 7/8"	1 15/16"	2"	2 1/16"	2 1/8"	2 3/16"
		1.688	1.750	1.813	1.875	1.938	2.000	2.063	2.125	2.188
1/2"	.500"	6.344	6.675	7.011	7.343	7.679	8.010	8.346	8.678	9.014
9/16"	.563"	6.764	7.137	7.516	7.889	8.268	8.640	9.019	9.392	9.771
5/8"	.625"	7.096	7.509	7.930	8.344	8.764	9.178	9.599	10.01	10.43
11/16"	.688"	.....	7.803	8.266	8.722	9.185	9.640	10.10	10.56	11.02
3/4"	.750"	.....	.....	.....	.....	9.516	10.01	10.52	11.01	11.52
13/16"	.813"	.....	.....	.....	.....	.....	.....	.....	.....	11.94

Wall Thickness		OUTSIDE DIAMETER IN INCHES								
B.W.G. or Fraction	Decimal Equivalent	2 1/4"	2 5/16"	2 3/8"	2 7/16"	2 1/2"	2 9/16"	2 5/8"	2 11/16"	2 3/4"
		2.250	2.313	2.375	2.438	2.500	2.563	2.625	2.688	2.750
No. 24	.022"	.4060	.....	.....	.....	.....	.....	.....	.....	.....
No. 23	.025"	.4606	.....	.....	.....	.....	.....	.....	.....	.....
No. 22	.028"	.6645	.6833	.7018	.7207	.7392	.....	.....	.....	.....
1/32"	.031"	.7347	.7555	.7761	.7969	.8174	.....	.....	.....	.....
No. 21	.032"	.7580	.7796	.8007	.8223	.8435	.....	.....	.....	.....
No. 20	.035"	.8280	.8515	.8747	.8982	.9214	.9450	.9681	.9917	1.015
No. 19	.042"	.9904	1.019	1.046	1.075	1.103	1.131	1.159	1.187	1.215
3/64"	.047"	1.106	1.137	1.169	1.200	1.231	1.263	1.294	1.326	1.357
No. 18	.049"	1.152	1.185	1.217	1.250	1.283	1.316	1.348	1.381	1.413
No. 17	.058"	1.358	1.397	1.435	1.474	1.513	1.552	1.590	1.629	1.668
1/16"	.063"	1.472	1.514	1.556	1.598	1.640	1.682	1.724	1.766	1.808
No. 16	.065"	1.517	1.561	1.604	1.647	1.690	1.734	1.777	1.821	1.864
No. 15	.072"	1.675	1.723	1.771	1.819	1.867	1.915	1.963	2.012	2.059
5/64"	.078"	1.809	1.862	1.913	1.966	2.018	2.070	2.122	2.174	2.226
No. 14	.083"	1.921	1.977	2.032	2.088	2.143	2.198	2.253	2.309	2.364
3/32"	.094"	2.164	2.228	2.290	2.353	2.415	2.479	2.541	2.604	2.666
No. 13	.095"	2.186	2.250	2.313	2.377	2.440	2.504	2.567	2.631	2.694
No. 12 or 7/64"	.109"	2.492	2.566	2.638	2.711	2.783	2.857	2.929	3.002	3.074
No. 11	.120"	2.730	2.811	2.890	2.971	3.050	3.131	3.210	3.291	3.371
1/8"	.125"	2.837	2.921	3.004	3.088	3.171	3.255	3.338	3.422	3.504
No. 10	.134"	3.028	3.118	3.207	3.297	3.386	3.476	3.565	3.655	3.744
9/64"	.141"	3.176	3.271	3.364	3.459	3.552	3.647	3.741	3.835	3.929
No. 9	.148"	3.323	3.422	3.520	3.620	3.718	3.817	3.915	4.015	4.113
5/32"	.156"	3.489	3.594	3.697	3.802	3.905	4.010	4.114	4.219	4.322
No. 8	.165"	3.674	3.785	3.894	4.005	4.115	4.226	4.335	4.446	4.555
11/64"	.172"	3.817	3.933	4.047	4.163	4.276	4.392	4.506	4.622	4.736
No. 7	.180"	3.979	4.100	4.220	4.341	4.460	4.581	4.700	4.821	4.941
3/16"	.188"	4.140	4.267	4.391	4.518	4.642	4.769	4.893	5.020	5.144
No. 6 or 13/64"	.203"	4.438	4.575	4.709	4.846	4.980	5.117	5.251	5.388	5.522
7/32"	.219"	4.750	4.898	5.043	5.190	5.335	5.482	5.627	5.775	5.920
No. 5	.220"	4.770	4.918	5.063	5.211	5.357	5.505	5.651	5.799	5.944
No. 4	.238"	5.114	5.274	5.432	5.592	5.750	5.910	6.067	6.228	6.385
1/4"	.250"	5.340	5.508	5.674	5.842	6.008	6.176	6.341	6.509	6.675
No. 3	.259"	5.507	5.682	5.853	6.027	6.199	6.373	6.545	6.719	6.890
9/32"	.281"	5.909	6.098	6.284	6.473	6.659	6.848	7.035	7.224	7.410
No. 2	.284"	5.963	6.154	6.342	6.533	6.721	6.912	7.101	7.292	7.480
No. 1	.300"	6.248	6.450	6.648	6.850	7.049	7.251	7.449	7.651	7.850
5/16"	.313"	6.475	6.686	6.893	7.104	7.311	7.521	7.729	7.939	8.147
11/32"	.344"	7.002	7.234	7.462	7.693	7.921	8.152	8.380	8.612	8.839
3/8"	.375"	7.509	7.762	8.010	8.262	8.511	8.763	9.011	9.264	9.512
7/16"	.438"	8.476	8.771	9.061	9.356	9.646	9.940	10.23	10.53	10.82
1/2"	.500"	9.345	9.681	10.01	10.35	10.68	11.02	11.35	11.68	12.02
9/16"	.563"	10.14	10.52	10.90	11.27	11.65	12.03	12.40	12.78	13.15
5/8"	.625"	10.85	11.27	11.68	12.10	12.52	12.94	13.35	13.77	14.18
11/16"	.688"	11.48	11.94	12.40	12.86	13.31	13.78	14.23	14.70	15.15
3/4"	.750"	12.02	12.52	13.02	13.52	14.02	14.52	15.02	15.52	16.02
13/16"	.813"	12.48	13.02	13.56	14.11	14.65	15.19	15.73	16.28	16.82
7/8"	.875"	.....	.....	14.02	14.61	15.19	15.77	16.35	16.94	17.52
15/16"	.938"	.....	.....	.....	.....	.....	16.28	16.90	17.53	18.15
No. 1	1.000"	.....	.....	.....	.....	.....	.....	.....	.....	18.69

ROUND SEAMLESS STEEL MECHANICAL TUBING (Continued)

Weight in pounds per foot.

Wall Thickness		OUTSIDE DIAMETER IN INCHES								
B.W.G. or Fraction	Decimal Equivalent	2 13/16"	2 7/8"	2 15/16"	3"	3 1/16"	3 1/8"	3 3/16"	3 1/4"	3 5/16"
		2.813	2.875	2.938	3.000	3.063	3.125	3.188	3.250	3.313
No. 20	.035"	1.038	1.062	1.085	1.108	1.132	1.155	1.179	1.202	1.225
No. 19	.042"	1.243	1.271	1.299	1.327	1.355	1.383	1.411	1.439	1.467
3/64"	.047"	1.388	1.420	1.451	1.482	1.514	1.545	1.577	1.608	1.639
No. 18	.049"	1.446	1.479	1.512	1.544	1.577	1.610	1.643	1.675	1.708
No. 17	.058"	1.707	1.745	1.784	1.822	1.861	1.900	1.939	1.977	2.016
1/16"	.063"	1.850	1.892	1.934	1.976	2.019	2.060	2.103	2.144	2.187
No. 16	.065"	1.908	1.951	1.994	2.037	2.081	2.124	2.168	2.211	2.255
No. 15	.072"	2.108	2.155	2.204	2.252	2.300	2.348	2.396	2.444	2.492
5/64"	.078"	2.278	2.330	2.382	2.434	2.487	2.538	2.591	2.642	2.695
No. 14	.083"	2.420	2.475	2.531	2.586	2.642	2.697	2.752	2.807	2.863
3/32"	.094"	2.730	2.792	2.855	2.917	2.981	3.043	3.106	3.168	3.232
No. 13	.095"	2.758	2.821	2.885	2.947	3.011	3.074	3.138	3.201	3.265
No. 12 or 7/64"	.109"	3.148	3.220	3.293	3.365	3.439	3.511	3.584	3.657	3.730
No. 11	.120"	3.451	3.531	3.612	3.691	3.772	3.851	3.932	4.011	4.092
1/8"	.125"	3.588	3.671	3.755	3.838	3.922	4.005	4.089	4.172	4.256
No. 10	.134"	3.834	3.923	4.013	4.102	4.192	4.280	4.371	4.459	4.550
9/64"	.141"	4.024	4.117	4.212	4.305	4.400	4.494	4.588	4.682	4.777
No. 9	.148"	4.212	4.310	4.410	4.508	4.608	4.706	4.805	4.903	5.003
5/32"	.156"	4.427	4.530	4.635	4.738	4.843	4.947	5.052	5.155	5.260
No. 8	.165"	4.666	4.776	4.887	4.996	5.107	5.216	5.327	5.436	5.547
11/64"	.172"	4.851	4.965	5.081	5.195	5.311	5.425	5.540	5.654	5.770
No. 7	.180"	5.062	5.181	5.302	5.421	5.542	5.661	5.783	5.902	6.023
3/16"	.188"	5.271	5.395	5.522	5.646	5.773	5.897	6.024	6.148	6.275
No. 6 or 13/64"	.203"	5.659	5.793	5.930	6.064	6.201	6.335	6.472	6.606	6.743
7/32"	.219"	6.067	6.212	6.360	6.505	6.652	6.797	6.944	7.089	7.237
No. 5	.220"	6.093	6.238	6.386	6.532	6.680	6.826	6.974	7.119	7.267
No. 4	.238"	6.545	6.703	6.863	7.021	7.181	7.338	7.498	7.656	7.816
1/4"	.250"	6.843	7.009	7.177	7.343	7.511	7.676	7.844	8.010	8.178
No. 3	.259"	7.065	7.236	7.410	7.582	7.756	7.928	8.102	8.273	8.448
9/32"	.281"	7.599	7.785	7.974	8.160	8.349	8.535	8.724	8.910	9.099
No. 2	.284"	7.671	7.859	8.050	8.238	8.429	8.617	8.808	8.996	9.187
No. 1	.300"	8.052	8.250	8.452	8.651	8.853	9.051	9.253	9.452	9.654
5/16"	.313"	8.357	8.564	8.775	8.982	9.193	9.400	9.611	9.818	10.03
11/32"	.344"	9.071	9.299	9.530	9.758	9.989	10.22	10.45	10.68	10.91
3/8"	.375"	9.764	10.01	10.26	10.51	10.77	11.01	11.27	11.51	11.77
7/16"	.438"	11.11	11.40	11.69	11.98	12.28	12.57	12.86	13.15	13.45
1/2"	.500"	12.35	12.68	13.02	13.35	13.69	14.02	14.35	14.69	15.02
9/16"	.563"	13.53	13.90	14.28	14.65	15.03	15.40	15.78	16.16	16.54
5/8"	.625"	14.60	15.02	15.44	15.85	16.27	16.69	17.11	17.52	17.94
11/16"	.688"	15.61	16.07	16.53	16.99	17.45	17.91	18.37	18.83	19.29
3/4"	.750"	16.52	17.02	17.53	18.02	18.53	19.02	19.53	20.03	20.53
13/16"	.813"	17.37	17.90	18.45	18.99	19.54	20.07	20.62	21.16	21.71
7/8"	.875"	18.11	18.69	19.28	19.86	20.45	21.03	21.61	22.19	22.78
15/16"	.938"	18.78	19.40	20.04	20.66	21.29	21.91	22.54	23.16	23.79
No. 1	1.000"	19.36	20.03	20.70	21.36	22.03	22.70	23.37	24.03	24.70

Wall Thickness		OUTSIDE DIAMETER IN INCHES								
B.W.G. or Fraction	Decimal Equivalent	3 3/8"	3 7/16"	3 1/2"	3 9/16"	3 5/8"	3 11/16"	3 3/4"	3 13/16"	3 7/8"
		3.375	3.438	3.500	3.563	3.625	3.688	3.750	3.813	3.875
No. 20	.035"	1.248	1.272	1.295	1.319	1.342	1.365	1.389	1.412	1.435
No. 19	.042"	1.495	1.523	1.551	1.579	1.607	1.635	1.663	1.692	1.719
3/64"	.047"	1.671	1.702	1.733	1.765	1.796	1.828	1.859	1.890	1.922
No. 18	.049"	1.741	1.774	1.806	1.839	1.871	1.904	1.937	1.970	2.002
No. 17	.058"	2.055	2.094	2.132	2.171	2.210	2.249	2.287	2.326	2.364
1/16"	.063"	2.228	2.271	2.313	2.355	2.397	2.439	2.481	2.523	2.565
No. 16	.065"	2.298	2.342	2.385	2.428	2.471	2.515	2.558	2.602	2.645
No. 15	.072"	2.540	2.588	2.636	2.684	2.732	2.781	2.828	2.877	2.924
5/64"	.078"	2.747	2.799	2.851	2.903	2.955	3.007	3.059	3.111	3.163
No. 14	.083"	2.918	2.974	3.029	3.085	3.140	3.196	3.251	3.306	3.361
3/32"	.094"	3.294	3.357	3.419	3.483	3.545	3.608	3.670	3.734	3.796
No. 13	.095"	3.328	3.392	3.455	3.519	3.582	3.645	3.708	3.772	3.835

ROUND SEAMLESS STEEL MECHANICAL TUBING (Continued)

Weight in pounds per foot.

Wall Thickness		OUTSIDE DIAMETER IN INCHES								
B.W.G. or Fraction	Decimal Equivalent	3 3/8"	3 7/16"	3 1/2"	3 9/16"	3 5/8"	3 11/16"	3 3/4"	3 13/16"	3 7/8"
		3.375	3.438	3.500	3.563	3.625	3.688	3.750	3.813	3.875
No.12or 7/64"	.109"	3.802	3.875	3.948	4.021	4.093	4.166	4.239	4.312	4.384
No. 11	.120"	4.172	4.252	4.332	4.413	4.492	4.573	4.652	4.733	4.812
1/8"	.125"	4.339	4.423	4.506	4.590	4.673	4.757	4.839	4.923	5.006
No. 10	.134"	4.638	4.728	4.817	4.907	4.996	5.086	5.175	5.265	5.354
9/64"	.141"	4.870	4.965	5.058	5.153	5.246	5.341	5.435	5.530	5.623
No. 9	.148"	5.101	5.200	5.298	5.398	5.496	5.595	5.693	5.793	5.891
5/32"	.156"	5.363	5.468	5.571	5.676	5.780	5.885	5.988	6.093	6.196
No. 8	.165"	5.657	5.768	5.877	5.988	6.097	6.208	6.317	6.429	6.538
11/64"	.172"	5.884	6.000	6.113	6.229	6.343	6.459	6.573	6.688	6.802
No. 7	.180"	6.142	6.263	6.382	6.503	6.623	6.744	6.863	6.984	7.103
3/16"	.188"	6.399	6.525	6.650	6.776	6.901	7.027	7.152	7.278	7.403
No. 6 or 13/64"	.203"	6.877	7.014	7.148	7.285	7.419	7.556	7.690	7.827	7.961
7/32"	.219"	7.382	7.529	7.674	7.821	7.966	8.114	8.259	8.406	8.551
No. 5	.220"	7.413	7.561	7.707	7.855	8.000	8.148	8.294	8.442	8.588
No. 4	.238"	7.974	8.134	8.291	8.452	8.609	8.769	8.927	9.087	9.245
1/4"	.250"	8.344	8.512	8.678	8.846	9.011	9.179	9.345	9.513	9.679
No. 3	.259"	8.619	8.793	8.965	9.139	9.311	9.485	9.657	9.831	10.00
9/32"	.281"	9.285	9.474	9.660	9.850	10.04	10.22	10.41	10.60	10.79
No. 2	.284"	9.375	9.566	9.755	9.946	10.13	10.32	10.51	10.70	10.89
No. 1	.300"	9.852	10.05	10.25	10.45	10.65	10.86	11.05	11.26	11.45
5/16"	.313"	10.24	10.45	10.65	10.86	11.07	11.28	11.49	11.70	11.91
11/32"	.344"	11.14	11.37	11.59	11.83	12.05	12.29	12.51	12.74	12.97
3/8"	.375"	12.02	12.27	12.52	12.77	13.02	13.27	13.52	13.77	14.02
7/16"	.438"	13.74	14.03	14.32	14.62	14.91	15.20	15.49	15.79	16.08
1/2"	.500"	15.35	15.69	16.02	16.36	16.69	17.02	17.36	17.69	18.02
9/16"	.563"	16.91	17.29	17.66	18.04	18.41	18.79	19.16	19.54	19.91
5/8"	.625"	18.36	18.78	19.19	19.61	20.03	20.45	20.86	21.28	21.69
11/16"	.688"	19.74	20.21	20.66	21.13	21.58	22.04	22.50	22.96	23.42
3/4"	.750"	21.03	21.53	22.03	22.53	23.03	23.53	24.03	24.53	25.03
13/16"	.813"	22.25	22.79	23.33	23.88	24.42	24.96	25.50	26.05	26.59
7/8"	.875"	23.36	23.95	24.53	25.12	25.70	26.29	26.87	27.46	28.04
15/16"	.938"	24.41	25.04	25.67	26.30	26.92	27.55	28.17	28.80	29.42
1"	1.000"	25.37	26.04	26.70	27.37	28.04	28.71	29.37	30.04	30.71
1 1/8"	1.125"	.....	.....	.....	29.29	30.04	30.79	31.54	32.30	33.04

Wall Thickness		OUTSIDE DIAMETER IN INCHES								
B.W.G. or Fraction	Decimal Equivalent	3 15/16"	4"	4 1/8"	4 1/4"	4 3/8"	4 1/2"	4 5/8"	4 3/4"	4 7/8"
		3.938	4.000	4.125	4.250	4.375	4.500	4.625	4.750	4.875
No. 20	.035"	1.459	.....	.....	.....	.....	.....	.....	.....	.....
No. 19	.042"	1.748	.....	.....	.....	.....	.....	.....	.....	.....
3/64"	.047"	1.953	.....	.....	.....	.....	.....	.....	.....	.....
No. 18	.049"	2.035	2.068	2.133	2.198	2.264	2.329	2.395	2.460	2.526
No. 17	.058"	2.403	2.442	2.519	2.597	2.674	2.752	2.829	2.906	2.984
1/16"	.063"	2.607	2.649	2.733	2.817	2.901	2.985	3.069	3.154	3.238
No. 16	.065"	2.689	2.732	2.818	2.905	2.992	3.079	3.166	3.252	3.339
No. 15	.072"	2.973	3.020	3.117	3.213	3.309	3.405	3.501	3.597	3.693
5/64"	.078"	3.216	3.267	3.371	3.475	3.580	3.684	3.788	3.892	3.996
No. 14	.083"	3.417	3.472	3.583	3.694	3.805	3.915	4.026	4.137	4.248
3/32"	.094"	3.859	3.921	4.047	4.172	4.298	4.423	4.549	4.674	4.800
No. 13	.095"	3.899	3.962	4.089	4.216	4.342	4.469	4.596	4.723	4.850
No. 12 or 7/64"	.109"	4.457	4.530	4.675	4.821	4.966	5.112	5.257	5.403	5.548
No. 11	.120"	4.893	4.973	5.133	5.293	5.453	5.613	5.774	5.934	6.094
1/8"	.125"	5.090	5.173	5.340	5.507	5.674	5.841	6.008	6.174	6.341
No. 10	.134"	5.444	5.533	5.712	5.890	6.069	6.248	6.427	6.606	6.785
9/64"	.141"	5.718	5.811	5.999	6.188	6.376	6.564	6.752	6.941	7.129
No. 9	.148"	5.991	6.089	6.286	6.484	6.681	6.879	7.077	7.274	7.472
5/32"	.156"	6.301	6.404	6.613	6.821	7.029	7.237	7.446	7.654	7.862
No. 8	.165"	6.649	6.758	6.978	7.199	7.419	7.639	8.859	8.080	8.300
11/64"	.172"	6.918	7.032	7.262	7.491	7.721	7.950	8.180	8.410	8.639
No. 7	.180"	7.224	7.344	7.584	7.824	8.064	8.305	8.545	8.785	9.026
3/16"	.188"	7.529	7.654	7.905	8.156	8.407	8.658	8.909	9.160	9.411

ROUND SEAMLESS STEEL MECHANICAL TUBING (Continued)

Weight in pounds per foot.

Wall Thickness		OUTSIDE DIAMETER IN INCHES								
B.W.G. or Fraction	Decimal Equivalent	3 15/16"	4"	4 1/8"	4 1/4"	4 3/8"	4 1/2"	4 5/8"	4 3/4"	4 7/8"
		3.938	4.000	4.125	4.250	4.375	4.500	4.625	4.750	4.875
No. 6 or 13/64"	.203"	8.098	8.232	8.503	8.774	9.045	9.316	9.587	9.858	10.13
7/32"	.219"	8.698	8.843	9.136	9.428	9.721	10.01	10.31	10.60	10.89
No. 5	.220"	8.736	8.881	9.175	9.469	9.763	10.06	10.35	10.64	10.94
No. 4	.238"	9.405	9.562	9.880	10.20	10.52	10.83	11.15	11.47	11.79
1/4"	.250"	9.847	10.01	10.35	10.68	11.01	11.35	11.68	12.02	12.35
No. 3	.259"	10.18	10.35	10.69	11.04	11.39	11.73	12.08	12.42	12.77
9/32"	.281"	10.97	11.16	11.54	11.91	12.29	12.66	13.04	13.42	13.79
No. 2	.284"	11.08	11.27	11.65	12.03	12.41	12.79	13.17	13.55	13.93
No. 1	.300"	11.66	11.85	12.26	12.66	13.06	13.46	13.86	14.26	14.66
5/16"	.313"	12.12	12.33	12.74	13.16	13.58	14.00	14.41	14.83	15.25
11/32"	.344"	13.20	13.43	13.89	14.35	14.81	15.27	15.73	16.19	16.65
3/8"	.375"	14.27	14.52	15.02	15.52	16.02	16.52	17.02	17.52	18.02
7/16"	.438"	16.37	16.66	17.25	17.83	18.42	19.00	19.59	20.17	20.76
1/2"	.500"	18.36	18.69	19.36	20.03	20.69	21.36	22.03	22.70	23.36
9/16"	.563"	20.29	20.67	21.42	22.17	22.92	23.67	24.42	25.18	25.93
5/8"	.625"	22.11	22.53	23.36	24.20	25.03	25.87	26.70	27.53	28.37
11/16"	.688"	23.88	24.34	25.25	26.17	27.09	28.01	28.93	29.85	30.77
3/4"	.750"	25.54	26.03	27.03	28.04	29.04	30.04	31.04	32.04	33.04
13/16"	.813"	27.13	27.67	28.76	29.84	30.93	32.01	33.10	34.18	35.27
7/8"	.875"	28.62	29.20	30.37	31.54	32.71	33.88	35.04	36.21	37.38
15/16"	.938"	30.05	30.67	31.93	33.18	34.43	35.68	36.94	38.19	39.44
1"	1.000"	31.38	32.04	33.38	34.71	36.05	37.38	38.72	40.05	41.39
1 1/8"	1.125"	33.80	34.54	36.05	37.55	39.05	40.55	42.05	43.55	45.06
1 1/4"	1.250"	.....	.....	.....	.....	.....	.....	45.06	46.73	48.39
1 3/8"	1.375"	.....	.....	.....	.....	.....	.....	47.73	49.56	51.40

Wall Thickness		OUTSIDE DIAMETER IN INCHES								
B.W.G. or Fraction	Decimal Equivalent	5"	5 1/8"	5 1/4"	5 3/8"	5 1/2"	5 5/8"	5 3/4"	5 7/8"	6"
		5.000	5.125	5.250	5.375	5.500	5.625	5.750	5.875	6.000
No. 18	.049"	2.591	.....	.....	.....	.....	.....	.....	.....	.....
No. 17	.058"	3.061	.....	.....	.....	.....	.....	.....	.....	.....
1/16"	.063"	3.322	3.406	3.490	3.574	3.658	3.742	3.826	3.911	.....
No. 16	.065"	3.426	3.513	3.599	3.686	3.773	3.860	3.947	4.033	.....
No. 15	.072"	3.789	3.886	3.982	4.078	4.174	4.270	4.366	4.462	.....
5/64"	.078"	4.100	4.204	4.308	4.413	4.517	4.621	4.725	4.829	.....
No. 14	.083"	4.359	4.469	4.580	4.691	4.802	4.913	5.023	5.134	5.245
3/32"	.094"	4.925	5.051	5.176	5.302	5.427	5.553	5.678	5.804	5.929
No. 13	.095"	4.977	5.103	5.230	5.357	5.484	5.611	5.738	5.864	5.991
No. 12 or 7/64"	.109"	5.694	5.839	5.985	6.130	6.276	6.421	6.567	6.712	6.858
No. 11	.120"	6.254	6.414	6.575	6.735	6.895	7.055	7.215	7.376	7.536
1/8"	.125"	6.508	6.675	6.842	7.009	7.176	7.343	7.509	7.676	7.843
No. 10	.134"	6.964	7.143	7.322	7.500	7.679	7.858	8.037	8.216	8.395
9/64"	.141"	7.317	7.505	7.694	7.882	8.070	8.258	8.446	8.635	8.823
No. 9	.148"	7.669	7.867	8.064	8.262	8.460	8.657	8.855	9.052	9.250
5/32"	.156"	8.070	8.279	8.487	8.695	8.904	9.112	9.320	9.528	9.737
No. 8	.165"	8.520	8.741	8.961	9.181	9.401	9.622	9.842	10.06	10.28
11/64"	.172"	8.869	9.098	9.328	9.558	9.787	10.02	10.25	10.48	10.71
No. 7	.180"	9.266	9.506	9.747	9.987	10.23	10.47	10.71	10.95	11.19
3/16"	.188"	9.662	9.913	10.16	10.41	10.67	10.92	11.17	11.42	11.67
No. 6 or 13/64"	.203"	10.40	10.67	10.94	11.21	11.48	11.76	12.03	12.30	12.57
7/32"	.219"	11.18	11.47	11.77	12.06	12.35	12.64	12.94	13.23	13.52
No. 5	.220"	11.23	11.52	11.82	12.11	12.41	12.70	12.99	13.29	13.58
No. 4	.238"	12.10	12.42	12.74	13.06	13.38	13.69	14.01	14.33	14.65
1/4"	.250"	12.68	13.02	13.35	13.68	14.02	14.35	14.69	15.02	15.35
No. 3	.259"	13.11	13.46	13.81	14.15	14.50	14.84	15.19	15.53	15.88
9/32"	.281"	14.16	14.54	14.91	15.29	15.66	16.04	16.41	16.79	17.16
No. 2	.284"	14.30	14.68	15.06	15.44	15.82	16.20	16.58	16.96	17.34
No. 1	.300"	15.06	15.46	15.86	16.26	16.66	17.06	17.46	17.86	18.26
5/16"	.313"	15.67	16.09	16.50	16.92	17.34	17.76	18.18	18.59	19.01
11/32"	.344"	17.11	17.57	18.02	18.48	18.94	19.40	19.86	20.32	20.78
3/8"	.375"	18.52	19.02	19.52	20.03	20.53	21.03	21.53	22.03	22.53

ROUND SEAMLESS STEEL MECHANICAL TUBING (Continued)

Weight in pounds per foot.

Wall Thickness		OUTSIDE DIAMETER IN INCHES								
B.W.G. or Fraction	Decimal Equivalent	5″ 5.000	5⅛″ 5.125	5¼″ 5.250	5⅜″ 5.375	5½″ 5.500	5⅝″ 5.625	5¾″ 5.750	5⅞″ 5.875	6″ 6.000
7/16″	.438″	21.34	21.93	22.51	23.09	23.68	24.26	24.85	25.43	26.02
1/2″	.500″	24.03	24.70	25.37	26.03	26.70	27.37	28.04	28.70	29.37
9/16″	.563″	26.68	27.43	28.18	28.93	29.69	30.44	31.19	31.94	32.69
5/8″	.625″	29.20	30.04	30.87	31.71	32.54	33.38	34.21	35.04	35.88
11/16″	.688″	31.68	32.60	33.52	34.44	35.36	36.28	37.19	38.11	39.03
3/4″	.750″	34.04	35.04	36.05	37.05	38.05	39.05	40.05	41.05	42.05
13/16″	.813″	36.36	37.44	38.53	39.61	40.70	41.78	42.87	43.95	45.04
7/8″	.875″	38.55	39.72	40.88	42.05	43.22	44.39	45.56	46.73	47.89
15/16″	.938″	40.69	41.94	43.20	44.45	45.70	46.95	48.21	49.46	50.71
1″	1.000″	42.72	44.06	45.39	46.73	48.06	49.40	50.73	52.07	53.40
1 1/8″	1.125″	46.56	48.06	49.56	51.06	52.57	54.07	55.57	57.07	58.57
1 1/4″	1.250″	50.06	51.73	53.40	55.07	56.74	58.41	60.08	61.74	63.41
1 3/8″	1.375″	53.23	55.07	56.90	58.74	60.58	62.41	64.25	66.08	67.92

Wall Thickness		OUTSIDE DIAMETER IN INCHES								
B.W.G. or Fraction	Decimal Equivalent	6⅛″ 6.125	6¼″ 6.250	6⅜″ 6.375	6½″ 6.500	6⅝″ 6.625	6¾″ 6.750	6⅞″ 6.875	7″ 7.000	7⅛″ 7.125
No. 14	.083″	5.356	5.467	.....	.....	.....	.....	.....	.....	.....
3/32″	.094″	6.055	6.180	.....	.....	.....	.....	.....	.....	.....
No. 13	.095″	6.118	6.245	.....	.....	.....	.....	.....	.....	.....
No. 12 or 7/64″	.109″	7.003	7.149	7.294	7.440	7.585	.....	.....	.....	.....
No. 11	.120″	7.696	7.856	8.016	8.177	8.337	.....	.....	.....	.....
1/8″	.125″	8.010	8.177	8.344	8.511	8.678	.....	.....	.....	.....
No. 10	.134″	8.574	8.753	8.932	9.111	9.289	9.468	9.647	.....	.....
9/64″	.141″	9.011	9.199	9.388	9.576	9.764	9.952	10.14	.....	.....
No. 9	.148″	9.447	9.645	9.843	10.04	10.24	10.44	10.63	10.83	11.03
5/32″	.156″	9.945	10.15	10.36	10.57	10.78	10.99	11.19	11.40	11.61
No. 8	.165″	10.50	10.72	10.94	11.16	11.38	11.60	11.82	12.04	12.26
11/64″	.172″	10.94	11.17	11.39	11.62	11.85	12.08	12.31	12.54	12.77
No. 7	.180″	11.43	11.67	11.91	12.15	12.39	12.63	12.87	13.11	13.35
3/16″	.188″	11.92	12.17	12.42	12.67	12.92	13.18	13.43	13.68	13.93
No. 6 or 13/64″	.203″	12.84	13.11	13.38	13.65	13.92	14.19	14.47	14.74	15.01
7/32″	.219″	13.81	14.11	14.40	14.69	14.98	15.28	15.57	15.86	16.15
No. 5	.220″	13.87	14.17	14.46	14.76	15.05	15.34	15.64	15.93	16.22
No. 4	.238″	14.96	15.28	15.60	15.92	16.23	16.55	16.87	17.19	17.51
1/4″	.250″	15.69	16.02	16.35	16.69	17.02	17.36	17.69	18.02	18.36
No. 3	.259″	16.23	16.57	16.92	17.26	17.61	17.95	18.30	18.65	18.99
9/32″	.281″	17.54	17.91	18.29	18.66	19.04	19.41	19.79	20.16	20.54
No. 2	.284″	17.72	18.10	18.47	18.85	19.23	19.61	19.99	20.37	20.75
No. 1	.300″	18.66	19.06	19.46	19.86	20.27	20.67	21.07	21.47	21.87
5/16″	.313″	19.43	19.85	20.26	20.68	21.10	21.52	21.94	22.35	22.77
11/32″	.344″	21.24	21.70	22.16	22.62	23.08	23.54	23.99	24.45	24.91
3/8″	.375″	23.03	23.53	24.03	24.53	25.03	25.53	26.03	26.53	27.03
7/16″	.438″	26.60	27.19	27.77	28.36	28.94	29.53	30.11	30.70	31.28
1/2″	.500″	30.04	30.71	31.37	32.04	32.71	33.38	34.04	34.71	35.38
9/16″	.563″	33.44	34.20	34.95	35.70	36.45	37.20	37.95	38.70	39.46
5/8″	.625″	36.71	37.55	38.38	39.22	40.05	40.88	41.72	42.55	43.39
11/16″	.688″	39.95	40.87	41.79	42.71	43.62	44.54	45.46	46.38	47.30
3/4″	.750″	43.05	44.06	45.06	46.06	47.06	48.06	49.06	50.06	51.06
13/16″	.813″	46.12	47.21	48.29	49.38	50.46	51.55	52.64	53.72	54.81
7/8″	.875″	49.06	50.23	51.40	52.57	53.73	54.90	56.07	57.24	58.41
15/16″	.938″	51.96	53.21	54.47	55.72	56.97	58.22	59.48	60.73	61.98
1″	1.000″	54.74	56.07	57.41	58.74	60.08	61.41	62.75	64.08	65.42
1 1/8″	1.125″	60.08	61.58	63.08	64.58	66.08	67.58	69.09	70.59	72.09
1 1/4″	1.250″	65.08	66.75	68.42	70.09	71.76	73.43	75.09	76.76	78.43
1 3/8″	1.375″	69.75	71.59	73.43	75.26	77.10	78.93	80.77	82.60	84.44

ROUND SEAMLESS STEEL MECHANICAL TUBING (Continued)

Weight in pounds per foot.

Wall Thickness		OUTSIDE DIAMETER IN INCHES								
B.W.G. or Fraction	Decimal Equivalent	7¼"	7⅜"	7½"	7⅝"	7¾"	8"	8¼"	8½"	8⅝"
		7.250	7.375	7.500	7.625	7.750	8.000	8.250	8.500	8.625
No. 9	.148"	11.23	11.42	.....	.....	.....	.....	.....	.....	.....
5/32"	.156"	11.82	12.03	.....	.....	.....	.....	.....	.....	.....
No. 8	.165"	12.49	12.71	.....	.....	.....	.....	.....	.....	.....
11/64"	.172"	13.00	13.23	.....	.....	.....	.....	.....	.....	.....
No. 7	.180"	13.59	13.83	.....	.....	.....	.....	.....	.....	.....
3/16"	.188"	14.18	14.43	14.68	14.93	15.18	15.69	.....	.....	.....
No. 6 or 13/64"	.203"	15.28	15.55	15.82	16.09	16.36	16.90	17.45	17.99	.....
7/32"	.219"	16.44	16.74	17.03	17.32	17.61	18.20	18.78	19.37	19.66
No. 5	.220"	16.52	16.81	17.11	17.40	17.69	18.28	18.87	19.45	19.75
No. 4	.238"	17.82	18.14	18.46	18.78	19.09	19.73	20.37	21.00	21.32
1/4"	.250"	18.69	19.02	19.36	19.69	20.03	20.69	21.36	22.03	22.36
No. 3	.259"	19.34	19.68	20.03	20.38	20.72	21.41	22.10	22.80	23.14
9/32"	.281"	20.91	21.29	21.66	22.04	22.42	23.17	23.92	24.67	25.04
No. 2	.284"	21.13	21.51	21.89	22.27	22.65	23.40	24.16	24.92	25.30
No. 1	.300"	22.27	22.67	23.07	23.47	23.87	24.67	25.47	26.27	26.67
5/16"	.313"	23.19	23.61	24.02	24.44	24.86	25.70	26.53	27.37	27.79
11/32"	.344"	25.37	25.83	26.29	26.75	27.21	28.13	29.05	29.96	30.42
3/8"	.375"	27.53	28.04	28.54	29.04	29.54	30.54	31.54	32.54	33.04
7/16"	.438"	31.87	32.45	33.03	33.62	34.20	35.37	36.54	37.71	38.30
1/2"	.500"	36.05	36.71	37.38	38.05	38.72	40.05	41.39	42.72	43.39
9/16"	.563"	40.21	40.96	41.71	42.46	43.21	44.72	46.22	47.72	48.48
5/8"	.625"	44.22	45.06	45.89	46.73	47.56	49.23	50.90	52.57	53.40
11/16"	.688"	48.22	49.14	50.05	50.97	51.89	53.73	55.56	57.40	58.32
3/4"	.750"	52.07	53.07	54.07	55.07	56.07	58.07	60.08	62.08	63.08
13/16"	.813"	55.89	56.98	58.06	59.15	60.23	62.40	64.57	66.74	67.83
7/8"	.875"	59.57	60.74	61.91	63.08	64.25	66.58	68.92	71.26	72.42
15/16"	.938"	63.23	64.48	65.74	66.99	68.24	70.75	73.25	75.75	77.01
1"	1.000"	66.75	68.09	69.42	70.76	72.09	74.76	77.43	80.10	81.44
1 1/8"	1.125"	73.59	75.09	76.60	78.10	79.60	82.60	85.61	88.61	90.11
1 1/4"	1.250"	80.10	81.77	83.44	85.11	86.78	90.11	93.45	96.79	98.46
1 3/8"	1.375"	86.27	88.11	89.95	91.78	93.62	97.29	101.0	104.6	106.5
1 1/2"	1.500"	.....	.....	96.12	98.12	100.1	104.1	108.1	112.1	114.1
1 5/8"	1.625"	.....	.....	102.0	104.1	106.3	110.6	115.0	119.3	121.5

Wall Thickness		OUTSIDE DIAMETER IN INCHES								
B.W.G. or Fraction	Decimal Equivalent	8¾"	9"	9¼"	9½"	9⅝"	9¾"	10"	10¼"	10½"
		8.750	9.000	9.250	9.500	9.625	9.750	10.000	10.250	10.500
7/32"	.219"	19.95	20.54	.....	.....	.....	.....	.....	.....	.....
No. 5	.220"	20.04	20.63	21.22	21.80	22.10	22.39	22.98	23.57	24.15
No. 4	.238"	21.64	22.27	22.91	23.54	23.86	24.18	24.81	25.45	26.08
1/4"	.250"	22.70	23.36	24.03	24.70	25.03	25.37	26.03	26.70	27.37
No. 3	.259"	23.49	24.18	24.87	25.56	25.91	26.25	26.94	27.64	28.33
9/32"	.281"	25.42	26.17	26.92	27.67	28.04	28.42	29.17	29.92	30.67
No. 2	.284"	25.68	26.44	27.19	27.95	28.33	28.71	29.47	30.23	30.99
No. 1	.300"	27.07	27.87	28.68	29.48	29.88	30.28	31.08	31.88	32.68
5/16"	.313"	28.20	29.04	29.87	30.71	31.13	31.55	32.38	33.22	34.05
11/32"	.344"	30.88	31.80	32.72	33.64	34.10	34.56	35.48	36.39	37.31
3/8"	.375"	33.54	34.54	35.54	36.55	37.05	37.55	38.55	39.55	40.55
7/16"	.438"	38.88	40.05	41.22	42.39	42.98	43.56	44.73	45.90	47.07
1/2"	.500"	40.06	45.39	46.73	48.06	48.73	49.40	50.73	52.07	53.40
9/16"	.563"	49.23	50.73	52.23	53.74	54.49	55.24	56.74	58.25	59.75
5/8"	.625"	54.23	55.90	57.57	59.24	60.08	60.91	62.58	64.25	65.92
11/16"	.688"	59.24	61.08	62.91	64.75	65.67	66.59	68.42	70.26	72.10
3/4"	.750"	64.08	66.08	68.09	70.09	71.09	72.09	74.09	76.10	78.10
13/16"	.813"	68.92	71.09	73.26	75.43	76.51	77.60	79.77	81.94	84.11
7/8"	.875"	73.59	75.93	78.26	80.60	81.77	82.94	85.27	87.61	89.95
15/16"	.938"	78.26	80.76	83.27	85.77	87.02	88.28	90.78	93.29	95.79
1"	1.000"	82.77	85.44	88.11	90.78	92.12	93.45	96.12	98.79	101.5
1 1/8"	1.125"	91.61	94.62	97.62	100.6	102.1	103.6	106.6	109.6	112.6
1 1/4"	1.250"	100.1	103.5	106.8	110.1	111.8	113.5	116.8	120.2	123.5
1 3/8"	1.375"	108.3	112.0	115.6	119.3	121.2	123.0	126.7	130.3	134.0
1 1/2"	1.500"	116.1	120.2	124.2	128.2	130.2	132.2	136.2	140.2	144.2
1 5/8"	1.625"	123.7	128.0	132.3	136.7	138.8	141.0	145.3	149.7	154.0

ROUND SEAMLESS STEEL MECHANICAL TUBING (Continued)

Weight in pounds per foot.

Wall Thickness		OUTSIDE DIAMETER IN INCHES								
B.W.G. or Fraction	Decimal Equivalent	10¾″ 10.750	11″ 11.000	11¼″ 11.250	11½″ 11.500	11¾″ 11.750	12″ 12.000	12¼″ 12.250	12½″ 12.500	12¾″ 12.750
No. 5	.220″	24.74	.....	.....	.....	.....	.....	.....	.....	.....
No. 4	.238″	26.72	.....	.....	.....	.....	.....	.....	.....	.....
¼″	.250″	28.04	.....	.....	.....	.....	.....	.....	.....	.....
No. 3	.259″	29.02	29.71	30.40	31.09	31.79	32.48	33.17	33.86	34.55
9/32″	.281″	31.42	32.20	32.95	33.70	34.45	35.20	35.95	36.70	37.45
No. 2	.284″	31.74	32.50	33.26	34.02	34.78	35.54	36.29	37.05	37.81
No. 1	.300″	33.48	34.28	35.08	35.89	36.69	37.49	38.29	39.09	39.89
5/16″	.313″	34.89	35.72	36.56	37.40	38.23	39.07	39.90	40.74	41.57
No. 0	.340″	38.23	38.70	39.61	40.52	41.42	42.33	43.24	44.15	45.05
11/32″	.344″	41.55	39.12	40.04	40.96	41.88	42.79	43.71	44.63	45.55
3/8″	.375″	48.24	42.55	43.56	44.56	45.56	46.56	47.56	48.56	49.56
No. 00	.380″	54.74	43.10	44.12	45.13	46.14	47.16	48.17	49.19	50.20
No. 000	.425″	61.25	48.00	49.14	50.27	51.40	52.54	53.67	54.81	55.94
7/16″	.438″	67.58	49.41	50.58	51.75	52.92	54.09	55.25	56.42	57.59
No. 0000	.454″	73.93	51.13	52.35	53.56	54.77	55.98	57.20	58.41	59.62
½″	.500″	80.10	56.07	57.41	58.74	60.08	61.41	62.75	64.08	65.42
9/16″	.563″	86.28	62.76	64.26	65.76	67.27	68.77	70.27	71.78	73.28
5/8″	.625″	92.28	69.25	70.92	72.59	74.26	75.93	77.60	79.27	80.94
11/16″	.688″	98.30	75.77	77.61	79.44	81.28	83.12	84.96	86.79	88.63
¾″	.750″	104.1	82.10	84.11	86.11	88.11	90.11	92.12	94.12	96.12
13/16″	.813″	115.6	88.45	90.62	92.79	94.96	97.13	99.31	101.5	103.7
⅞″	.875″	126.8	94.62	96.96	99.29	101.6	104.0	106.3	108.6	111.0
15/16″	.938″	137.7	100.8	103.3	105.8	108.3	110.8	113.3	115.8	118.3
1″	1.000″	148.2	106.8	109.5	112.1	114.8	117.5	120.2	122.8	125.5
1 1/8″	1.125″	158.4	118.7	121.7	124.7	127.7	130.7	133.7	136.7	139.7
1¼″	1.250″	.....	130.2	133.5	136.8	140.2	143.5	146.9	150.2	153.5
1 3/8″	1.375″	.....	141.3	145.0	148.7	152.4	156.1	159.7	163.4	167.0
1½″	1.500″	.....	152.2	156.2	160.2	164.2	168.2	172.2	176.2	180.2
1 5/8″	1.625″	.....	162.7	167.0	171.4	175.7	180.1	184.4	188.7	193.1
1¾″	1.750″	.....	172.9	177.6	182.2	186.9	191.6	196.2	200.9	205.6
2″	2.000″	.....	192.2	197.6	202.9	208.3	213.6	218.9	224.3	229.6

Wall Thickness		OUTSIDE DIAMETER IN INCHES								
B.W.G. or Fraction	Decimal Equivalent	13″ 13.000	13¼″ 13.250	13½″ 13.500	13¾″ 13.750	14″ 14.000	14⅜″ 14.375			
No. 3	.259″	35.24	35.94	36.63	37.32	38.01	39.05	.....	.....	.....
9/32″	.281″	38.20	38.96	39.71	40.46	41.21	42.33	.....	.....	.....
No. 2	.284″	38.57	39.33	40.09	40.84	41.60	42.74	.....	.....	.....
No. 1	.300″	40.69	41.49	42.29	43.09	43.90	45.10	.....	.....	.....
5/16″	.313″	42.41	43.25	44.08	44.92	45.75	47.01	.....	.....	.....
No. 0	.340″	45.96	46.87	47.79	48.70	49.61	50.97	.....	.....	.....
11/32″	.344″	46.46	47.38	48.30	49.22	50.14	51.51	.....	.....	.....
3/8″	.375″	50.56	51.57	52.57	53.57	54.57	56.07	.....	.....	.....
No. 00	.380″	51.22	52.23	53.24	54.25	55.27	56.79	.....	.....	.....
No. 000	.425″	57.08	58.21	59.35	60.48	61.62	63.32	.....	.....	.....
7/16″	.438″	58.76	59.93	61.10	62.27	63.44	65.20	.....	.....	.....
No. 0000	.454″	60.83	62.04	63.26	64.47	65.68	67.50	.....	.....	.....
½″	.500″	66.75	68.09	69.42	70.76	72.09	74.09	.....	.....	.....
9/16″	.563″	74.78	76.28	77.79	79.29	80.79	83.05	.....	.....	.....
5/8″	.625″	82.60	84.27	85.94	87.61	89.28	91.78	.....	.....	.....
11/16″	.688″	90.47	92.30	94.14	95.98	97.81	100.6	.....	.....	.....
¾″	.750″	98.12	100.1	102.1	104.1	106.1	109.1	.....	.....	.....
13/16″	.813″	105.8	108.0	110.2	112.3	114.5	117.8	.....	.....	.....
⅞″	.875″	113.3	115.6	118.0	120.3	122.7	126.2	.....	.....	.....
15/16″	.938″	120.8	123.3	125.8	128.4	130.9	134.6	.....	.....	.....
1″	1.000″	128.2	130.8	133.5	136.2	138.8	142.8	.....	.....	.....
1 1/8″	1.125″	142.7	145.7	148.7	151.7	154.7	159.2	.....	.....	.....
1¼″	1.250″	156.9	160.2	163.5	166.9	170.2	175.2	.....	.....	.....
1 3/8″	1.375″	170.7	174.4	178.1	181.7	185.4	190.9	.....	.....	.....
1½″	1.500″	184.2	188.2	192.2	196.2	200.3	206.3	.....	.....	.....
1 5/8″	1.625″	197.4	201.8	206.1	210.4	214.8	221.3	.....	.....	.....
1¾″	1.750″	210.3	214.9	219.6	224.3	229.0	236.0	.....	.....	.....
2″	2.000″	235.0	240.3	245.6	251.0	256.3	264.3	.....	.....	.....

PROPERTIES OF TUBULAR AND SOLID BEAMS

Any member of a structure whose principal function is to resist bending actions is known as a beam. The following is an elementary discussion of the various factors influencing the design of beams. In this discussion beams are assumed to be of uniform cross section throughout, the fibre stress to be within the elastic limit of the material and the loads and reactions to lie in a vertical plane perpendicular to the axis of the beam before loading.

Beams fall under four main classifications:

1. **Cantilever Beams** having one end fixed and the other end unsupported (figure 1).

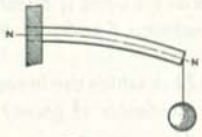


Figure 1

2. **Simple Beams** resting on two supports (figure 2).

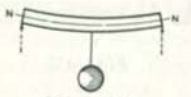


Figure 2

3. **Fixed Beams** having one or both ends fixed (figure 3).

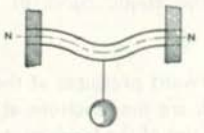


Figure 3

Fixed beams are stronger than simply supported beams of the same size and material since there is a change in bending moment due to the end resisting moment.

4. Continuous Beams resting on three or more supports (figure 4).

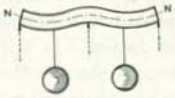


Figure 4

The principal stresses in simple beams are tension and compression. The fibres above the neutral surface (figure 2, N-N) are under compressional stresses, thereby shortened, while those below are under tensional stresses and consequently lengthened. The fibres along the neutral surface plane N-N are not stressed. The stress on any fibre of a beam is directly proportional to the distance of the fibre from the neutral surface. See figure 5.

Neutral Surface: The plane N-N at which the fibres are not stressed. This neutral surface always passes through the center of gravity of the cross section.

Neutral Axis: The line of intersection of the neutral surface and a cross sectional plane. See figure 5.

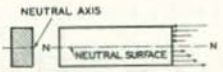


Figure 5

Elastic Curve: The curve formed by the line N-N, or neutral surface of a beam as it deflects under its own weight and the weight of loads upon it.

Maximum Deflection: The greatest distance from the neutral surface of the unloaded beam to a point on the elastic curve of the loaded beam (see Pages M47-50).

Reactions at Supports: The upward pressures at the supports which prevent the beam from moving downwards are the reactions at supports. It is a fundamental principle of mechanics that the sum of the loads must equal the sum of the reactions. In the case of simple and cantilever beams, the reactions are determined by applying conditions of static equilibrium in which for a system of vertical forces in the same plane the algebraic sum of all the forces must equal zero. The reactions are determined from the equation of the elastic curve in the case of fixed beams. For continuous beams the theorem of three moments may be used.

PROPERTIES OF BEAMS (Continued)

Shearing Stresses: A beam when loaded is subjected to transverse stresses which tend to shear the beam as illustrated at section X-X (figure 6).

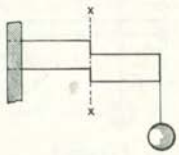


Figure 6

At any cross section, such as X-X, the vertical shear is equal to the algebraic sum of all the forces on either side of the section. The forces are usually taken to the left, thus the vertical shear equals the reaction at the left support minus the sum of the loads (including the weight of the beam) between the left support and the section considered. Forces which act upward are considered positive and downward forces negative when acting to the left of the section considered. The signs are reversed for forces to the right of the section. Generally the shearing stresses for steel beams are much smaller than those of tension and compression and may be ignored. However, if the loads are near the support and the beam is short the shearing stress may be greater than the bending stresses. Shearing stress is considered to be uniform over the cross section.

Bending Moment: The tendency of the external forces acting on a beam to produce rotation about any chosen cross section is called the bending moment. This tendency, or bending moment, is the product of the force W acting on the beam multiplied by the lever arm L, or WL, at section Y-Y (figure 7).

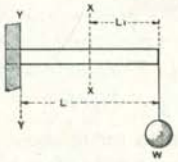


Figure 7

Similarly at section X-X, the bending moment is WL. Bending moment is usually expressed in inch pounds, the force W being in pounds and the lever arms L and L_1 in inches. Where the lever arm is in feet the bending moment is in foot pounds. Bending moments to the left of the section considered and which tend to produce clockwise rotation are positive; those which tend to produce counterclockwise rotation are negative. Bending moments to the right of the section considered

are reversed from those to the left. The algebraic sum of the moments = 0. Thus in figure 8, assuming a point of moments at the right support R_2

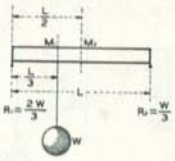


Figure 8

$$O = R_1 L - \frac{2WL}{3}$$

or $R_1 = \frac{2W}{3}$

Similarly assuming a point of moments at left support $R_2 = \frac{W}{3}$, then the bending moment at section $M_1 = \frac{R_1 L}{3}$ or $\frac{2}{9}$ WL and at M_2 considering forces to left

$$\left(\frac{2W}{3} \times \frac{L}{2}\right) - W \times \left(\frac{L}{2} - \frac{L}{3}\right) = \frac{WL}{6}$$

to right $\frac{W}{3} \times \frac{L}{2} = \frac{WL}{6}$

Beams must be designed for the maximum shearing stresses and bending moments.

Resisting Moment: The external forces acting on a beam create horizontal internal forces which resist the action of the external forces (see figure 9).

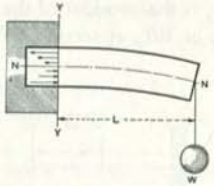


Figure 9

Thus the tendency of the beam to rotate about section Y-Y is resisted by the internal tensile forces above the neutral surface N-N and the internal compressive forces below. Thus it is evident that the sum of moments of each of the internal resisting forces must equal the bending moment WL. The moments for the individual internal forces are equal to the product of the internal force multiplied by its distance from the neutral surface N-N. Then the resisting moment for steel not stressed beyond the elastic limit is

$$M_R = fZ = f\frac{I}{C} \text{ where}$$

(Continued on the following page)

PROPERTIES OF BEAMS (Continued)

M_R = Resisting moment in inch pounds

f = Stress, pounds per square inch, in fibre farthest from neutral surface, N-N.

I = Moment of inertia of cross section.

C = Distance from neutral surface, N-N, to extreme fibre.

Z = Section modulus = $\frac{I}{C}$

Moment of Inertia: I. This is the property of the cross section which determines the stiffness of the beam or its ability to resist deflection. It is the sum of the products of each of the elementary areas "a" multiplied by the square of their distance "b" from the neutral axis, figure 10.

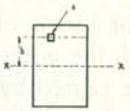


Figure 10

Other things being equal the stiffness of a beam is proportional to its moment of inertia of cross section.

Section Modulus: Z. This is the property of the cross section which determines the strength of the beam. The section modulus is found by dividing the Moment of Inertia by the distance from the neutral surface to the extreme fibre, or $Z = \frac{I}{C}$. The two properties, Moment of Inertia and Section Modulus, are of the greatest importance in designing beams.

Strength of Beams: The maximum load a beam can safely support is one which develops the maximum safe working stress in the extreme or most strained fibre. The suitable cross section can be determined by satisfying the equation.

$$M = M_R = fZ = f\frac{I}{C}$$

where M = maximum bending moment.

The transverse shear due to external forces must be resisted by internal transverse stresses at the section, or $S = f_s A$

in which S = shearing force in pounds

f_s = safe shearing stress in pounds per square inch

A = area of cross section in inches.

For formulas applying to various conditions of loading and supporting beams, see Pages M47-50. The properties of beam cross sections are shown on Pages M55-6.

FACTORS OF SAFETY

In designing a structure each member should be capable of resisting the greatest straining action to which it may be subject. Since it is not always possible to calculate conditions accurately and to allow for inaccuracies and defects in materials, a safe load as calculated should be only a fractional part of the breaking load. This ratio of safe working stress to the ultimate strength of the material is the Factor of Safety, and is usually based on the ultimate strength of the material, although in some cases the elastic limit is used.

There is no fixed rule for Factor of Safety. It depends on the type of forces to be resisted, the material the member is made from, the damage which would be caused by failure and other considerations. It is usually governed by the judgment and experience of the designer. Various types of loading and suggested factors of safety are as follows:

Static Load: Loading resulting in constant straining action. This type of loading can be calculated with reasonable accuracy. Safety factor 3 or 4.

Alternating Load: Where there is an alternating of the load resulting in the stresses being reversed, as from tension to compression. A safety factor of at least 10 should be used.

Suddenly Applied Load: When a load is applied suddenly, but without a blow, the factor of safety should be not less than 6 or 8.

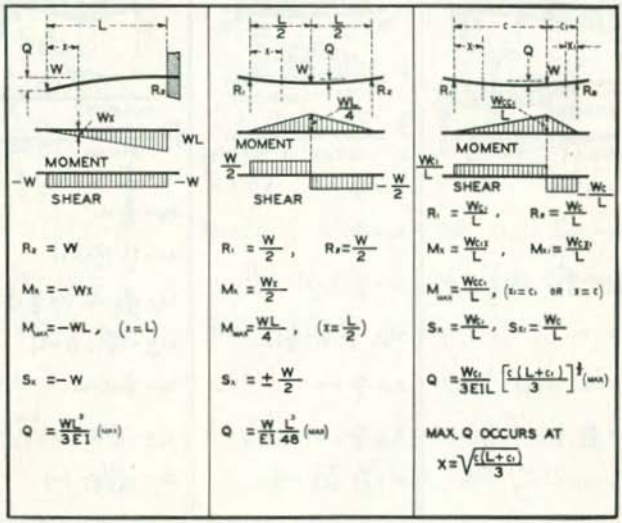
Impact Load: An impact load is one which is in motion when it comes into contact with the member in question. The deformation and stresses are greater than those of equal static loads and the factor of safety should be considered as a special case.

BEAMS

DEFINITIONS OF TERMS

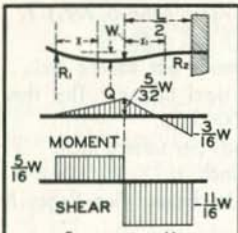
A —Area of cross section in square inches. See Pages M55-6, M61-7.
D —Diameter in inches.
E —Modulus of elasticity of the material in pounds per square inch. This value is usually placed at 29,000,000 for steel tubing. The shearing modulus of elasticity is usually placed at 12,000,000.
f —Fibre stress (tension or compression) in pounds per square inch.
f_s —Fibre stress (shearing) in pounds per square inch.
I —Moment of inertia of the cross section of the beam. See Pages M45, M68-74.
L —Length of beam in inches.
M —Bending moment in inch pounds.
M_R —Resisting moment in inch pounds. See Page M44, M48-50.
Q —Deflection of beam in inches.
R_1, R_2 —Reactions at supports in pounds.
S —Vertical shearing force in pounds.
T —Total load in pounds.
W —Concentrated load on beam.
w —Uniform load per unit of length.
wL —Total uniform load.
Z —Section modulus or $\frac{I}{C}$. See Pages M45, M75-81.

BEAMS OF UNIFORM CROSS SECTION LOADED TRANSVERSELY



BEAMS

BEAMS OF UNIFORM CROSS SECTION LOADED TRANSVERSELY (CONTINUED)



$R_1 = \frac{5}{16}W$, $R_2 = \frac{11}{16}W$

$M_x = \frac{5}{16}Wx$

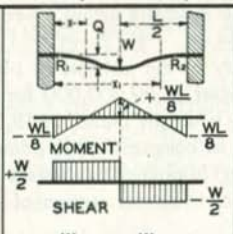
$M_{x_1} = WL\left(\frac{5}{32} - \frac{11}{16}\frac{x_1}{L}\right)$

$M_{MAX} = -\frac{3}{16}WL, \left(x_1 = \frac{L}{2}\right)$

$S_x = +\frac{5}{16}W$, $S_{x_1} = -\frac{11}{16}W$

$S_{MAX} = -\frac{11}{16}W$, $\left(x = \frac{L}{2}\text{ to }x = L\right)$

$Q = \frac{W}{EI}\frac{7L^3}{768}$



$R_1 = \frac{W}{2}$, $R_2 = \frac{W}{2}$

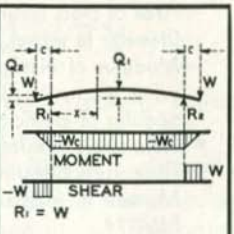
$M_x = \frac{WL}{2}\left(\frac{x}{L} - \frac{1}{4}\right)$

$M_{x_1} = \frac{WL}{2}\left(\frac{x}{L} - \frac{3}{4}\right)$

$M_{MAX} = \frac{WL}{8}, \left(x = \frac{L}{2}\right)$

$S_x = \frac{W}{2}$ $S_{x_1} = -\frac{W}{2}$

$Q = \frac{W}{EI}\frac{L^3}{192}$ (MAX)



$R_1 = W$

$R_2 = W$

$M_x = -Wc$

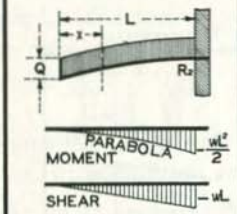
S BETWEEN W & $R_1 = -W$

S BETWEEN R_1 & $R_2 = 0$

S BETWEEN R_2 & $W = +W$

$Q_1 = \frac{W}{EI}\frac{L^3}{8}\frac{c}{L}$ (MAX)

$Q_2 = \frac{W}{EI}\frac{c^2}{3}\left(c + \frac{3L}{2}\right)$ (MAX)



$R_2 = wL$

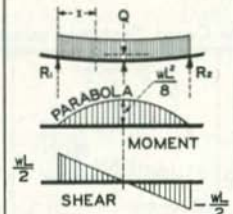
$M_x = -\frac{wx^2}{2}$

$M_{MAX} = -\frac{wL^2}{2}$, $(x = L)$

$S_x = -wx$

$S_{MAX} = -wL$, $(x = L)$

$Q = \frac{wL}{EI}\frac{L^3}{8}$ (MAX)



$R_1 = \frac{wL}{2}$

$R_2 = \frac{wL}{2}$

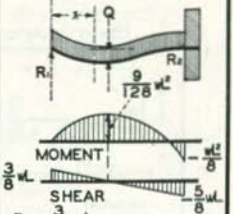
$M_x = \frac{wx}{2}(L - x)$

$M_{MAX} = \frac{wL^2}{8}$, $\left(x = \frac{1}{2}L\right)$

$S_x = \frac{wL}{2} - wx$

$S_{MAX} = \frac{wL}{2}$, $(x = 0)$

$Q = \frac{wL}{EI}\frac{5L^3}{384}$ (MAX)



$R_1 = \frac{3}{8}wL$

$R_2 = \frac{5}{8}wL$

$M_x = \frac{wx}{2}\left(\frac{3}{4}L - x\right)$

$M_{MAX} = \frac{9}{128}wL^2$, $\left(x = \frac{3}{8}L\right)$

$M_{MAX} = -\frac{wL^2}{8}$, $(x = L)$

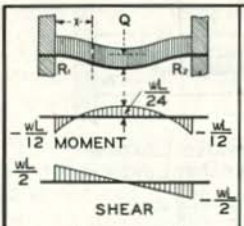
$S_x = \frac{3}{8}wL - wx$

$S_{MAX} = -\frac{5}{8}wL$

$Q = \frac{wL^4}{185\,EI}$ (MAX)

BEAMS

BEAMS OF UNIFORM CROSS SECTION LOADED TRANSVERSELY (CONTINUED)



$R_1 = \frac{wL}{2}$, $R_2 = \frac{wL}{2}$

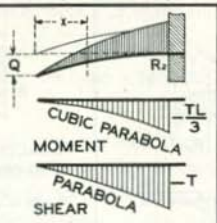
$M_x = -\frac{wL^2}{2}\left(\frac{1}{6} - \frac{x}{L} + \frac{x^2}{L^2}\right)$

$M_{MAX.} = -\frac{1}{12}wL^2$, $(x = 0 \text{ OR } x = L)$

$S_x = \frac{wL}{2} - wx$

$S_{MAX.} = \pm\frac{wL}{2}$

$Q = \frac{wL^4}{384\,EI}$ (MAX.)



$R_2 =$ T = TOTAL LOAD

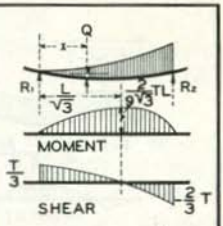
$M_x = -\frac{T}{3}\frac{x^3}{L^2}$

$M_{MAX.} = -\frac{TL}{3}$

$S_x = -\frac{Tx^2}{L^2}$

$S_{MAX.} = -T$

$Q = \frac{T}{EI}\frac{L^3}{15}$ (MAX.)



$R_1 = \frac{1}{3}$ T , $R_2 = \frac{2}{3}$ T

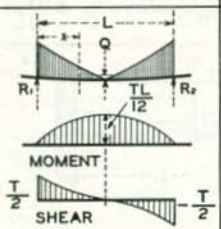
$M_x = \frac{Tx}{3}\left(1 - \frac{x^2}{L^2}\right)$

$M_{MAX.} = \frac{2}{9\sqrt{3}}$ TL, $\left(x = \frac{L}{\sqrt{3}}\right)$

$S_x = T\left(\frac{1}{3} - \frac{x^2}{L^2}\right)$

$S_{MAX.} = -\frac{2}{3}$ T, $(x = L)$

$Q = 0.01304\frac{TL^3}{EI}$ (MAX.)



$R_1 = \frac{T}{2}$, $R_2 = \frac{T}{2}$

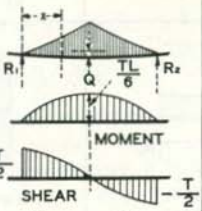
$M_x = Tx\left(\frac{1}{2} - \frac{x}{L} + \frac{2x^2}{3L^2}\right)$

$M_{MAX.} = \frac{TL}{12}$, $\left(x = \frac{1}{2}L\right)$

$S_x = T\left(\frac{1}{2} - \frac{2x}{L} + \frac{2x^2}{L^2}\right)$

$S_{MAX.} = \pm\frac{T}{2}$, $(x = 0)$

$Q = \frac{3TL^3}{EI\,320}$ (MAX.)



$R_1 = \frac{T}{2}$, $R_2 = \frac{T}{2}$

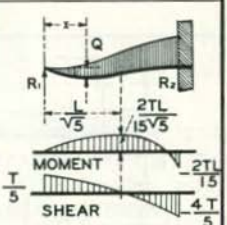
$M_x = Tx\left(\frac{1}{2} - \frac{2}{3}\frac{x^2}{L^2}\right)$

$M_{MAX.} = \frac{TL}{6}$, $\left(x = \frac{1}{2}L\right)$

$S_x = T\left(\frac{1}{2} - \frac{2x^2}{L^2}\right)$

$S_{MAX.} = \pm\frac{T}{2}$, $(x = 0)$

$Q = \frac{TL^3}{EI\,60}$ (MAX.)



$R_1 = \frac{T}{5}$, $R_2 = \frac{4T}{5}$

$M_x = Tx\left(\frac{1}{5} - \frac{x^2}{3L^2}\right)$

$M_{MAX.} = -\frac{2}{15}$ TL AT SUPPORT 2

$S_x = T\left(\frac{1}{5} - \frac{x^2}{L^2}\right)$

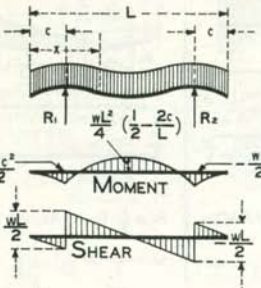
$S_{MAX.} = -\frac{4T}{5}$

$Q = \frac{16\,TL^3}{1500\sqrt{5}EI}$

$= \frac{0.00477\,TL^3}{EI}$ (MAX.)

BEAMS

BEAMS OF UNIFORM CROSS SECTION LOADED TRANSVERSELY (CONTINUED)



$R_1 = \frac{wL}{2} \qquad R_2 = \frac{wL}{2}$

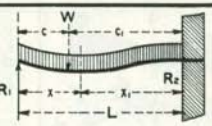
$M_x = \frac{wL}{2}x\left(1-\frac{c}{x}-\frac{x}{L}\right), (x > c)$

$M_x = -\frac{wx^2}{2}, \quad (x \leqq c)$

$M_{MAX} = \frac{wL^2}{4}\left(\frac{1}{2}-\frac{2c}{L}\right), c \leqq \left(\frac{\sqrt{2}-1}{2}\right)L$

$S_x = \frac{wL}{2} - wx, (x > c)$

$S_x = -wx, (x \leqq c)$



CONCENTRATED LOAD=W
UNIFORMLY DIST LOAD= wL

$R_1 = W\frac{c_1^2(3c+2c_1)}{2L^3} + \frac{3}{8}wL$

$R_2 = W\frac{(2c^2+6cc_1+3c_1^2)c}{2L^3} + \frac{5}{8}wL$

$M_x = W\frac{cc_1(2c+c_1)}{2L^2} + w\frac{L^2}{8}$

$M_W = W\frac{cc_1^2(3c+2c_1)}{2L^3} + wL\frac{(3c_1-c)c}{8L}$

(a) $\frac{W}{wL} < \frac{L^2}{4c_1^2}\frac{5c-3c_1}{3c+2c_1}$

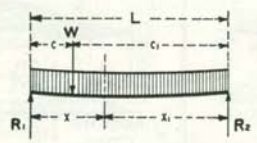
$M_{c_{MAX}} = \frac{R_1^2}{2w}, \quad (x = \frac{R_1}{w})$

(b) $\frac{W}{wL} < \frac{L^2(3c_1-5c)}{4c(2c^2+6cc_1+3c_1^2)}$

$M_{c_{1MAX}} = W_c + \frac{(R_1-W)^2}{2w}, \quad (x = \frac{R_1-W}{w})$

DEFLECTION UNDER-W

$Q = \frac{W}{E1}\frac{c^2c_1^3(4c+3c_1)}{12L^3} + \frac{wL}{E1}\frac{cc_1^2(3c+c_1)}{48L}$



CONCENTRATED LOAD=W
UNIFORMLY DIST LOAD= wL, $c < c_1$

$R_1 = W\frac{c_1}{L} + \frac{wL}{2}$

$R_2 = W\frac{c}{L} + \frac{wL}{2}$

(a) $\frac{W}{wL} < \frac{c_1-c}{2c}$

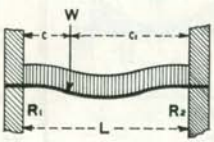
$M_{MAX} = R_2\frac{x_1}{2} = \frac{R_2^2L}{2W}, \quad (x_1 = \frac{R_2}{w})$

(b) $\frac{W}{wL} > \frac{c_1-c}{2c}$

$M_{MAX} = \left(W + \frac{wL}{2}\right)\frac{cc_1}{L}, \quad (x_1 = c_1)$

DEFLECTION OF BEAM UNDER W

$Q = \left(W + \frac{L^2+cc_1}{8cc_1}\right)\frac{c^2c_1^2}{3E1L}$



$c < c_1$

$R_1 = W\frac{(3c+c_1)c_1^2}{L^3} + \frac{wL}{2}$

$R_2 = W\frac{(c+3c_1)c^2}{L^3} + \frac{wL}{2}$

$M_{MAX} = M_1 = W\frac{cc_1^2}{L^2} + \frac{wL^2}{12}$

DEFLECTION UNDER W

$Q = \frac{1}{E1}\left(W\frac{c^3c_1^3}{3L^3} + w\frac{c^2c_1^2}{24}\right)$

TORSION

When a material is subjected to torsion, the stresses introduced are shear, tension and compression, all three stresses being of equal intensity.

In the case of cast iron, which has a high resistance to shear and a low resistance to tension, the failure will be a tension failure, with a fracture very near to a helicoid.

In other materials, with reverse characteristics, the failure will be a shear failure and the fracture a right section. If a force (P, figure 11) acts on a shaft fixed at one end it will produce torsional stresses in the shaft. The twisting moment equals Pr, which is the product of the twisting force and the distance of the force from the axis of the shaft. The twisting moment is usually expressed in inch pounds, the distance in inches and the force in pounds. When the material is not stressed beyond its elastic limit:

A—The torsional moment at any cross section of a shaft under torsional stress is equal to the algebraic sum of the torsional moments acting between the section and the free end.

B —Each section of the shaft between the force P and the fixed end is rotated about the axis of the shaft.

C—The amount of rotation of any section will vary directly with the torsional force applied and with the distance of the section from the fixed end.

D —The amount of rotation of any point on a cross section will vary directly with its distance from the axis of the shaft.

From figure 11 it is seen that when the shaft is acted upon by the force P, the straight line *ab* becomes the helix *ac*. The angle *cxb* is called the angle of torsion, and the arc *cb* is the arc of torsion.

The amount of rotation of any point on a cross section of a shaft under torsional stress being proportional to its distance from the axis, and assuming the stresses to be within the elastic limit of the material, it follows that the stress in such a cross section varies directly from zero at the axis to a maximum at the fibre most distant from the axis.

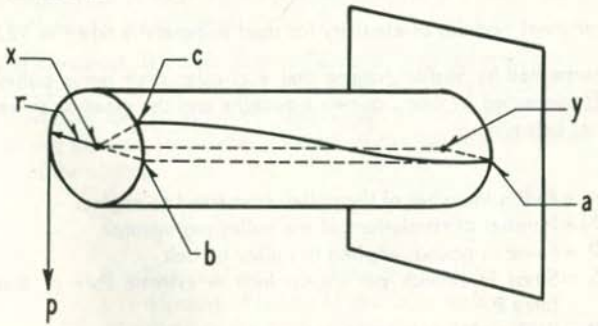


Figure 11

Torsional Formula: For a condition of equilibrium (when the material is not stressed beyond its elastic limit) it may be proved for round shafts that:

$$M_t = M_r = S\frac{I_P}{c}\text{; or } S = \frac{M_t C}{I_P}$$

where

M_t = Twisting moment in inch pounds.
M_r = Resisting moment in inch pounds.
S = Stress in pounds per square inch in the extreme fibre.
I_P = Polar moment of inertia. For circular cross sections the polar moment of inertia equals twice the moment of inertia.
c = Distance in inches of extreme fibre from axis of rotation.

$Z_P = 2xZ = \frac{I_P}{c}$ = Polar section modulus for circular cross sections.

From this it is seen that the unit stress in the surface fibre of a shaft under torsional stress is equal to the torsional moment divided by the polar section modulus of the section. Since torsional stress is not uniformly distributed over the cross sectional area there can be no unit area over which the stress is uniform. Hence the unit stress S is the stress in a hypothetical area of one square inch, each element of which is subjected to the same stress as the surface fibre.

For circular cross sections the polar section modulus is equal to twice the section modulus, or:

$$Z_P = 0.196\frac{(D^4 - d^4)}{D} = 2xZ$$

where

D = Outside diameter of tube in inches.
d = Inside diameter of tube in inches.

In the case of a circular bar, d = 0 and the formula becomes:

$Z_P = 0.196\ D^3$

For other than circular cross sections Z_P does not equal the polar moment of inertia divided by the distance of the extreme fibre from the axis of rotation.

The torsional modulus of elasticity for steel is generally taken as 12,000,000.

Power Transmitted by Shafts: Assume that a circular shaft has a pulley at each end, both connected by belts, one to a machine and the other to an engine, and that neither belt slips—

and let

r = Radius in inches of the pulley connected to engine.
N = Number of revolutions of the pulley per minute.
P = Force in pounds applied to pulley by belt.
S = Stress in pounds per square inch in extreme fibre of shaft due to force P.
R = Radius of shaft in inches.

Then at each revolution of the pulley, the work performed by the force P is $2\pi rP$, and in N revolutions is $2\pi rNP$.

Therefore, horse-power $= \dfrac{2\pi rNP}{33000 \times 12}$

Twisting moment $= M_t = Pr = \dfrac{SI_P}{R}$

Hence horse-power $\dfrac{2\pi NSI_P}{33000 \times 12 \times R}$

For circular cross sections $I_P = \dfrac{\pi R^4}{2}$

Substituting, horse-power $= \dfrac{\pi^2 NSR^2}{396000}$

COLUMNS

A structural part that is subjected to compression and whose length is such that it will buckle or bend before it breaks is a *Column*. The length will depend upon the material in the column. The length of a column is the distance unsupported against lateral bending. Since the stresses in a loaded column are very complicated, no exact formula for them has ever been devised. The column formulas now used are the outcome of experiment and deduction.

The maximum stress on the surface fibre of a loaded column is composed of two stresses:

(1) The unit stress due solely to compression.
(2) The unit stress due to the bending of the column.

The maximum fibre stress occurs in the fibre most distant from the neutral axis on the concaved side of the deflected column.

The condition of its ends has a relation to the strength of a column. The ends may be square (or flat), round, fixed, held by a pin, one end square and one rounded, etc. Columns with both ends square are strongest. Since most columns have square fixed ends, and since the formulas for fixed end columns have a large factor of safety, these are the formulas in general use except where they are obviously inapplicable.

Radius of Gyration: The strength of a column is measured by the radius of gyration of its cross section. Other things being equal, the column with the greater radius of gyration will be the stronger. The radius of gyration of a cross section is equal to the square root of the quotient of the moment of inertia divided by the area of the section.

$$R = \sqrt{\frac{I}{A}}$$

R = Radius of gyration of the cross section.
I = Moment of Inertia of the cross section.
A = Area of the cross section in square inches.

Ratio of Slenderness: This is the ratio between the unsupported length of the column and the least radius of gyration of the cross section. Both are expressed in inches.

$$\text{Ratio of Slenderness} = \frac{L}{R}$$

L = Unsupported length of column in inches.
R = Least radius of gyration in inches.

Building codes usually limit the unsupported length of a column to 120 times its least radius of gyration. In short the ratio of slenderness must not exceed 120 or the allowable unit stress is very much reduced.

Strength of Columns: The City of Chicago and the American Railway Engineering Association have adopted the following right line formula for steel columns:

S = 16000—70L/R*
S = Allowable compressive stress for steel in pounds per square inch.
L = Unsupported length of column in inches.
R = Least radius of gyration in inches.

This formula applies to columns with flat ends having a ratio of slenderness not greater than 120 except when used as secondary members having a maximum allowable unit stress of 14,000 pounds per square inch and having the resultant of the compressive loads in line with the axis of the column.

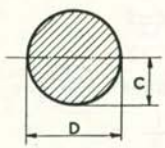
Loaded columns which have a ratio of slenderness of approximately 20 or under, and which fail, will fail primarily because of direct compression. Columns with a slenderness ratio between 20 and 150 will fail by a combination of compression and bending stresses. Columns with a ratio of slenderness in excess of 150 will fail chiefly because of bending stresses.

Values for the radius of gyration of different sizes of tubing are given on Pages M82 to M88. On Page M53 are formulas for the radius of gyration of various shapes of tubular and solid cross sections.

*A. I. S. C. formula may be used:

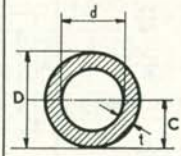
$$S = \frac{18000}{1 + \frac{1}{18000}\left(\frac{L}{R}\right)^2}$$

PROPERTIES OF SECTIONS



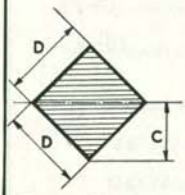
SOLID ROUND

$A = 0.7854\ D^2$
$W = 2.6700\ D^2$
$I = 0.0491\ D^4$
$Z = 0.0982\ D^3$
$R = \frac{D}{4}$
$C = \frac{D}{2}$



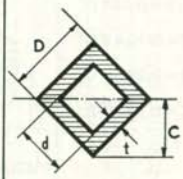
ROUND TUBE

$A = 3.1416(D-t)t$
$W = 10.6802(D-t)t$
$I = 0.0491(D^4-d^4)$
$Z = 0.0982\frac{(D^4-d^4)}{D}$
$R = \frac{\sqrt{D^2+d^2}}{4}$
$C = \frac{D}{2}$



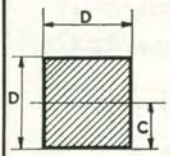
SOLID SQUARE ON EDGE

$A = D^2$
$W = 3.3996\ D^2$
$I = \frac{D^4}{12}$
$Z = 0.1179\ D^3$
$R = 0.2887\ D$
$C = 0.7071\ D$



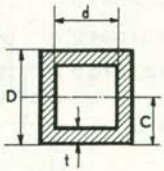
SQUARE TUBE ON EDGE

$A = D^2-d^2$
$= 4\ (D-t)t$
$W = 13.5984\ (D-t)t$
$I = \frac{D^4-d^4}{12}$
$Z = 0.1179\ \frac{D^4-d^4}{D}$
$R = 0.2887\sqrt{D^2+d^2}$
$C = 0.7071\ D$



SOLID SQUARE

$A = D^2$
$W = 3.3996\ D^2$
$I = \frac{D^4}{12}$
$Z = \frac{D^3}{6}$
$R = 0.2887\ D$
$C = \frac{D}{2}$



SQUARE TUBE

$A = D^2-d^2$
$= 4\ (D-t)t$
$W = 13.5984\ (D-t)t$
$I = \frac{D^4-d^4}{12}$
$Z = \frac{D^4-d^4}{6D}$
$R = 0.2887\sqrt{D^2+d^2}$
$C = \frac{D}{2}$

A = AREA OF CROSS SECTION.

W = WEIGHT IN POUNDS PER LINEAL FOOT BASED ON ONE CUBIC INCH OF STEEL = .2833 POUND.

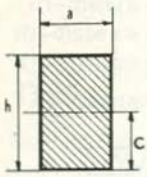
I = MOMENT OF INERTIA.

Z = SECTION MODULUS.

R = RADIUS OF GYRATION.

C = DISTANCE OF EXTREME FIBRE FROM NEUTRAL AXIS.

PROPERTIES OF SECTIONS (Continued)



$A = ah$

$W = 3.400\,ah$

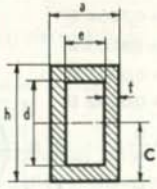
$I = \frac{ah^3}{12}$

$Z = \frac{ah^2}{6}$

$R = 0.2887$

$C = \frac{h}{2}$

RECTANGULAR SOLID



$A = ah - ed$

$W = 6.7992\,(a + h - 2t)t$

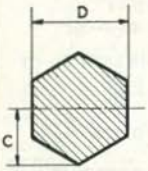
$I = \frac{ah^3 - ed^3}{12}$

$Z = \frac{ah^3 - ed^3}{6h}$

$R = 0.2887\sqrt{\frac{ah^3 - ed^3}{ah - ed}}$

$C = \frac{h}{2}$

RECTANGULAR TUBE



$A = 0.8661\,D^2$

$W = 2.9444\,D^2$

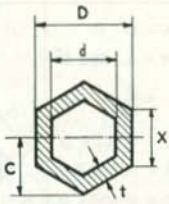
$I = 0.0601\,D^4$

$Z = 0.1042\,D^3$

$R = 0.2635\,D$

$C = 0.5773\,D$

SOLID HEXAGON ON EDGE



$A = 3.4641\,(D - t)\,t$

$W = 11.7765\,(D - t)\,t$

$I = 0.0601\,(D^4 - d^4)$

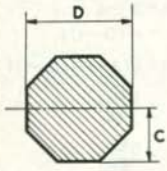
$Z = 0.1042\,\frac{(D^4 - d^4)}{D}$

$R = 0.2635\sqrt{D^2 + d^2}$

$C = 0.5773\,D$

$X = 0.5773\,D$

HEXAGON TUBE ON EDGE



$A = 0.8284\,D^2$

$W = 2.8163\,D^2$

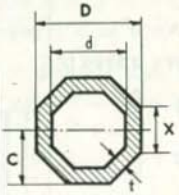
$I = 0.0547\,D^4$

$Z = 0.1094\,D^3$

$R = 0.2570\,D$

$C = \frac{D}{2}$

SOLID OCTAGON



$A = 3.3138\,(D - t)\,t$

$W = 11.2652\,(D - t)\,t$

$I = 0.0547\,(D^4 - d^4)$

$Z = 0.1094\,\frac{(D^4 - d^4)}{D}$

$R = 0.2570\sqrt{D^2 + d^2}$

$C = \frac{D}{2}$

$X = 0.4142\,D$

OCTAGON TUBE

A = AREA OF CROSS SECTION.

W = WEIGHT IN POUNDS PER LINEAL FOOT BASED ON ONE CUBIC INCH OF STEEL = .2833 POUND.

I = MOMENT OF INERTIA.

Z = SECTION MODULUS.

R = RADIUS OF GYRATION.

C = DISTANCE OF EXTREME FIBRE FROM NEUTRAL AXIS.

STANDARD PIPE COLUMNS

(Loads in tons of 2000 pounds, based on New York and Chicago Building Laws)

$$S = 16{,}000 - 70\,L/R.$$

S = allowable compressive stress for steel, pounds per square inch;
L = length of column in inches; R = least radius of gyration in inches;
Maximum allowable compressive stress = 14,000 pounds per square inch.

Length, Feet	NOMINAL PIPE SIZE								
	2″	2½″	3″	3½″	4″	4½″	5″	6″	7″
	THICKNESS								
	.154	.203	.216	.226	.237	.247	.258	.280	.301
36	.....	.....	.....	.....	.....	.....	.....	.....	15.00
33	.....	.....	.....	.....	.....	.....	.....	10.20	18.37
30	.....	.....	.....	.....	.....	.....	.....	13.33	21.73
27	.....	.....	.....	.....	.....	.....	8.43	16.46	25.10
24	.....	.....	.....	.....	.....	7.41	11.32	19.60	28.47
22	.....	.....	.....	.....	5.96	9.25	13.24	21.68	30.71
20	.....	.....	.....	4.60	7.73	11.09	15.16	23.77	32.96
18	.....	.....	.....	6.28	9.50	12.94	17.09	25.86	35.20
16	.....	.....	4.96	7.97	11.26	14.78	19.01	27.95	37.45
14	.....	3.06	6.57	9.65	13.03	16.62	20.93	30.04	39.69
13	.....	3.81	7.37	10.49	13.91	17.54	21.90	31.08	40.81
12	.....	4.57	8.18	11.33	14.79	18.46	22.86	32.12	41.94
11	2.29	5.32	8.98	12.18	15.68	19.38	23.82	33.17	43.06
10	2.86	6.08	9.78	13.02	16.56	20.30	24.78	34.21	44.18
9	3.44	6.83	10.59	13.86	17.44	21.22	25.74	35.26	45.30
8	4.01	7.59	11.39	14.70	18.33	22.14	26.71	36.30	46.43
7	4.58	8.34	12.20	15.54	19.21	23.06	27.67	37.34	47.55
6	5.16	9.10	13.00	16.38	20.09	23.98	28.63	38.39	48.48
5	5.73	9.86	13.81	17.23	20.98	24.90	29.59	39.07	48.48

Length, Feet	NOMINAL PIPE SIZE						
	8″	9″	10″	11″	12″	13″	14″
	THICKNESS						
	.322	.342	.365	.375	.375	.375	.375
40	19.16	28.77	40.81	51.26	60.68	72.45	81.88
36	23.96	33.87	46.26	56.85	66.27	78.05	87.47
33	27.57	37.70	50.34	61.05	70.47	82.25	91.67
30	31.17	41.53	54.43	65.24	74.67	86.44	95.87
27	34.77	45.35	58.51	69.44	78.86	90.64	100.06
24	38.37	49.18	62.59	73.64	83.06	94.84	104.26
22	40.78	51.73	65.32	76.43	85.86	97.64	107.06
20	43.18	54.28	68.04	79.23	88.65	100.43	109.86
18	45.58	56.83	70.76	82.03	91.45	103.23	112.65
16	47.98	59.38	73.48	84.83	94.25	106.03	115.45
14	50.38	61.93	76.21	87.62	97.05	108.83	118.25
13	51.58	63.21	77.57	89.02	98.45	110.23	119.65
12	52.78	64.49	78.93	90.42	99.85	111.62	120.61
11	53.99	65.76	80.29	91.82	101.24	112.36	120.61
10	55.19	67.04	81.65	93.22	102.05	112.36	120.61
9	56.39	68.31	83.01	93.81	102.05	112.36	120.61
8	57.59	69.59	83.36	93.81	102.05	112.36	120.61
7	58.79	69.82	83.36	93.81	102.05	112.36	120.61
6	58.79	69.82	83.36	93.81	102.05	112.36	120.61
5	58.79	69.82	83.36	93.81	102.05	112.36	120.61

Loads above or to the left of the heavy line correspond to values of L/R greater than 120.

EXTRA STRONG PIPE COLUMNS

(Loads in tons of 2000 pounds, based on New York and Chicago Building Laws)

$S = 16{,}000 - 70\ L/R.$

S = allowable compressive stress for steel, pounds per square inch;
L = length of column in inches; R = least radius of gyration in inches;
Maximum allowable compressive stress = 14,000 pounds per square inch.

Length, Feet	NOMINAL PIPE SIZE								
	2″	2½″	3″	3½″	4″	4½″	5″	6″	7″
	THICKNESS								
	.218	.276	.300	.318	.337	.355	.375	.432	.500
36	.....	.....	.....	.....	.....	.....	.....	.....	22.52
33	.....	.....	.....	.....	.....	.....	.....	14.16	28.11
30	.....	.....	.....	.....	.....	.....	.....	18.99	33.69
27	.....	.....	.....	.....	.....	.....	11.21	23.81	39.28
24	.....	.....	.....	.....	.....	9.74	15.39	28.64	44.86
22	.....	.....	.....	.....	7.68	12.38	18.19	31.86	48.58
20	.....	.....	.....	5.78	10.19	15.02	20.98	35.07	52.31
18	.....	.....	.....	8.14	12.69	17.66	23.77	38.29	56.03
16	.....	.....	6.29	10.51	15.20	20.31	26.56	41.51	59.75
14	.....	3.69	8.52	12.87	17.71	22.95	29.35	44.72	63.48
13	.....	4.71	9.64	14.06	18.96	24.27	30.75	46.33	65.34
12	.....	5.74	10.75	15.24	20.22	25.59	32.15	47.94	67.20
11	2.91	6.76	11.87	16.42	21.47	26.91	33.54	49.55	69.06
10	3.72	7.79	12.98	17.60	22.72	28.23	34.94	51.16	70.92
9	4.53	8.81	14.09	18.79	23.98	29.55	36.33	52.76	72.78
8	5.34	9.83	15.21	19.97	25.23	30.88	37.73	54.37	74.64
7	6.15	10.86	16.32	21.15	26.48	32.20	39.12	55.98	76.51
6	6.96	11.88	17.44	22.33	27.74	33.52	40.52	57.59	78.34
5	7.77	12.91	18.55	23.52	28.99	34.84	41.92	58.83	78.34

Length, Feet	NOMINAL PIPE SIZE						
	8″	9″	10″	11″	12″	13″	14″
	THICKNESS						
	.500	.500	.500	.500	.500	.500	.500
40	27.60	40.14	54.25	66.80	79.36	95.06	107.62
36	35.05	47.59	61.71	74.26	86.82	102.52	115.08
33	40.64	53.18	67.30	79.85	92.41	108.11	120.67
30	46.23	58.77	72.89	85.45	98.00	113.70	126.27
27	51.81	64.36	78.48	91.04	103.60	119.30	131.86
24	57.40	69.95	84.07	96.63	109.19	124.89	137.45
22	61.13	73.68	87.80	100.36	112.92	128.62	141.18
20	64.85	77.40	91.53	104.09	116.65	132.35	144.91
18	68.58	81.13	95.26	107.82	120.38	136.08	148.64
16	72.30	84.86	98.98	111.54	124.11	139.81	152.37
14	76.03	88.58	102.71	115.27	127.84	143.54	156.10
13	77.89	90.45	104.58	117.14	129.70	145.40	157.97
12	79.75	92.31	106.44	119.00	131.56	147.27	159.44
11	81.61	94.17	108.30	120.87	133.43	148.44	159.44
10	83.48	96.04	110.17	122.73	134.70	148.44	159.44
9	85.34	97.90	112.03	123.70	134.70	148.44	159.44
8	87.20	99.76	112.70	123.70	134.70	148.44	159.44
7	89.06	100.33	112.70	123.70	134.70	148.44	159.44
6	89.34	100.33	112.70	123.70	134.70	148.44	159.44
5	89.34	100.33	112.70	123.70	134.70	148.44	159.44

Loads above or to the left of the heavy line correspond to values of L/R greater than 120.

DOUBLE EXTRA STRONG PIPE COLUMNS

(Loads in tons of 2000 pounds, based on New York and Chicago Building Laws)

$$S = 16{,}000 - 70\,L/R.$$

S = allowable compressive stress for steel, pounds per square inch;
L = length of column in inches; R = least radius of gyration in inches;
Maximum allowable compressive stress = 14,000 pounds per square inch.

Length, Feet	NOMINAL PIPE SIZE									
	2″	2½″	3″	3½″	4″	4½″	5″	6″	7″	8″
	THICKNESS									
	.436	.552	.600	.636	.674	.710	.750	.864	.875	.875
40	.....	.....	.....	.....	.....	.....	.....	.....	.....	40.64
36	.....	.....	.....	.....	.....	.....	.....	.....	31.86	53.61
33	.....	.....	.....	.....	.....	.....	.....	19.87	41.57	63.35
30	.....	.....	.....	.....	.....	.....	.....	29.43	51.29	73.08
27	.....	.....	.....	.....	.....	.....	16.05	39.00	61.00	82.82
24	.....	.....	.....	.....	.....	13.81	24.35	48.57	70.72	92.55
22	.....	.....	.....	.....	10.31	19.04	29.88	54.94	77.19	99.04
20	.....	.....	.....	7.13	15.27	24.27	35.41	61.32	83.67	105.53
18	.....	.....	.....	11.79	20.22	29.50	40.94	67.70	90.15	112.02
16	.....	.....	8.65	16.46	25.17	34.73	46.47	74.08	96.63	118.51
14	.....	4.17	13.03	21.12	30.13	39.95	52.00	80.46	103.10	125.00
13	.....	6.17	15.22	23.45	32.61	42.57	54.77	83.64	106.34	128.25
12	.....	8.18	17.42	25.78	35.08	45.18	57.54	86.83	109.58	131.49
11	3.78	10.18	19.61	28.12	37.56	47.80	60.30	90.02	112.82	134.74
10	5.37	12.18	21.80	30.45	40.04	50.41	63.07	93.21	116.06	137.98
9	6.96	14.19	24.00	32.78	42.52	53.02	65.83	96.40	119.29	141.23
8	8.55	16.19	26.19	35.11	44.99	55.64	68.60	99.59	122.53	144.47
7	10.13	18.20	28.38	37.45	47.47	58.25	71.36	102.78	125.77	147.72
6	11.72	20.20	30.57	39.78	49.95	60.87	74.13	105.97	129.01	149.13
5	13.31	22.21	32.77	42.11	52.42	63.48	76.89	109.15	129.89	149.13

Loads above or to the left of the heavy line correspond to values of L/R greater than 120.

ROUND

SEAMLESS STEEL MECHANICAL TUBING

IRON PIPE SIZES

Standard weights and dimensions.

Size (Nominal Inside Diameter), Inch	Outside Diameter, Inch	"Standard" Pipe			"Extra Strong" Pipe		"Double Extra Strong" Pipe	
		Number of Threads per Inch	Thickness, Inch	Weight of Pipe per Linear Foot, Plain Ends, Lb.	Thickness, Inch	Weight of Pipe per Linear Foot, Plain Ends, Lb.	Thickness, Inch	Weight of Pipe per Linear Foot, Plain Ends, Lb.
⅛	0.405	27	0.068	.244	0.095	0.31	.....	.....
¼	0.540	18	0.088	.424	0.119	0.54	.....	.....
⅜	0.675	18	0.091	.567	0.126	0.74	.....	.....
½	0.840	14	0.109	.850	0.147	1.09	0.294	1.71
¾	1.050	14	0.113	1.130	0.154	1.47	0.308	2.44
1	1.315	11½	0.133	1.678	0.179	2.17	0.358	3.66
1¼	1.660	11½	0.140	2.272	0.191	3.00	0.382	5.21
1½	1.900	11½	0.145	2.717	0.200	3.63	0.400	6.41
2	2.375	11½	0.154	3.652	0.218	5.02	0.436	9.03
2½	2.875	8	0.203	5.793	0.276	7.66	0.552	13.70
3	3.500	8	0.216	7.575	0.300	10.25	0.600	18.58
3½	4.000	8	0.226	9.109	0.318	12.51	0.636	22.85
4	4.500	8	0.237	10.790	0.337	14.98	0.674	27.54
4½	5.000	8	0.247	12.538	0.355	17.61	0.710	32.53
5	5.563	8	0.258	14.617	0.375	20.78	0.750	38.55
6	6.625	8	0.280	18.974	0.432	28.57	0.864	53.16
7	7.625	8	0.301	23.544	0.500	38.05	0.875	63.08
*8	8.625	8	0.277	24.696	.....	.....	0.875	72.42
8	8.625	8	0.322	28.554	0.500	43.39	.....	.....
9	9.625	8	0.342	33.907	0.500	48.73	.....	.....
*10	10.750	8	0.279	31.201	.....	.....	.....	.....
*10	10.750	8	0.307	34.240	.....	.....	.....	.....
10	10.750	8	0.365	40.483	0.500	54.74	.....	.....
11	11.750	8	0.375	45.557	0.500	60.08	.....	.....
*12	12.750	8	0.330	43.773	.....	.....	.....	.....
12	12.750	8	0.375	49.562	0.500	65.42	.....	.....

**Unless specifically stated on the order the lighter weights will not be furnished. Weights given in the table are for pipes up to and including 12" in nominal inside diameter, with threaded ends and couplings; sizes larger than those shown in the table are measured by the outside diameter and will be furnished with plain ends unless otherwise specified. For such sizes it will be necessary to accept Manufacturers' weights or calculate the weights on the basis of one cubic inch of steel weighing .2833 pound.*

PROPERTIES OF SEAMLESS STEEL TUBING

SECTIONAL AREA OF WALL IN SQUARE INCHES

Outside Diameter Inches	THICKNESS IN GAGES							
	24 B.W.G.	23 B.W.G.	22 B.W.G.	21 B.W.G.	20 B.W.G.	19 B.W.G.	18 B.W.G.	17 B.W.G.
1/4	.0157	.0176	.0195	.0219	.0236	.0274	.0309	.0349
5/16	.0200	.0225	.0250	.0281	.0305	.0356	.0405	.0463
3/8	.0243	.0274	.0305	.0344	.0373	.0439	.0501	.0577
7/16	.0287	.0323	.0360	.0407	.0442	.0521	.0598	.0691
1/2	.0330	.0373	.0415	.0470	.0511	.0604	.0694	.0805
9/16	.0373	.0422	.0470	.0533	.0580	.0686	.0790	.0919
5/8	.0416	.0471	.0525	.0596	.0648	.0769	.0886	.1033
11/16	.0459	.0520	.0580	.0658	.0717	.0851	.0982	.1147
3/4	.0503	.0569	.0635	.0721	.0786	.0934	.1079	.1260
13/16	.0546	.0618	.0690	.0784	.0854	.1016	.1175	.1374
7/8	.0589	.0667	.0745	.0847	.0923	.1099	.1271	.1488
15/16	.0632	.0716	.0800	.0910	.0992	.1181	.1367	.1602
1	.0675	.0765	.0855	.0973	.1061	.1264	.1463	.1716
1 1/16	.0719	.0814	.0909	.1035	.1129	.1346	.1560	.1830
1 1/8	.0762	.0863	.0964	.1098	.1198	.1428	.1656	.1944
1 3/16	.0805	.0913	.1019	.1161	.1267	.1511	.1752	.2058
1 1/4	.0848	.0962	.1074	.1224	.1335	.1593	.1848	.2171
1 5/16	.0891	.1011	.1129	.1287	.1404	.1676	.1945	.2285
1 3/8	.0935	.1060	.1184	.1350	.1473	.1758	.2041	.2399
1 7/16	.0978	.1109	.1239	.1412	.1542	.1841	.2137	.2513
1 1/2	.1021	.1158	.1294	.1475	.1610	.1923	.2233	.2627
1 5/8	.1107	.1256	.1404	.1601	.1748	.2088	.2426	.2855
1 3/4	.1194	.1354	.1514	.1727	.1885	.2253	.2618	.3083
1 7/8	.1280	.1452	.1624	.1852	.2023	.2418	.2810	.3310
2	.1367	.1551	.1734	.1978	.2160	.2583	.3003	.3538
2 1/8	.....	.....	.....	.....	.....	.....	.3195	.3766
2 1/4	.....	.....	.....	.....	.....	.....	.3388	.3994
2 3/8	.....	.....	.....	.....	.....	.....	.3580	.4221
2 1/2	.....	.....	.....	.....	.....	.....	.3773	.4449
2 5/8	.....	.....	.....	.....	.....	.....	.3965	.4677
2 3/4	.....	.....	.....	.....	.....	.....	.4157	.4905
2 7/8	.....	.....	.....	.....	.....	.....	.4350	.5132
3	.....	.....	.....	.....	.....	.....	.4542	.5360
3 1/8	.....	.....	.....	.....	.....	.....	.4735	.5588
3 1/4	.....	.....	.....	.....	.....	.....	.4927	.5816

Outside Diameter Inches	THICKNESS IN GAGES							
	16 B.W.G.	15 B.W.G.	14 B.W.G.	13 B.W.G.	12 B.W.G.	11 B.W.G.	10 B.W.G.	9 B.W.G.
1/4	.0377	.0402	.0435	.0462	.....	.....	.....	.....
5/16	.0505	.0544	.0598	.0649	.0696	.0725	.....	.....
3/8	.0633	.0685	.0761	.0835	.0910	.0961	.1014	.....
7/16	.0760	.0826	.0924	.1022	.1124	.1196	.1277	.....
1/2	.0888	.0968	.1087	.1208	.1338	.1432	.1540	.1636
9/16	.1015	.1109	.1250	.1395	.1552	.1668	.1803	.1927
5/8	.1143	.1250	.1413	.1581	.1766	.1903	.2066	.2217
11/16	.1271	.1392	.1576	.1768	.1980	.2139	.2330	.2508
3/4	.1398	.1533	.1739	.1954	.2195	.2375	.2593	.2799
13/16	.1526	.1674	.1902	.2141	.2409	.2610	.2856	.3089
7/8	.1654	.1816	.2065	.2327	.2623	.2846	.3119	.3380
15/16	.1781	.1957	.2228	.2514	.2837	.3081	.3382	.3670
1	.1909	.2099	.2391	.2700	.3051	.3317	.3645	.3961
1 1/16	.2036	.2240	.2554	.2887	.3265	.3553	.3908	.4252
1 1/8	.2164	.2381	.2717	.3074	.3479	.3788	.4171	.4542

SECTIONAL AREA OF WALL IN SQUARE INCHES (Continued)

Outside Diameter Inches	THICKNESS IN GAGES							
	16 B.W.G.	15 B.W.G.	14 B.W.G.	13 B.W.G.	12 B.W.G.	11 B.W.G.	10 B.W.G.	9 B.W.G.
1 3/16	.2292	.2523	.2880	.3260	.3693	.4024	.4434	.4833
1 1/4	.2419	.2664	.3042	.3447	.3907	.4260	.4698	.5123
1 5/16	.2547	.2805	.3205	.3633	.4121	.4495	.4961	.5414
1 3/8	.2675	.2947	.3368	.3820	.4335	.4731	.5224	.5705
1 7/16	.2802	.3088	.3531	.4006	.4549	.4966	.5487	.5995
1 1/2	.2930	.3230	.3694	.4193	.4763	.5202	.5750	.6286
1 5/8	.3185	.3512	.4020	.4566	.5191	.5673	.6276	.6867
1 3/4	.3440	.3795	.4346	.4939	.5619	.6144	.6802	.7448
1 7/8	.3696	.4078	.4672	.5312	.6047	.6616	.7329	.8029
2	.3951	.4361	.4998	.5685	.6475	.7087	.7855	.8610
2 1/4	.4461	.4926	.5650	.6431	.7331	.8029	.8907	.9773
2 3/8	.4717	.5209	.5976	.6804	.7759	.8501	.9434	1.0354
2 1/2	.4972	.5492	.6302	.7177	.8187	.8972	.9960	1.0935
2 5/8	.5227	.5774	.6628	.7550	.8615	.9443	1.0486	1.1516
2 3/4	.5482	.6057	.6954	.7923	.9043	.9914	1.1012	1.2098
2 7/8	.5738	.6340	.7280	.8296	.9471	1.0386	1.1538	1.2679
3	.5993	.6622	.7606	.8670	.9899	1.0857	1.2065	1.3260
3 1/4	.6503	.7188	.8258	.9416	1.0755	1.1799	1.3117	1.4422
3 3/8	.6759	.7471	.8583	.9789	1.1183	1.2271	1.3643	1.5004
3 1/2	.7014	.7753	.8909	1.0162	1.1611	1.2742	1.4169	1.5585
3 5/8	.7269	.8036	.9235	1.0535	1.2039	1.3213	1.4696	1.6166
3 3/4	.7524	.8319	.9561	1.0908	1.2468	1.3684	1.5222	1.6747
3 7/8	.7780	.8602	.9887	1.1281	1.2896	1.4156	1.5748	1.7328
4	.8035	.8884	1.0213	1.1654	1.3324	1.4627	1.6274	1.7910
4 1/4	.8545	.9450	1.0865	1.2400	1.4180	1.5569	1.7327	1.9072
4 1/2	.9056	1.0015	1.1517	1.3146	1.5036	1.6512	1.8379	2.0234
4 3/4	.9566	1.0581	1.2169	1.3892	1.5892	1.7454	1.9432	2.1397
5	1.0077	1.1146	1.2821	1.4639	1.6748	1.8397	2.0484	2.2559
5 1/4	1.0587	1.1712	1.3473	1.5385	1.7604	1.9339	2.1537	2.3722
5 1/2	1.1098	1.2277	1.4124	1.6131	1.8460	2.0282	2.2589	2.4884
5 3/4	.....	.....	.....	.....	.....	.....	2.3641	2.6046
6	.....	.....	.....	.....	.....	.....	2.4694	2.7209
6 1/4	.....	.....	.....	.....	.....	.....	2.5746	2.8371
6 1/2	.....	.....	.....	.....	.....	.....	2.6799	2.9533
6 3/4	.....	.....	.....	.....	.....	.....	2.7851	3.0696
7	.....	.....	.....	.....	.....	.....	2.8904	3.1858
7 1/4	.....	.....	.....	.....	.....	.....	2.9956	3.3021
7 1/2	.....	.....	.....	.....	.....	.....	3.1008	3.4183
7 3/4	.....	.....	.....	.....	.....	.....	3.2061	3.5345
8	.....	.....	.....	.....	.....	.....	3.3113	3.6508
8 1/4	.....	.....	.....	.....	.....	.....	3.4166	3.7670
8 1/2	.....	.....	.....	.....	.....	.....	3.5218	3.8833
8 3/4	.....	.....	.....	.....	.....	.....	3.6271	3.9995
9	.....	.....	.....	.....	.....	.....	3.7323	4.1157

Outside Diameter Inches	THICKNESS IN GAGES AND FRACTIONS OF AN INCH							
	5/32"	8 B.W.G.	7 B.W.G.	3/16"	6 B.W.G.	7/32"	5 B.W.G.	4 B.W.G.
5/8	.2300	.2384	.2516	.2577	.....	.....	.....	.....
11/16"	.2607	.2708	.2869	.2945	.3089	.3221	.3231	.3360
3/4	.2914	.3032	.3223	.3313	.3488	.3650	.3663	.3828
13/16"	.3221	.3356	.3576	.3681	.3887	.4080	.4095	.4295
7/8	.3528	.3680	.3930	.4049	.4285	.4509	.4527	.4762
15/16"	.3834	.4004	.4283	.4417	.4684	.4939	.4959	.5230
1	.4141	.4328	.4636	.4786	.5082	.5368	.5390	.5697

SECTIONAL AREA OF WALL IN SQUARE INCHES (Continued)

Outside Diameter Inches	THICKNESS IN GAGES AND FRACTIONS OF AN INCH							
	1/16"	8 B.W.G.	7 B.W.G.	3/16"	6 B.W.G.	7/32"	5 B.W.G.	4 B.W.G.
1 1/16	.4448	.4652	.4990	.5154	.5481	.5798	.5822	.6164
1 1/8	.4755	.4976	.5343	.5522	.5879	.6227	.6254	.6632
1 3/16	.5062	.5300	.5697	.5890	.6278	.6657	.6686	.7099
1 1/4	.5368	.5624	.6050	.6258	.6677	.7086	.7118	.7566
1 5/16	.5675	.5948	.6404	.6626	.7075	.7516	.7550	.8034
1 3/8	.5982	.6272	.6757	.6994	.7474	.7946	.7982	.8501
1 7/16	.6289	.6596	.7111	.7363	.7872	.8375	.8414	.8968
1 1/2	.6596	.6920	.7464	.7731	.8271	.8805	.8846	.9435
1 5/8	.7209	.7568	.8171	.8467	.9068	.9664	.9710	1.0370
1 3/4	.7823	.8216	.8878	.9203	.9865	1.0523	1.0574	1.1305
1 7/8	.8436	.8864	.9585	.9940	1.0663	1.1382	1.1438	1.2239
2	.9050	.9511	1.0291	1.0676	1.1460	1.2241	1.2302	1.3174
2 1/8	.9664	1.0159	1.0998	1.1412	1.2257	1.3100	1.3166	1.4109
2 1/4	1.0277	1.0807	1.1705	1.2149	1.3054	1.3959	1.4030	1.5043
2 3/8	1.0891	1.1455	1.2412	1.2885	1.3851	1.4818	1.4894	1.5978
2 1/2	1.1504	1.2103	1.3119	1.3621	1.4648	1.5677	1.5758	1.6912
2 5/8	1.2118	1.2751	1.3826	1.4358	1.5446	1.6536	1.6622	1.7847
2 3/4	1.2732	1.3399	1.4533	1.5094	1.6243	1.7395	1.7486	1.8782
2 7/8	1.3345	1.4047	1.5239	1.5830	1.7040	1.8254	1.8350	1.9716
3	1.3959	1.4695	1.5946	1.6566	1.7837	1.9113	1.9213	2.0651
3 1/8	1.4572	1.5343	1.6653	1.7303	1.8634	1.9972	2.0077	2.1586
3 1/4	1.5186	1.5991	1.7360	1.8039	1.9432	2.0831	2.0941	2.2520
3 3/8	1.5800	1.6639	1.8067	1.8775	2.0229	2.1690	2.1805	2.3455
3 1/2	1.6413	1.7287	1.8774	1.9512	2.1026	2.2549	2.2669	2.4389
3 5/8	1.7027	1.7935	1.9481	2.0248	2.1823	2.3408	2.3533	2.5324
3 3/4	1.7640	1.8583	2.0187	2.0984	2.2620	2.4267	2.4397	2.6259
3 7/8	1.8254	1.9231	2.0894	2.1721	2.3417	2.5126	2.5261	2.7193
4	1.8867	1.9879	2.1601	2.2457	2.4215	2.5985	2.6125	2.8128
4 1/8	1.9481	2.0527	2.2308	2.3193	2.5012	2.6844	2.6989	2.9063
4 1/4	2.0095	2.1175	2.3015	2.3930	2.5809	2.7703	2.7853	2.9997
4 3/8	2.0708	2.1823	2.3722	2.4666	2.6606	2.8562	2.8717	3.0932
4 1/2	2.1322	2.2471	2.4429	2.5402	2.7403	2.9421	2.9581	3.1866
4 5/8	2.1935	2.3118	2.5135	2.6139	2.8201	3.0280	3.0445	3.2801
4 3/4	2.2549	2.3766	2.5842	2.6875	2.8998	3.1139	3.1309	3.3736
4 7/8	2.3163	2.4414	2.6549	2.7611	2.9795	3.1998	3.2173	3.4670
5	2.3776	2.5062	2.7256	2.8347	3.0592	3.2857	3.3036	3.5605
5 1/4	2.5003	2.6358	2.8670	2.9820	3.2186	3.4575	3.4764	3.7474
5 1/2	2.6231	2.7654	3.0083	3.1293	3.3781	3.6293	3.6492	3.9343
5 3/4	2.7458	2.8950	3.1497	3.2765	3.5375	3.8012	3.8220	4.1213
6	2.8685	3.0246	3.2911	3.4238	3.6969	3.9730	3.9948	4.3082
6 1/4	2.9912	3.1542	3.4325	3.5711	3.8564	4.1448	4.1676	4.4951
6 1/2	3.1139	3.2838	3.5738	3.7183	4.0158	4.3166	4.3404	4.6820
6 3/4	3.2367	3.4134	3.7152	3.8656	4.1753	4.4884	4.5132	4.8690
7	3.3594	3.5430	3.8566	4.0128	4.3347	4.6602	4.6860	5.0559
7 1/4	3.4821	3.6726	3.9979	4.1601	4.4941	4.8320	4.8587	5.2428
7 1/2	3.6048	3.8021	4.1393	4.3074	4.6536	5.0038	5.0315	5.4297
7 3/4	3.7275	3.9317	4.2807	4.4546	4.8130	5.1756	5.2043	5.6167
8	3.8502	4.0613	4.4221	4.6019	4.9724	5.3474	5.3771	5.8036
8 1/4	3.9730	4.1909	4.5634	4.7492	5.1319	5.5192	5.5499	5.9905
8 1/2	4.0957	4.3205	4.7048	4.8964	5.2913	5.6910	5.7227	6.1774
8 3/4	4.2184	4.4501	4.8462	5.0437	5.4507	5.8628	5.8955	6.3644
9	4.3411	4.5797	4.9875	5.1909	5.6102	6.0346	6.0683	6.5513
9 1/4	.....	.....	.....	.....	5.7697	6.2065	6.2411	6.7383
9 1/2	.....	.....	.....	.....	.....	.....	6.4139	6.9252
9 3/4	.....	.....	.....	.....	.....	.....	6.5867	7.1121
10	.....	.....	.....	.....	.....	.....	6.7595	7.2991
10 1/4	.....	.....	.....	.....	.....	.....	.....	7.4860
10 1/2	.....	.....	.....	.....	.....	.....	.....	7.6729

SECTIONAL AREA OF WALL IN SQUARE INCHES (Continued)

Outside Diameter Inches	THICKNESS IN GAGES AND FRACTIONS OF AN INCH							
	1/4"	3 B.W.G.	9/32"	2 B.W.G.	1 B.W.G.	5/16"	0 B.W.G.	11/32"
11/16	.3436	.....	.....	.....	.....	.....	.....	.....
3/4	.3926	.3995	.4141	.4157	.4241	.4295	.....	.....
13/16	.4417	.4503	.4693	.4715	.4830	.4908	.5046	.5062
7/8	.4908	.5012	.5246	.5272	.5419	.5522	.5714	.5737
15/16	.5399	.5520	.5798	.5830	.6008	.6135	.6382	.6412
1	.5890	.6029	.6350	.6388	.6597	.6749	.7049	.7086
1 1/16	.6381	.6537	.6902	.6945	.7186	.7363	.7717	.7761
1 1/8	.6872	.7046	.7455	.7503	.7775	.7976	.8384	.8436
1 3/16	.7363	.7554	.8007	.8061	.8364	.8590	.9052	.9111
1 1/4	.7853	.8063	.8559	.8618	.8953	.9203	.9720	.9786
1 5/16	.8344	.8572	.9111	.9176	.9542	.9817	1.0387	1.0461
1 3/8	.8835	.9080	.9664	.9734	1.0131	1.0431	1.1055	1.1136
1 7/16	.9326	.9589	1.0216	1.0291	1.0720	1.1044	1.1722	1.1811
1 1/2	.9817	1.0097	1.0768	1.0849	1.1309	1.1658	1.2390	1.2486
1 5/8	1.0799	1.1114	1.1873	1.1964	1.2487	1.2885	1.3725	1.3836
1 3/4	1.1780	1.2131	1.2977	1.3079	1.3665	1.4112	1.5060	1.5186
1 7/8	1.2762	1.3148	1.4081	1.4195	1.4844	1.5339	1.6395	1.6536
2	1.3744	1.4166	1.5186	1.5310	1.6022	1.6566	1.7731	1.7886
2 1/8	1.4726	1.5183	1.6290	1.6425	1.7200	1.7794	1.9066	1.9236
2 1/4	1.5707	1.6200	1.7395	1.7540	1.8378	1.9021	2.0401	2.0586
2 3/8	1.6689	1.7217	1.8499	1.8656	1.9556	2.0248	2.1736	2.1935
2 1/2	1.7671	1.8234	1.9604	1.9771	2.0734	2.1475	2.3071	2.3285
2 5/8	1.8653	1.9251	2.0708	2.0886	2.1912	2.2702	2.4407	2.4635
2 3/4	1.9634	2.0268	2.1813	2.2001	2.3000	2.3930	2.5742	2.5985
2 7/8	2.0616	2.1285	2.2917	2.3117	2.4268	2.5157	2.7077	2.7335
3	2.1598	2.2302	2.4022	2.4232	2.5446	2.6384	2.8412	2.8685
3 1/8	2.2580	2.3319	2.5126	2.5347	2.6625	2.7611	2.9747	3.0035
3 1/4	2.3561	2.4336	2.6231	2.6463	2.7803	2.8838	3.1082	3.1385
3 3/8	2.4543	2.5354	2.7335	2.7578	2.8981	3.0066	3.2418	3.2735
3 1/2	2.5525	2.6371	2.8440	2.8693	3.0159	3.1293	3.3753	3.4085
3 5/8	2.6507	2.7388	2.9544	2.9808	3.1337	3.2520	3.5088	3.5434
3 3/4	2.7488	2.8405	3.0648	3.0924	3.2515	3.3747	3.6423	3.6784
3 7/8	2.8470	2.9422	3.1753	3.2039	3.3693	3.4974	3.7758	3.8134
4	2.9452	3.0439	3.2857	3.3154	3.4871	3.6201	3.9093	3.9484
4 1/8	3.0434	3.1456	3.3962	3.4269	3.6049	3.7429	4.0429	4.0834
4 1/4	3.1415	3.2473	3.5066	3.5385	3.7227	3.8656	4.1764	4.2184
4 3/8	3.2397	3.3490	3.6171	3.6500	3.8405	3.9883	4.3099	4.3534
4 1/2	3.3379	3.4507	3.7275	3.7615	3.9584	4.1110	4.4434	4.4884
4 5/8	3.4361	3.5524	3.8380	3.8730	4.0762	4.2337	4.5769	4.6234
4 3/4	3.5342	3.6542	3.9484	3.9846	4.1940	4.3565	4.7105	4.7584
4 7/8	3.6324	3.7559	4.0589	4.0961	4.3118	4.4792	4.8440	4.8933
5	3.7306	3.8576	4.1693	4.2076	4.4296	4.6019	4.9775	5.0283
5 1/8	3.8288	3.9593	4.2798	4.3192	4.5474	4.7246	5.1110	5.1633
5 1/4	3.9269	4.0610	4.3902	4.4307	4.6652	4.8473	5.2445	5.2983
5 1/2	4.1233	4.2644	4.6111	4.6537	4.9008	5.0928	5.5116	5.5683
5 3/4	4.3196	4.4678	4.8320	4.8768	5.1365	5.3382	5.7786	5.8383
6	4.5160	4.6712	5.0529	5.0998	5.3721	5.5836	6.0456	6.1083
6 1/4	4.7123	4.8747	5.2738	5.3229	5.6077	5.8291	6.3127	6.3782
6 1/2	4.9087	5.0781	5.4947	5.5459	5.8433	6.0745	6.5797	6.6482
6 3/4	5.1050	5.2815	5.7156	5.7690	6.0789	6.3200	6.8467	6.9182
7	5.3014	5.4849	5.9365	5.9920	6.3146	6.5654	7.1138	7.1882
7 1/4	5.4977	5.6883	6.1573	6.2151	6.5502	6.8108	7.3808	7.4582
7 1/2	5.6941	5.8918	6.3782	6.4382	6.7858	7.0563	7.6478	7.7281
7 3/4	5.8904	6.0952	6.5991	6.6612	7.0214	7.3017	7.9149	7.9981
8	6.0868	6.2986	6.8200	6.8843	7.2570	7.5471	8.1819	8.2681
8 1/4	6.2831	6.5020	7.0409	7.1073	7.4926	7.7926	8.4489	8.5381
8 1/2	6.4795	6.7054	7.2618	7.3304	7.7283	8.0380	8.7160	8.8081
8 3/4	6.6758	6.9088	7.4827	7.5534	7.9639	8.2834	8.9830	9.0780

SECTIONAL AREA OF WALL IN SQUARE INCHES (Continued)

Outside Diameter Inches	THICKNESS IN GAGES AND FRACTIONS OF AN INCH							
	1/4"	3 B.W.G.	9/32"	2 B.W.G.	1 B.W.G.	5/16"	0 B.W.G.	11/32"
9	6.8722	7.1123	7.7036	7.7765	8.1995	8.5289	9.2501	9.3480
9 1/4	7.0686	7.3157	7.9246	7.9996	8.4352	8.7744	9.5172	9.6181
9 1/2	7.2649	7.5192	8.1455	8.2226	8.6708	9.0198	9.7842	9.8881
9 3/4	7.4613	7.7226	8.3663	8.4457	8.9064	9.2653	10.0512	10.1580
10	7.6577	7.9260	8.5872	8.6688	9.1421	9.5107	10.3183	10.4280
10 1/4	7.8540	8.1294	8.8081	8.8918	9.3777	9.7561	10.5853	10.6980
10 1/2	8.0504	8.3328	9.0290	9.1149	9.6133	10.0016	10.8523	10.9680
10 3/4	.....	8.5363	9.2499	9.3379	9.8489	10.2470	11.1194	11.2380
11	.....	8.7397	9.4708	9.5610	10.0845	10.4925	11.3864	11.5079
11 1/4	.....	8.9431	9.6917	9.7840	10.3202	10.7379	11.6535	11.7779
11 1/2	.....	9.1465	9.9126	10.0071	10.5558	10.9833	11.9205	12.0479
11 3/4	.....	9.3499	10.1335	10.2301	10.7914	11.2288	12.1875	12.3179
12	.....	9.5534	10.3544	10.4532	11.0270	11.4742	12.4546	12.5879

Outside Diameter Inches	THICKNESS IN GAGES AND FRACTIONS OF AN INCH						
	3/8"	00 B.W.G.	000 B.W.G.	7/16"	0000 B.W.G.	1/2"	9/16"
13/16	.5154	.....	.....	.....	.....	.....	.....
7/8	.5890	.....	.....	.....	.....	.....	.....
15/16	.6626	.6655	.6842	.6872	.....	.....	.....
1	.7363	.7401	.7677	.7731	.7787	.....	.....
1 1/16	.8099	.8147	.8511	.8590	.8678	.....	.....
1 1/8	.8835	.8893	.9346	.9449	.9570	.9817	.....
1 3/16	.9572	.9639	1.0180	1.0308	1.0461	1.0799	.....
1 1/4	1.0308	1.0386	1.1015	1.1167	1.1353	1.1780	.....
1 5/16	1.1044	1.1132	1.1849	1.2026	1.2244	1.2762	.....
1 3/8	1.1780	1.1878	1.2684	1.2885	1.3136	1.3744	1.4358
1 7/16	1.2517	1.2624	1.3518	1.3744	1.4027	1.4726	1.5462
1 1/2	1.3253	1.3370	1.4353	1.4603	1.4918	1.5707	1.6566
1 5/8	1.4726	1.4862	1.6022	1.6321	1.6701	1.7671	1.8775
1 3/4	1.6198	1.6355	1.7691	1.8039	1.8484	1.9634	2.0984
1 7/8	1.7671	1.7847	1.9360	1.9757	2.0267	2.1598	2.3193
2	1.9144	1.9339	2.1029	2.1475	2.2050	2.3561	2.5402
2 1/8	2.0616	2.0831	2.2698	2.3193	2.3833	2.5525	2.7611
2 1/4	2.2089	2.2324	2.4366	2.4911	2.5616	2.7488	2.9820
2 3/8	2.3561	2.3816	2.6035	2.6629	2.7398	2.9452	3.2029
2 1/2	2.5034	2.5308	2.7704	2.8347	2.9181	3.1415	3.4238
2 5/8	2.6507	2.6800	2.9373	3.0066	3.0964	3.3379	3.6447
2 3/4	2.7979	2.8293	3.1042	3.1784	3.2747	3.5342	3.8656
2 7/8	2.9452	2.9785	3.2711	3.3502	3.4530	3.7306	4.0865
3	3.0925	3.1277	3.4380	3.5220	3.6313	3.9269	4.3074
3 1/8	3.2397	3.2769	3.6049	3.6938	3.8096	4.1233	4.5283
3 1/4	3.3870	3.4262	3.7718	3.8656	3.9878	4.3196	4.7492
3 3/8	3.5342	3.5754	3.9387	4.0374	4.1661	4.5160	4.9700
3 1/2	3.6815	3.7246	4.1056	4.2092	4.3444	4.7123	5.1909
3 5/8	3.8288	3.8738	4.2725	4.3810	4.5227	4.9087	5.4118
3 3/4	3.9760	4.0231	4.4394	4.5528	4.7010	5.1050	5.6327
3 7/8	4.1233	4.1723	4.6063	4.7246	4.8793	5.3014	5.8536
4	4.2706	4.3215	4.7732	4.8964	5.0576	5.4977	6.0745
4 1/8	4.4178	4.4708	4.9401	5.0682	5.2358	5.6941	6.2954
4 1/4	4.5651	4.6200	5.1070	5.2400	5.4141	5.8904	6.5163
4 3/8	4.7123	4.7692	5.2739	5.4118	5.5924	6.0868	6.7372
4 1/2	4.8596	4.9184	5.4408	5.5836	5.7707	6.2831	6.9581
4 5/8	5.0069	5.0677	5.6077	5.7554	5.9490	6.4795	7.1790
4 3/4	5.1541	5.2169	5.7746	5.9273	6.1273	6.6758	7.3999
4 7/8	5.3014	5.3661	5.9415	6.0991	6.3055	6.8722	7.6208
5	5.4487	5.5153	6.1084	6.2709	6.4838	7.0685	7.8417

SECTIONAL AREA OF WALL IN SQUARE INCHES (Continued)

Outside Diameter Inches	THICKNESS IN GAGES AND FRACTIONS OF AN INCH						
	3/8"	00 B.W.G.	000 B.W.G.	7/16"	0000 B.W.G.	1/2"	9/16"
5 1/8	5.5959	5.6646	6.2753	6.4427	6.6621	7.2649	8.0626
5 1/4	5.7432	5.8138	6.4422	6.6145	6.8404	7.4612	8.2834
5 3/8	5.8904	5.9630	6.6091	6.7863	7.0187	7.6576	8.5043
5 1/2	6.0377	6.1122	6.7760	6.9581	7.1970	7.8539	8.7252
5 3/4	6.3322	6.4107	7.1098	7.3017	7.5535	8.2466	9.1670
6	6.6267	6.7091	7.4436	7.6453	7.9101	8.6393	9.6088
6 1/4	6.9213	7.0076	7.7774	7.9889	8.2667	9.0320	10.0506
6 1/2	7.2158	7.3060	8.1112	8.3325	8.6233	9.4247	10.4924
6 3/4	7.5103	7.6045	8.4449	8.6761	8.9798	9.8174	10.9342
7	7.8048	7.9029	8.7787	9.0198	9.3364	10.2101	11.3760
7 1/4	8.0994	8.2014	9.1125	9.3634	9.6930	10.6028	11.8177
7 1/2	8.3939	8.4998	9.4463	9.7070	10.0495	10.9955	12.2595
7 3/4	8.6884	8.7983	9.7801	10.0506	10.4061	11.3882	12.7013
8	8.9829	9.0967	10.1139	10.3942	10.7627	11.7809	13.1431
8 1/4	9.2775	9.3952	10.4477	10.7378	11.1193	12.1736	13.5849
8 1/2	9.5720	9.6936	10.7815	11.0814	11.4758	12.5663	14.0267
8 3/4	9.8665	9.9921	11.1153	11.4250	11.8324	12.9590	14.4685
9	10.1610	10.2906	11.4491	11.7687	12.1890	13.3517	14.9102
9 1/4	10.4556	10.5891	11.7830	12.1123	12.5456	13.7445	15.3521
9 1/2	10.7502	10.8875	12.1168	12.4560	12.9022	14.1372	15.7939
9 3/4	11.0447	11.1860	12.4506	12.7996	13.2588	14.5299	16.2357
10	11.3392	11.4844	12.7843	13.1432	13.6153	14.9226	16.6775
10 1/4	11.6337	11.7829	13.1181	13.4868	13.9719	15.3153	17.1193
10 1/2	11.9283	12.0813	13.4519	13.8304	14.3285	15.7080	17.5611
10 3/4	12.2228	12.3798	13.7857	14.1740	14.6850	16.1007	18.0028
11	12.5173	12.6782	14.1195	14.5176	15.0416	16.4934	18.4446
11 1/4	12.8118	12.9767	14.4533	14.8612	15.3982	16.8861	18.8864
11 1/2	13.1064	13.2751	14.7871	15.2049	15.7548	17.2788	19.3282
11 3/4	13.4009	13.5736	15.1209	15.5485	16.1113	17.6715	19.7700
12	13.6954	13.8720	15.4547	15.8921	16.4679	18.0642	20.2118
12 1/4	13.9899	14.1705	15.7885	16.2357	16.8245	18.4569	20.6536
12 1/2	14.2845	14.4690	16.1223	16.5793	17.1810	18.8496	21.0954
12 3/4	14.5790	14.7674	16.4561	16.9229	17.5376	19.2423	21.5371
13	.....	.....	.....	17.2665	17.8942	19.6350	21.9789
13 1/4	.....	.....	.....	17.6101	18.2508	20.0277	22.4207
13 1/2	.....	.....	.....	17.9538	18.6073	20.4204	22.8625
13 3/4	.....	.....	.....	.....	.....	20.8131	23.3043

Outside Diameter Inches	THICKNESS IN FRACTIONS OF AN INCH						
	5/8"	11/16"	3/4"	13/16"	7/8"	15/16"	1"
1 7/8	1.5953	.....	.....	.....	.....	.....	.....
1 1/2	1.7180	.....	.....	.....	.....	.....	.....
1 5/8	1.9634	.....	.....	.....	.....	.....	.....
1 3/4	2.2089	.....	.....	.....	.....	.....	.....
1 7/8	2.4543	.....	.....	.....	.....	.....	.....
2	2.6998	.....	.....	.....	.....	.....	.....
2 1/8	2.9452	3.1047	3.2397	3.3502	3.4361	3.4974	3.5342
2 1/4	3.1906	3.3747	3.5342	3.6692	3.7797	3.8656	3.9269
2 3/8	3.4361	3.6447	3.8288	3.9883	4.1233	4.2337	4.3196
2 1/2	3.6815	3.9147	4.1233	4.3074	4.4669	4.6019	4.7123
2 5/8	3.9269	4.1847	4.4178	4.6264	4.8105	4.9700	5.1050
2 3/4	4.1724	4.4546	4.7123	4.9455	5.1541	5.3382	5.4977
2 7/8	4.4178	4.7246	5.0069	5.2646	5.4977	5.7064	5.8904
3	4.6633	4.9946	5.3014	5.5836	5.8413	6.0745	6.2831
3 1/8	4.9087	5.2646	5.5959	5.9027	6.1850	6.4427	6.6758
3 1/4	5.1541	5.5346	5.8904	6.2218	6.5286	6.8108	7.0685

SECTIONAL AREA OF WALL IN SQUARE INCHES (Concluded)

Outside Diameter Inches	THICKNESS IN FRACTIONS OF AN INCH						
	5/8"	11/16"	3/4"	13/16"	7/8"	15/16"	1"
3 3/4	5.3996	5.8045	6.1850	6.5408	6.8722	7.1790	7.4612
3 7/8	5.6450	6.0745	6.4795	6.8599	7.2158	7.5471	7.8539
3 1/2	5.8904	6.3445	6.7740	7.1790	7.5594	7.9153	8.2466
3 5/8	6.1359	6.6145	7.0685	7.4980	7.9030	8.2834	8.6393
3 3/4	6.3813	6.8845	7.3631	7.8171	8.2466	8.6516	9.0320
3 7/8	6.6267	7.1544	7.6576	8.1362	8.5902	9.0198	9.4247
4							
4 1/8	6.8722	7.4244	7.9521	8.4553	8.9339	9.3879	9.8174
4 1/4	7.1176	7.6944	8.2466	8.7743	9.2775	9.7561	10.2101
4 3/8	7.3631	7.9644	8.5412	9.0934	9.6211	10.1242	10.6028
4 1/2	7.6085	8.2344	8.8357	9.4125	9.9647	10.4924	10.9955
4 5/8	7.8539	8.5043	9.1302	9.7315	10.3083	10.8605	11.3882
4 3/4	8.0994	8.7743	9.4247	10.0506	10.6519	11.2287	11.7809
4 7/8	8.3448	9.0443	9.7193	10.3697	10.9955	11.5968	12.1736
5	8.5902	9.3143	10.0138	10.6887	11.3391	11.9650	12.5663
5 1/8	8.8357	9.5843	10.3083	11.0078	11.6827	12.3332	12.9590
5 1/4	9.0811	9.8542	10.6028	11.3269	12.0264	12.7013	13.3517
5 3/8	9.3266	10.1242	10.8974	11.6459	12.3700	13.0695	13.7444
5 1/2	9.5720	10.3942	11.1919	11.9650	12.7136	13.4376	14.1371
5 3/4	10.0629	10.9342	11.7809	12.6031	13.4008	14.1739	14.9225
6	10.5537	11.4741	12.3700	13.2413	14.0880	14.9102	15.7079
6 1/4	11.0446	12.0141	12.9590	13.8794	14.7753	15.6466	16.4933
6 1/2	11.5355	12.5540	13.5481	14.5175	15.4625	16.3829	17.2787
6 3/4	12.0264	13.0940	14.1371	15.1557	16.1497	17.1192	18.0641
7	12.5172	13.6340	14.7262	15.7938	16.8369	17.8555	18.8495
7 1/4	13.0081	14.1739	15.3152	16.4320	17.5241	18.5918	19.6349
7 1/2	13.4990	14.7139	15.9043	17.0701	18.2114	19.3281	20.4203
7 3/4	13.9899	15.2539	16.4933	17.7082	18.8986	20.0644	21.2057
8	14.4807	15.7938	17.0824	18.3464	19.5858	20.8007	21.9911
8 1/4	14.9716	16.3338	17.6714	18.9845	20.2730	21.5370	22.7765
8 1/2	15.4625	16.8737	18.2605	19.6226	20.9603	22.2734	23.5619
8 3/4	15.9534	17.4137	18.8495	20.2608	21.6475	23.0097	24.3473
9	16.4442	17.9537	19.4386	20.8989	22.3347	23.7460	25.1327
9 1/4	16.9352	18.4937	20.0277	21.5371	23.0220	24.4824	25.9182
9 1/2	17.4261	19.0337	20.6168	22.1753	23.7093	25.2187	26.7036
9 3/4	17.9169	19.5736	21.2058	22.8134	24.3965	25.9550	27.4890
10	18.4078	20.1136	21.7949	23.4516	25.0837	26.6913	28.2744
10 1/4	18.8987	20.6536	22.3839	24.0897	25.7709	27.4276	29.0598
10 1/2	19.3896	21.1935	22.9730	24.7278	26.4582	28.1640	29.8452
10 3/4	19.8804	21.7335	23.5620	25.3660	27.1454	28.9003	30.6306
11	20.3713	22.2735	24.1511	26.0041	27.8326	29.6366	31.4160
11 1/4	20.8622	22.8134	24.7401	26.6422	28.5198	30.3729	32.2014
11 1/2	21.3531	23.3534	25.3292	27.2804	29.2071	31.1092	32.9868
11 3/4	21.8439	23.8933	25.9182	27.9185	29.8943	31.8455	33.7722
12	22.3348	24.4333	26.5073	28.5567	30.5815	32.5818	34.5576
12 1/4	22.8257	24.9733	27.0963	29.1948	31.2687	33.3181	35.3430
12 1/2	23.3166	25.5132	27.6854	29.8329	31.9559	34.0545	36.1284
12 3/4	23.8074	26.0532	28.2744	30.4711	32.6432	34.7908	36.9138
13	24.2983	26.5932	28.8635	31.1092	33.3304	35.5271	37.6992
13 1/4	24.7892	27.1331	29.4525	31.7473	34.0176	36.2634	38.4846
13 1/2	25.2801	27.6731	30.0416	32.3855	34.7049	36.9997	39.2700
13 3/4	25.7709	28.2130	30.6306	33.0236	35.3921	37.7360	40.0554
14	26.2618	28.7530	31.2197	33.6618	36.0793	38.4723	40.8408

MOMENT OF INERTIA, I, FOR NEUTRAL AXIS THROUGH CENTER OF SECTION

Outside Diameter Inches	THICKNESS IN GAGES							
	24 B.W.G.	23 B.W.G.	22 B.W.G.	21 B.W.G.	20 B.W.G.	19 B.W.G.	18 B.W.G.	17 B.W.G.
1/4	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001
5/16	.0002	.0002	.0002	.0002	.0002	.0003	.0003	.0003
3/8	.0003	.0004	.0004	.0005	.0005	.0006	.0006	.0007
7/16	.0006	.0006	.0007	.0008	.0009	.0010	.0011	.0012
1/2	.0009	.0010	.0011	.0012	.0013	.0015	.0017	.0020
9/16	.0013	.0015	.0016	.0018	.0020	.0023	.0026	.0029
5/8	.0018	.0021	.0023	.0026	.0028	.0032	.0037	.0041
11/16	.0025	.0028	.0031	.0035	.0038	.0044	.0050	.0057
3/4	.0033	.0037	.0041	.0046	.0050	.0058	.0066	.0076
13/16	.0042	.0047	.0053	.0059	.0064	.0075	.0085	.0098
7/8	.0053	.0060	.0066	.0075	.0081	.0095	.0108	.0124
15/16	.0066	.0074	.0082	.0093	.0101	.0118	.0135	.0155
1	.0080	.0091	.0101	.0114	.0123	.0145	.0165	.0191
1 1/16	.0097	.0109	.0121	.0137	.0149	.0175	.0200	.0231
1 1/8	.0115	.0130	.0145	.0164	.0178	.0209	.0240	.0277
1 3/16	.0136	.0154	.0171	.0194	.0210	.0248	.0284	.0329
1 1/4	.0160	.0180	.0200	.0227	.0246	.0291	.0333	.0386
1 5/16	.0185	.0209	.0233	.0264	.0286	.0338	.0388	.0450
1 3/8	.0214	.0241	.0268	.0304	.0330	.0391	.0449	.0521
1 7/16	.0245	.0276	.0308	.0349	.0379	.0448	.0515	.0598
1 1/2	.0279	.0315	.0350	.0397	.0432	.0511	.0588	.0684
1 5/8	.0355	.0402	.0447	.0508	.0552	.0654	.0753	.0877
1 3/4	.0445	.0504	.0561	.0637	.0693	.0822	.0947	.1104
1 7/8	.0549	.0621	.0692	.0786	.0856	.1016	.1172	.1367
2	.0668	.0756	.0843	.0958	.1043	.1238	.1429	.1669
2 1/8	.....	.....	.....	.....	.....	.....	.1722	.2013
2 1/4	.....	.....	.....	.....	.....	.....	.2052	.2400
2 3/8	.....	.....	.....	.....	.....	.....	.2422	.2834
2 1/2	.....	.....	.....	.....	.....	.....	.2834	.3318
2 5/8	.....	.....	.....	.....	.....	.....	.3290	.3854
2 3/4	.....	.....	.....	.....	.....	.....	.3792	.4445
2 7/8	.....	.....	.....	.....	.....	.....	.4344	.5093
3	.....	.....	.....	.....	.....	.....	.4946	.5802
3 1/8	.....	.....	.....	.....	.....	.....	.5601	.6573
3 1/4	.....	.....	.....	.....	.....	.....	.6312	.7410

Outside Diameter Inches	THICKNESS IN GAGES							
	16 B.W.G.	15 B.W.G.	14 B.W.G.	13 B.W.G.	12 B.W.G.	11 B.W.G.	10 B.W.G.	9 B.W.G.
1/4	.0001	.0001	.0001	.0001	.....	.....	.....	.....
5/16	.0004	.0004	.0004	.0004	.0004	.0004	.....	.....
3/8	.0007	.0008	.0008	.0009	.0009	.0009	.0009	.....
7/16	.0013	.0014	.0015	.0016	.0016	.0017	.0017	.....
1/2	.0021	.0022	.0024	.0026	.0027	.0028	.0029	.0029
9/16	.0031	.0034	.0037	.0039	.0042	.0043	.0045	.0046
5/8	.0045	.0048	.0053	.0057	.0061	.0064	.0066	.0069
11/16	.0062	.0066	.0073	.0079	.0085	.0089	.0094	.0098
3/4	.0082	.0089	.0098	.0107	.0116	.0122	.0128	.0134
13/16	.0107	.0115	.0128	.0140	.0152	.0161	.0170	.0178
7/8	.0136	.0147	.0163	.0179	.0196	.0207	.0221	.0232
15/16	.0170	.0184	.0205	.0225	.0247	.0263	.0280	.0296
1	.0209	.0227	.0253	.0279	.0307	.0327	.0349	.0370
1 1/16	.0254	.0276	.0308	.0341	.0375	.0400	.0429	.0456
1 1/8	.0305	.0331	.0371	.0411	.0454	.0485	.0521	.0554
1 5/16	.0362	.0394	.0441	.0490	.0542	.0580	.0625	.0666

MOMENT OF INERTIA, I, FOR NEUTRAL AXIS THROUGH CENTER OF SECTION (Continued)

Outside Diameter Inches	THICKNESS IN GAGES							
	16 B.W.G.	15 B.W.G.	14 B.W.G.	13 B.W.G.	12 B.W.G.	11 B.W.G.	10 B.W.G.	9 B.W.G.
1¼	.0426	.0463	.0520	.0578	.0641	.0687	.0741	.0791
1⅝	.0496	.0541	.0608	.0677	.0752	.0807	.0872	.0932
1⅜	.0575	.0627	.0705	.0786	.0874	.0939	.1017	.1089
1⅞	.0661	.0721	.0813	.0907	.1010	.1086	.1177	.1262
1½	.0755	.0825	.0930	.1039	.1159	.1247	.1354	.1453
1⅝	.0970	.1061	.1198	.1341	.1499	.1616	.1758	.1891
1¾	.1222	.1338	.1513	.1696	.1899	.2051	.2235	.2409
1⅞	.1515	.1659	.1879	.2109	.2366	.2559	.2793	.3015
2	.1851	.2029	.2300	.2585	.2904	.3143	.3436	.3715
2¼	.2665	.2924	.3321	.3740	.4211	.4568	.5005	.5424
2⅜	.3148	.3456	.3929	.4429	.4991	.5418	.5943	.6447
2½	.3687	.4050	.4607	.5197	.5863	.6369	.6991	.7591
2⅝	.4285	.4708	.5359	.6050	.6830	.7424	.8157	.8864
2¾	.4943	.5434	.6189	.6990	.7898	.8590	.9445	1.0271
2⅞	.5666	.6230	.7100	.8024	.9072	.9872	1.0862	1.1821
3	.6456	.7101	.8096	.9155	1.0357	1.1276	1.2414	1.3518
3¼	.8250	.9079	1.0360	1.1726	1.3280	1.4471	1.5949	1.7387
3⅜	.9260	1.0193	1.1635	1.3175	1.4928	1.6273	1.7945	1.9571
3½	1.0349	1.1394	1.3011	1.4739	1.6707	1.8219	2.0099	2.1932
3⅝	1.1520	1.2686	1.4491	1.6421	1.8623	2.0314	2.2420	2.4474
3¾	1.2776	1.4073	1.6080	1.8228	2.0679	2.2565	2.4914	2.7207
3⅞	1.4121	1.5557	1.7780	2.0161	2.2881	2.4975	2.7585	3.0135
4	1.5557	1.7141	1.9597	2.2228	2.5235	2.7551	3.0441	3.3267
4¼	1.8713	2.0626	2.3592	2.6774	3.0416	3.3224	3.6732	4.0167
4½	2.2271	2.4554	2.8097	3.1902	3.6261	3.9626	4.3835	4.7961
4¾	2.6253	2.8951	3.3142	3.7646	4.2811	4.6803	5.1799	5.6703
5	3.0683	3.3845	3.8758	4.4041	5.0106	5.4797	6.0675	6.6448
5¼	3.5586	3.9261	4.4974	5.1123	5.8186	6.3654	7.0510	7.7251
5½	4.0985	4.5226	5.1822	5.8925	6.7092	7.3418	8.1355	8.9166
5¾	.....	.....	.....	.....	.....	.....	9.3259	10.2247
6	.....	.....	.....	.....	.....	.....	10.6271	11.6550
6¼	.....	.....	.....	.....	.....	.....	12.0441	13.2127
6½	.....	.....	.....	.....	.....	.....	13.5817	14.9035
6¾	.....	.....	.....	.....	.....	.....	15.2450	16.7327
7	.....	.....	.....	.....	.....	.....	17.0389	18.7058
7¼	.....	.....	.....	.....	.....	.....	18.9682	20.8282
7½	.....	.....	.....	.....	.....	.....	21.0379	23.1054
7¾	.....	.....	.....	.....	.....	.....	23.2530	25.5428
8	.....	.....	.....	.....	.....	.....	25.6184	28.1460
8¼	.....	.....	.....	.....	.....	.....	28.1390	30.9202
8½	.....	.....	.....	.....	.....	.....	30.8197	33.8711
8¾	.....	.....	.....	.....	.....	.....	33.6656	37.0039
9	.....	.....	.....	.....	.....	.....	36.6814	40.3243

Outside Diameter Inches	THICKNESS IN GAGES AND FRACTIONS OF AN INCH							
	5/32"	8 B.W.G.	7 B.W.G.	3/16"	6 B.W.G.	7/32"	5 B.W.G.	4 B.W.G.
5/8	.0070	.0071	.0072	.0072	.....	.....	.....	.....
11/16	.0099	.0101	.0104	.0104	.0106	.0107	.0107	.0108
3/4	.0137	.0140	.0143	.0145	.0148	.0150	.0150	.0152
13/16	.0183	.0187	.0193	.0195	.0200	.0204	.0204	.0207
7/8	.0238	.0244	.0253	.0257	.0263	.0269	.0270	.0275
15/16	.0304	.0312	.0324	.0330	.0340	.0348	.0349	.0356
1	.0381	.0391	.0408	.0415	.0429	.0441	.0442	.0453
1 1/16	.0470	.0484	.0506	.0515	.0534	.0550	.0551	.0567
1 1/8	.0572	.0590	.0618	.0630	.0655	.0676	.0678	.0699

MOMENT OF INERTIA, I, FOR NEUTRAL AXIS THROUGH CENTER OF SECTION (Continued)

Outside Diameter Inches	THICKNESS IN GAGES AND FRACTIONS OF AN INCH							
	5/32"	8 B.W.G.	7 B.W.G.	3/16"	6 B.W.G.	7/32"	5 B.W.G.	4 B.W.G.
1 3/16	.0688	.0710	.0745	.0762	.0793	.0820	.0822	.0850
1 1/4	.0819	.0846	.0890	.0910	.0949	.0984	.0987	.1022
1 5/16	.0965	.0999	.1052	.1077	.1125	.1168	.1172	.1216
1 3/8	.1129	.1169	.1233	.1263	.1321	.1375	.1379	.1433
1 7/16	.1309	1357	.1434	.1470	.1540	.1605	.1610	.1676
1 1/2	.1508	1565	.1655	.1698	.1781	.1859	.1865	.1945
1 5/8	.1966	.2042	.2165	.2224	.2338	.2446	.2454	.2567
1 3/4	.2507	.2608	.2771	.2849	.3002	.3147	.3158	.3310
1 7/8	.3141	.3270	.3481	.3581	.3781	.3974	.3985	.4186
2	.3873	.4035	.4303	.4431	.4684	.4928	.4946	.5206
2 1/8	.4711	.4913	.5245	.5405	.5723	.6028	.6052	.6379
2 1/4	.5663	.5909	.6317	.6513	.6904	.7282	.7312	.7718
2 3/8	.6735	.7032	.7525	.7763	.8239	.8700	.8736	.9234
2 1/2	.7934	.8290	.8879	.9165	.9736	1.0292	1.0335	1.0936
2 5/8	.9269	.9689	1.0387	1.0726	1.1405	1.2067	1.2118	1.2837
2 3/4	1.0745	1.1238	1.2057	1.2455	1.3255	1.4036	1.4096	1.4947
2 7/8	1.2371	1.2943	1.3897	1.4362	1.5295	1.6208	1.6279	1.7277
3	1.4153	1.4813	1.5916	1.6453	1.7535	1.8595	1.8677	1.9839
3 1/8	1.6099	1.6856	1.8122	1.8739	1.9984	2.1206	2.1301	2.2642
3 1/4	1.8215	1.9078	2.0522	2.1228	2.2651	2.4050	2.4159	2.5698
3 3/8	2.0509	2.1488	2.3127	2.3928	2.5546	2.7139	2.7263	2.9018
3 1/2	2.2989	2.4093	2.5943	2.6848	2.8678	3.0482	3.0623	3.2613
3 5/8	2.5661	2.6900	2.8979	2.9997	3.2056	3.4089	3.4248	3.6494
3 3/4	2.8532	2.9917	3.2243	3.3383	3.5691	3.7971	3.8149	4.0671
3 7/8	3.1610	3.3153	3.5744	3.7015	3.9590	4.2137	4.2336	4.5156
4	3.4902	3.6613	3.9489	4.0901	4.3764	4.6597	4.6819	4.9960
4 1/8	3.8416	4.0307	4.3488	4.5051	4.8221	5.1362	5.1608	5.5094
4 1/4	4.2157	4.4241	4.7749	4.9472	5.2972	5.6442	5.6713	6.0568
4 3/8	4.6134	4.8423	5.2278	5.4174	5.8025	6.1846	6.2145	6.6393
4 1/2	5.0354	5.2861	5.7086	5.9165	6.3389	6.7585	6.7914	7.2582
4 5/8	5.4823	5.7562	6.2181	6.4454	6.9075	7.3668	7.4029	7.9143
4 3/4	5.9550	6.2535	6.7570	7.0049	7.5092	8.0107	8.0500	8.6089
4 7/8	6.4541	6.7785	7.3261	7.5959	8.1448	8.6910	8.7339	9.3430
5	6.9803	7.3322	7.9264	8.2192	8.8154	9.4089	9.4555	10.1178
5 1/4	8.1171	8.5285	9.2236	9.5664	10.2649	10.9611	11.0158	11.7936
5 1/2	9.3710	9.8483	10.6552	11.0534	11.8654	12.6754	12.7390	13.6451
5 3/4	10.7480	11.2977	12.2278	12.6871	13.6242	14.5598	14.6333	15.6809
6	12.2536	12.8828	13.9481	14.4744	15.5488	16.6224	16.7068	17.9100
6 1/4	13.8937	14.6098	15.8226	16.4222	17.6467	18.8712	18.9675	20.3410
6 1/2	15.6740	16.4845	17.8581	18.5373	19.9254	21.3143	21.4236	22.9828
6 3/4	17.6003	18.5132	20.0610	20.8268	22.3923	23.9598	24.0832	25.8439
7	19.6783	20.7020	22.4381	23.2975	25.0550	26.8156	26.9543	28.9334
7 1/4	21.9138	23.0567	25.0635	25.9562	27.9208	29.8899	30.0450	32.2598
7 1/2	24.3125	25.5837	27.7413	28.8100	30.9973	33.1907	33.3636	35.8320
7 3/4	26.8802	28.2889	30.6807	31.8657	34.2920	36.7261	36.9179	39.6587
8	29.6226	31.1783	33.8207	35.1302	37.8122	40.5041	40.7163	43.7487
8 1/4	32.5455	34.2582	37.1679	38.6104	41.5656	44.5327	44.7667	48.1108
8 1/2	35.6546	37.5345	40.7291	42.3133	45.5595	48.8200	49.0772	52.7536
8 3/4	38.9557	41.0133	44.5109	46.2456	49.8014	53.3742	53.6560	57.6860
9	42.4546	44.7007	48.5198	50.4144	54.2088	58.2031	58.5111	62.9168
9 1/4	.....	.....	.....	.....	59.0745	63.3312	63.6671	68.4723
9 1/2	.....	.....	.....	.....	.....	.....	69.1006	74.3275
9 3/4	.....	.....	.....	.....	.....	.....	74.8349	80.5075
10	.....	.....	.....	.....	.....	.....	80.8780	87.0208
10 1/4	.....	.....	.....	.....	.....	.....	.....	93.8764
10 1/2	.....	.....	.....	.....	.....	.....	.....	101.0830

MOMENT OF INERTIA, I, FOR NEUTRAL AXIS THROUGH CENTER OF SECTION (Continued)

Outside Diameter Inches	THICKNESS IN GAGES AND FRACTIONS OF AN INCH							
	1/4"	3 B.W.G.	9/32"	2 B.W.G.	1 B.W.G.	5/16"	0 B.W.G.	11/32"
11/16	.0109	.....	.....	.....	.....	.....	.....	.....
3/4	.0153	.0153	.0154	.0154	.0155	.0155	.....	.....
13/16	.0209	.0210	.0212	.0212	.0212	.0213	.0213	.0213
7/8	.0278	.0279	.0283	.0283	.0284	.0285	.0287	.0287
15/16	.0361	.0363	.0369	.0370	.0372	.0374	.0377	.0377
1	.0460	.0464	.0472	.0473	.0478	.0481	.0485	.0486
1 1/16	.0576	.0582	.0594	.0596	.0603	.0607	.0615	.0615
1 1/8	.0711	.0719	.0737	.0739	.0748	.0755	.0767	.0768
1 3/16	.0866	.0877	.0901	.0903	.0917	.0926	.0943	.0945
1 1/4	.1043	.1057	.1088	.1092	.1110	.1123	.1146	.1149
1 5/16	.1242	.1261	.1301	.1305	.1330	.1347	.1378	.1381
1 3/8	.1466	.1489	.1540	.1546	.1577	.1599	.1640	.1644
1 7/16	.1716	.1745	.1808	.1815	.1854	.1882	.1934	.1940
1 1/2	.1994	.2028	.2105	.2114	.2162	.2197	.2263	.2271
1 5/8	.2636	.2685	.2797	.2810	.2880	.2931	.3031	.3043
1 3/4	.3405	.3472	.3627	.3645	.3745	.3817	.3960	.3978
1 7/8	.4312	.4402	.4610	.4634	.4769	.4868	.5066	.5090
2	.5368	.5486	.5757	.5789	.5968	.6099	.6363	.6397
2 1/8	.6586	.6735	.7083	.7124	.7354	.7524	.7869	.7913
2 1/4	.7976	.8163	.8599	.8651	.8942	.9157	.9598	.9654
2 3/8	.9550	.9780	1.0320	1.0384	1.0745	1.1014	1.1566	1.1637
2 1/2	1.1320	1.1599	1.2257	1.2335	1.2777	1.3107	1.3788	1.3877
2 5/8	1.3297	1.3632	1.4424	1.4518	1.5052	1.5453	1.6282	1.6389
2 3/4	1.5493	1.5890	1.6833	1.6946	1.7585	1.8064	1.9061	1.9191
2 7/8	1.7918	1.8386	1.9499	1.9632	2.0387	2.0956	2.2141	2.2296
3	2.0586	2.1132	2.2432	2.2588	2.3474	2.4142	2.5540	2.5723
3 1/8	2.3506	2.4139	2.5648	2.5829	2.6860	2.7638	2.9271	2.9485
3 1/4	2.6691	2.7419	2.9157	2.9366	3.0557	3.1457	3.3350	3.3599
3 3/8	3.0152	3.0984	3.2974	3.3214	3.4580	3.5615	3.7794	3.8081
3 1/2	3.3900	3.4846	3.7112	3.7385	3.8943	4.0124	4.2618	4.2947
3 5/8	3.7948	3.9018	4.1582	4.1892	4.3659	4.5001	4.7837	4.8212
3 3/4	4.2307	4.3510	4.6399	4.6748	4.8742	5.0258	5.3468	5.3893
3 7/8	4.6987	4.8335	5.1576	5.1967	5.4207	5.5911	5.9525	6.0004
4	5.2001	5.3505	5.7124	5.7561	6.0066	6.1974	6.6025	6.6562
4 1/8	5.7361	5.9032	6.3057	6.3544	6.6334	6.8461	7.2983	7.3583
4 1/4	6.3077	6.4927	6.9388	6.9929	7.3024	7.5387	8.0415	8.1083
4 3/8	6.9161	7.1203	7.6130	7.6728	8.0151	8.2766	8.8336	8.9077
4 1/2	7.5625	7.7871	8.3297	8.3954	8.7728	9.0612	9.6763	9.7581
4 5/8	8.2480	8.4944	9.0899	9.1622	9.5768	9.8939	10.5710	10.6611
4 3/4	8.9737	9.2433	9.8952	9.9744	10.4287	10.7763	11.5193	11.6183
4 7/8	9.7409	10.0351	10.7468	10.8332	11.3296	11.7098	12.5231	12.6313
5	10.5507	10.8708	11.6459	11.7400	12.2811	12.6957	13.5832	13.7016
5 1/8	11.4041	11.7518	12.5938	12.6962	13.2846	13.7356	14.7018	14.8308
5 1/4	12.3025	12.6791	13.5919	13.7030	14.3413	14.8308	15.8803	16.0205
5 1/2	14.2384	14.6778	15.7438	15.8736	16.6201	17.1932	18.4233	18.5879
5 3/4	16.3675	16.8763	18.1118	18.2624	19.1286	19.7942	21.2247	21.4162
6	18.6992	19.2843	20.7064	20.8797	21.8779	22.6455	24.2969	24.5182
6 1/4	21.2425	21.9113	23.5377	23.7361	24.8791	25.7585	27.6526	27.9065
6 1/2	24.0068	24.7667	26.6163	26.8421	28.1430	29.1448	31.3041	31.5939
6 3/4	27.0011	27.8602	29.9525	30.2080	31.6809	32.8158	34.2641	35.5928
7	30.2347	31.2013	33.5566	33.8443	35.5038	36.7831	39.5450	39.9161
7 1/4	33.7168	34.7995	37.4389	37.7615	39.6226	41.0581	44.1593	44.5763
7 1/2	37.4567	38.6643	41.6099	41.9700	44.0485	45.6524	49.1197	49.5861
7 3/4	41.4634	42.8053	46.0799	46.4804	48.7925	50.5774	54.4385	54.9581
8	45.7463	47.2320	50.8592	51.3030	53.8656	55.8447	60.1284	60.7051
8 1/4	50.3145	51.9540	55.9581	56.4482	59.2789	61.4658	66.2018	66.8396
8 1/2	55.1772	56.9807	61.3872	61.9267	65.0434	67.4521	72.6712	73.3744

MOMENT OF INERTIA, I, FOR NEUTRAL AXIS THROUGH CENTER OF SECTION (Continued)

Outside Diameter Inches	THICKNESS IN GAGES AND FRACTIONS OF AN INCH							
	1/4"	3 B.W.G.	9/32"	2 B.W.G.	1 B.W.G.	5/16"	0 B.W.G.	11/32"
8 3/4	60.3437	62.3218	67.1566	67.7487	71.1702	73.8153	79.5492	80.3221
9	65.8231	67.9867	73.2768	73.9249	77.6703	80.5667	86.8483	87.6952
9 1/4	71.6430	74.0040	79.7786	80.4862	84.5765	87.7406	94.6053	95.5313
9 1/2	77.7774	80.3469	86.6331	87.4037	91.8582	95.3050	102.7862	103.7956
9 3/4	84.2526	87.0423	93.8697	94.7066	99.5464	103.2924	111.4258	112.5236
10	91.0774	94.0998	101.4983	102.4055	107.6522	111.7142	120.5367	121.7278
10 1/4	98.2614	101.5289	109.5296	110.5109	116.1867	120.5819	130.1314	131.4210
10 1/2	105.8136	109.3392	117.9740	119.0332	125.1609	129.9071	140.2225	141.6158
10 3/4	.....	117.5403	126.8416	127.9829	134.5858	139.7012	150.8223	152.3248
11	.....	126.1415	136.1430	137.3703	144.4725	149.9758	161.9435	163.5608
11 1/4	.....	135.1525	145.8885	147.2060	154.8321	160.7423	173.5986	175.3363
11 1/2	.....	144.5828	156.0882	157.5006	165.6755	172.0123	185.8001	187.6641
11 3/4	.....	154.4420	166.7530	168.2643	177.0138	183.7973	198.5605	200.5566
12	.....	164.7396	177.8926	179.5077	188.8582	196.1087	211.8923	214.0269

Outside Diameter Inches	THICKNESS IN GAGES AND FRACTIONS OF AN INCH						
	3/8"	00 B.W.G.	000 B.W.G.	7/16"	0000 B.W.G.	1/2"	9/16"
13/16	.0213	.....	.....	.....	.....	.....	.....
7/8	.0287	.....	.....	.....	.....	.....	.....
15/16	.0378	.0378	.0379	.0379	.....	.....	.....
1	.0488	.0489	.0490	.0490	.0490	.....	.....
1 1/16	.0620	.0621	.0624	.0624	.0625	.....	.....
1 1/8	.0776	.0777	.0783	.0784	.0785	.0786	.....
1 3/16	.0958	.0959	.0969	.0971	.0973	.0975	.....
1 1/4	.1167	.1170	.1185	.1188	.1191	.1196	.....
1 5/16	.1407	.1410	.1434	.1438	.1443	.1452	.....
1 3/8	.1679	.1684	.1717	.1723	.1731	.1744	.1752
1 7/16	.1986	.1992	.2037	.2046	.2057	.2078	.2091
1 1/2	.2329	.2337	.2397	.2410	.2424	.2454	.2475
1 5/8	.3135	.3148	.3245	.3267	.3293	.3347	.3392
1 3/4	.4112	.4132	.4281	.4316	.4357	.4448	.4528
1 7/8	.5280	.5308	.5525	.5576	.5637	.5779	.5911
2	.6655	.6693	.6995	.7067	.7155	.7363	.7566
2 1/8	.8254	.8305	.8712	.8810	.8932	.9223	.9518
2 1/4	1.0095	1.0161	1.0694	1.0825	1.0988	1.1382	1.1794
2 3/8	1.2195	1.2278	1.2963	1.3132	1.3344	1.3863	1.4419
2 1/2	1.4570	1.4675	1.5536	1.5751	1.6021	1.6689	1.7420
2 5/8	1.7240	1.7368	1.8434	1.8703	1.9040	1.9884	2.0822
2 3/4	2.0219	2.0375	2.1676	2.2006	2.2422	2.3469	2.4650
2 7/8	2.3527	2.3714	2.5282	2.5682	2.6188	2.7469	2.8932
3	2.7180	2.7402	2.9272	2.9751	3.0358	3.1906	3.3693
3 1/8	3.1195	3.1456	3.3664	3.4232	3.4954	3.6804	3.8959
3 1/4	3.5590	3.5895	3.8479	3.9147	3.9997	4.2184	4.4755
3 3/8	4.0382	4.0735	4.3735	4.4514	4.5506	4.8071	5.1108
3 1/2	4.5587	4.5994	4.9454	5.0354	5.1504	5.4487	5.8043
3 5/8	5.1225	5.1689	5.5653	5.6688	5.8011	6.1455	6.5587
3 3/4	5.7311	5.7838	6.2353	6.3535	6.5048	6.8998	7.3765
3 7/8	6.3863	6.4459	6.9574	7.0916	7.2636	7.7140	8.2603
4	7.0898	7.1569	7.7334	7.8850	8.0796	8.5902	9.2126
4 1/8	7.8434	7.9185	8.5653	8.7358	8.9549	9.5310	10.2362
4 1/4	8.6487	8.7326	9.4552	9.6460	9.8915	10.5384	11.3336
4 3/8	9.5076	9.6007	10.4049	10.6176	10.8915	11 6149	12.5073
4 1/2	10.4216	10.5248	11.4164	11.6526	11.9571	12.7627	13.7599
4 5/8	11.3926	11.5064	12.4916	12.7531	13.0903	13.9841	15.0941
4 3/4	12.4223	12.5475	13.6326	13.9210	14.2932	15.2815	16.5125

MOMENT OF INERTIA, I, FOR NEUTRAL AXIS THROUGH CENTER OF SECTION (Continued)

Outside Diameter Inches	THICKNESS IN GAGES AND FRACTIONS OF AN INCH						
	3/8"	00 B.W.G.	000 B.W.G.	7/16"	0000 B.W.G.	1/2"	9/16"
4 3/8	13.5124	13.6497	14.8413	15.1584	15.5680	16.6571	18.0175
5	14.6646	14.8148	16.1195	16.4672	16.9166	18.1132	19.6119
5 1/8	15.8807	16.0445	17.4694	17.8496	18.3412	19.6522	21.2981
5 1/4	17.1623	17.3406	18.8928	19.3074	19.8439	21.2763	23.0789
5 3/8	18.5113	18.7049	20.3917	20.8427	21.4267	22.9878	24.9567
5 1/2	19.9292	20.1390	21.9680	22.4576	23.0918	24.7891	26.9341
5 3/4	22.9792	23.2239	25.3609	25.9340	26.6771	28.6701	31.1984
6	26.3259	26.6092	29.0870	29.7526	30.6165	32.9376	35.8924
6 1/4	29.9833	30.3091	33.1621	33.9297	34.9266	37.6101	41.0368
6 1/2	33.9652	34.3375	37.6017	38.4812	39.6243	42.7060	46.6523
6 3/4	38.2852	38.7083	42.4215	43.4233	44.7262	48.2437	52.7597
7	42.9574	43.4356	47.6372	48.7721	50.2490	54.2415	59.3796
7 1/4	47.9953	48.5333	53.2644	54.5437	55.2094	60.7180	66.5327
7 1/2	53.4130	54.0155	59.3188	60.7542	62.6243	67.6915	74.2398
7 3/4	59.2241	59.8961	65.8159	67.4197	69.5102	75.1804	82.5216
8	65.4425	66.1891	72.7715	74.5564	76.8838	83.2031	91.3987
8 1/4	72.0819	72.9086	80.2010	82.1803	84.7620	91.7780	100.8920
8 1/2	79.1562	80.0684	88.1206	90.3075	93.1614	100.9236	111.0220
8 3/4	86.6793	87.6827	96.5454	98.9542	102.0988	110.6583	121.8095
9	94.6648	95.7653	105.4913	108.1364	111.5907	121.0004	133.2753
9 1/4	103.1532	104.3572	115.0034	117.9006	121.6854	132.0023	145.4773
9 1/2	112.1074	113.4209	125.0408	128.2049	132.3396	143.6175	158.3649
9 3/4	121.5657	122.9950	135.6464	139.0932	143.5986	155.8956	171.9931
10	131.5418	133.0937	146.8357	150.5816	155.4794	168.8549	186.3824
10 1/4	142.0496	143.7308	158.6244	162.6863	167.9985	182.5139	201.5538
10 1/2	153.1028	154.9204	171.0282	175.4234	181.1728	196.8910	217.5278
10 3/4	164.7153	166.6764	184.0627	188.8089	195.0188	212.0046	234.3251
11	176.9010	179.0128	197.7436	202.8590	209.5535	227.8731	251.9666
11 1/4	189.6735	191.9438	212.0865	217.5898	224.7933	244.5149	270.4730
11 1/2	203.0467	205.4832	227.1071	233.0173	240.7551	261.9485	289.8648
11 3/4	217.0345	219.6450	242.8210	249.1578	257.4556	280.1922	310.1628
12	231.6505	234.4432	259.2438	266.0273	274.9116	299.2645	331.3878
12 1/4	246.9087	249.8919	276.3914	283.6419	293.1396	319.1838	353.5605
12 1/2	262.8229	266.0049	294.2792	302.0178	312.1565	339.9684	376.7016
12 3/4	279.4068	282.7964	312.9229	321.1710	331.9790	361.6368	400.8317
13	.....	.....	.....	341.1177	352.6238	384.2075	425.9717
13 1/4	.....	.....	.....	361.8339	374.1075	407.6988	452.1422
13 1/2	.....	.....	.....	383.4559	396.4470	432.1291	479.3639
13 3/4	.....	.....	.....	.....	.....	457.5169	507.6576

Outside Diameter Inches	THICKNESS IN FRACTIONS OF AN INCH						
	5/8"	11/16"	3/4"	13/16"	7/8"	15/16"	1"
1 7/8	.2095	.....	*	.....	.....	.....	.....
1 1/2	.2483	.....	.....	.....	.....	.....	.....
1 5/8	.3413	.....	.....	.....	.....	.....	.....
1 3/4	.4573	.....	.....	.....	.....	.....	.....
1 7/8	.5992	.....	.....	.....	.....	.....	.....
2	.7698	.....	.....	.....	.....	.....	.....
2 1/8	.9721	.9854	.9934	.9978	.9999	1.0007	1.0009
2 1/4	1.2089	1.2292	1.2425	1.2505	1.2549	1.2570	1.2578
2 3/8	1.4831	1.5127	1.5330	1.5462	1.5543	1.5587	1.5608
2 1/2	1.7976	1.8388	1.8683	1.8887	1.9019	1.9099	1.9144
2 5/8	2.1552	2.2108	2.2520	2.2816	2.3019	2.3151	2.3232
2 3/4	2.5588	2.6319	2.6875	2.7287	2.7582	2.7786	2.7918
2 7/8	3.0113	3.1051	3.1782	3.2338	3.2750	3.3045	3.3249

MOMENT OF INERTIA, I, FOR NEUTRAL AXIS THROUGH CENTER OF SECTION (Concluded)

Outside Diameter Inches	THICKNESS IN FRACTIONS OF AN INCH						
	5/8"	11/16"	3/4"	13/16"	7/8"	15/16"	1"
3	3.5156	3.6337	3.7275	3.8006	3.8562	3.8974	3.9269
3 1/8	4.0746	4.2209	4.3390	4.4328	4.5058	4.5614	4.6027
3 1/4	4.6911	4.8698	5.0161	5.1342	5.2279	5.3010	5.3566
3 3/8	5.3679	5.5835	5.7622	5.9085	6.0266	6.1204	6.1934
3 1/2	6.1081	6.3652	6.5807	6.7594	6.9057	7.0238	7.1176
3 5/8	6.9144	7.2181	7.4752	7.6908	7.8695	8.0158	8.1339
3 3/4	7.7897	8.1454	8.4491	8.7062	8.9218	9.1005	9.2468
3 7/8	8.7369	9.1502	9.5058	9.8096	10.0667	10.2822	10.4609
4	9.7589	10.2356	10.6488	11.0045	11.3083	11.5654	11.7809
4 1/8	10.8586	11.4049	11.8816	12.2948	12.6505	12.9542	13.2114
4 1/4	12.0388	12.6612	13.2075	13.6842	14.0974	14.4531	14.7568
4 3/8	13.3024	14.0077	14.6301	15.1764	15.6531	16.0663	16.4220
4 1/2	14.6523	15.4475	16.1528	16.7752	17.3215	17.7981	18.2114
4 5/8	16.0914	16.9838	17.7790	18.4842	19.1066	19.6529	20.1296
4 3/4	17.6225	18.6198	19.5122	20.3074	21.0126	21.6350	22.1813
4 7/8	19.2485	20.3586	21.3558	22.2482	23.0434	23.7487	24.3711
5	20.9723	22.2034	23.3134	24.3107	25.2031	25.9982	26.7035
5 1/8	22.7968	24.1573	25.3883	26.4983	27.4956	28.3880	29.1832
5 1/4	24.7248	26.2235	27.5840	28.8150	29.9250	30.9223	31.8147
5 3/8	26.7593	28.4053	29.9039	31.2644	32.4954	33.6055	34.6027
5 1/2	28.9030	30.7056	32.3516	33.8503	35.2108	36.4418	37.5518
5 3/4	33.5299	35.6750	37.6438	39.4464	41.0924	42.5911	43.9516
6	38.6285	41.1568	43.4883	45.6334	47.6023	49.4049	51.0508
6 1/4	44.2217	47.1766	49.9126	52.4410	54.7725	56.9175	58.8864
6 1/2	50.3327	53.7594	56.9444	59.8992	62.6353	65.1636	67.4951
6 3/4	56.9845	60.9308	64.6112	68.0379	71.2229	74.1777	76.9137
7	64.1999	68.7160	72.9407	76.8871	80.5675	83.9942	87.1791
7 1/4	72.0021	77.1402	81.9605	86.4766	90.7013	94.6477	98.3281
7 1/2	80.4141	86.2288	91.6983	96.8363	101.6567	106.1727	110.3975
7 3/4	89.4588	96.0072	102.1815	107.9962	113.4656	118.6037	123.4240
8	99.1593	106.5006	113.4378	119.9862	126.1605	131.9752	137.4446
8 1/4	109.5386	117.7343	125.4949	132.8362	139.7734	146.3218	152.4961
8 1/2	120.6197	129.7337	138.3804	146.5760	154.3366	161.6779	168.6151
8 3/4	132.4256	142.5240	152.1218	161.2357	169.8824	178.0781	185.8387
9	144.9794	156.1306	166.7467	176.8451	186.4429	195.5568	204.2035
9 1/4	158.3446	170.6227	182.3298	193.4839	204.1028	214.2037	223.8039
9 1/2	172.4666	185.9417	198.8090	211.0871	222.7941	233.9483	244.5671
9 3/4	187.4057	202.1531	216.2548	229.7299	242.5972	254.8752	266.5823
10	203.1848	219.2823	234.6949	249.4424	263.5441	277.0191	289.8864
10 1/4	219.8270	237.3546	254.1569	270.2544	285.6671	300.4145	314.5162
10 1/2	237.3553	256.3952	274.6685	292.1960	308.9984	325.0959	340.5085
10 3/4	255.7928	276.4295	296.2571	315.2970	333.5702	351.0978	367.9002
11	275.1623	297.4829	318.9505	339.5873	359.4149	378.4547	396.7280
11 1/4	295.4871	319.5806	342.7763	365.0968	386.5645	407.2012	427.0288
11 1/2	316.7899	342.7480	367.7621	391.8556	415.0513	437.3719	458.8395
11 3/4	339.0940	367.0103	393.9354	419.8935	444.9076	469.0011	492.1968
12	362.4223	392.3929	421.3240	449.2403	476.1655	502.1235	527.1376
12 1/4	386.7977	418.9211	449.9555	479.9261	508.8572	536.7735	563.6987
12 1/2	412.2434	446.6202	479.8574	511.9807	543.0151	572.9857	601.9169
12 3/4	438.7823	475.5155	511.0574	545.4341	578.6713	610.7946	641.8291
13	466.4375	505.6324	543.5830	580.3162	615.8580	650.2348	683.4720
13 1/4	495.2320	536.9962	577.4620	616.6569	654.6075	691.3407	726.8825
13 1/2	525.1888	569.6322	612.7220	654.4862	694.9520	734.1469	772.0975
13 3/4	556.3306	603.5656	649.3905	693.8339	736.9237	778.6879	819.1537
14	588.6812	638.8219	687.4951	734.7299	780.5548	824.9982	868.0880

SECTION MODULUS, Z, FOR NEUTRAL AXIS THROUGH CENTER OF SECTION

Outside Diameter Inches	THICKNESS IN GAGES							
	24 B.W.G.	23 B.W.G.	22 B.W.G.	21 B.W.G.	20 B.W.G.	19 B.W.G.	18 B.W.G.	17 B.W.G.
1/4	.0008	.0009	.0009	.0010	.0011	.0012	.0013	.0014
5/16	.0013	.0015	.0016	.0017	.0019	.0021	.0023	.0025
3/8	.0020	.0022	.0024	.0027	.0029	.0033	.0036	.0040
7/16	.0028	.0031	.0034	.0038	.0041	.0047	.0052	.0058
1/2	.0037	.0042	.0046	.0051	.0055	.0063	.0071	.0080
9/16	.0048	.0054	.0059	.0066	.0072	.0083	.0093	.0105
5/8	.0060	.0067	.0075	.0084	.0090	.0105	.0118	.0134
11/16	.0074	.0083	.0091	.0103	.0111	.0129	.0146	.0166
3/4	.0088	.0099	.0110	.0124	.0134	.0156	.0177	.0202
13/16	.0105	.0118	.0130	.0147	.0159	.0186	.0211	.0242
7/8	.0122	.0137	.0152	.0172	.0186	.0218	.0248	.0285
15/16	.0141	.0159	.0176	.0199	.0215	.0253	.0288	.0332
1	.0161	.0182	.0202	.0228	.0247	.0290	.0331	.0382
1 1/16	.0183	.0206	.0229	.0259	.0280	.0330	.0377	.0435
1 1/8	.0206	.0232	.0258	.0291	.0316	.0373	.0427	.0493
1 3/16	.0230	.0259	.0288	.0326	.0354	.0418	.0479	.0554
1 1/4	.0256	.0288	.0321	.0363	.0394	.0465	.0534	.0618
1 5/16	.0283	.0319	.0355	.0402	.0436	.0515	.0592	.0686
1 3/8	.0311	.0351	.0391	.0443	.0481	.0568	.0653	.0758
1 7/16	.0340	.0385	.0428	.0485	.0527	.0624	.0717	.0833
1 1/2	.0372	.0420	.0467	.0530	.0576	.0682	.0784	.0912
1 5/8	.0438	.0495	.0551	.0625	.0680	.0805	.0927	.1080
1 3/4	.0509	.0576	.0641	.0728	.0792	.0939	.1083	.1262
1 7/8	.0586	.0663	.0739	.0839	.0913	.1084	.1250	.1458
2	.0668	.0756	.0843	.0958	.1043	.1238	.1429	.1669
2 1/8	.....	.....	.....	.....	.....	.....	.1621	.1894
2 1/4	.....	.....	.....	.....	.....	.....	.1824	.2133
2 3/8	.....	.....	.....	.....	.....	.....	.2040	.2387
2 1/2	.....	.....	.....	.....	.....	.....	.2267	.2654
2 5/8	.....	.....	.....	.....	.....	.....	.2506	.2936
2 3/4	.....	.....	.....	.....	.....	.....	.2758	.3233
2 7/8	.....	.....	.....	.....	.....	.....	.3022	.3543
3	.....	.....	.....	.....	.....	.....	.3297	.3868
3 1/8	.....	.....	.....	.....	.....	.....	.3585	.4206
3 1/4	.....	.....	.....	.....	.....	.....	.3884	.4560

Outside Diameter Inches	THICKNESS IN GAGES							
	16 B.W.G.	15 B.W.G.	14 B.W.G.	13 B.W.G.	12 B.W.G.	11 B.W.G.	10 B.W.G.	9 B.W.G.
1/4	.0014	.0014	.0015	.0015	.....	.....	.....	.....
5/16	.0026	.0027	.0028	.0029	.0029	.0029	.....	.....
3/8	.0042	.0044	.0046	.0048	.0050	.0050	.0051	.....
7/16	.0062	.0065	.0070	.0073	.0076	.0078	.0080	.....
1/2	.0085	.0091	.0098	.0104	.0110	.0113	.0117	.0119
9/16	.0113	.0121	.0131	.0141	.0150	.0155	.0161	.0165
5/8	.0145	.0155	.0169	.0183	.0196	.0205	.0214	.0221
11/16	.0181	.0194	.0213	.0231	.0249	.0261	.0274	.0285
3/4	.0220	.0237	.0261	.0285	.0309	.0325	.0343	.0358
13/16	.0264	.0285	.0315	.0345	.0375	.0396	.0420	.0440
7/8	.0312	.0337	.0374	.0410	.0448	.0475	.0505	.0531
15/16	.0363	.0393	.0437	.0481	.0528	.0561	.0598	.0631
1	.0419	.0454	.0506	.0559	.0614	.0654	.0699	.0740
1 1/16	.0478	.0519	.0580	.0642	.0707	.0754	.0809	.0858
1 1/8	.0542	.0589	.0659	.0730	.0807	.0862	.0927	.0985
1 3/16	.0610	.0663	.0743	.0825	.0913	.0977	.1053	.1121

SECTION MODULUS, Z, FOR NEUTRAL AXIS THROUGH CENTER OF SECTION
(Continued)

Outside Diameter Inches	THICKNESS IN GAGES							
	16 B.W.G.	15 B.W.G.	14 B.W.G.	13 B.W.G.	12 B.W.G.	11 B.W.G.	10 B.W.G.	9 B.W.G.
1 1/4	.0681	.0742	.0833	.0925	.1026	.1100	.1187	.1266
1 5/16	.0757	.0825	.0927	.1032	.1146	.1230	.1329	.1421
1 3/8	.0836	.0912	.1026	.1144	.1272	.1367	.1479	.1584
1 7/16	.0920	.1004	.1131	.1262	.1405	.1511	.1638	.1756
1 1/2	.1007	.1100	.1240	.1385	.1545	.1663	.1805	.1938
1 5/8	.1194	.1306	.1475	.1650	.1845	.1989	.2164	.2327
1 3/4	.1397	.1529	.1729	.1939	.2171	.2345	.2555	.2754
1 7/8	.1616	.1770	.2004	.2250	.2524	.2729	.2979	.3216
2	.1851	.2029	.2300	.2585	.2904	.3143	.3436	.3715
2 1/4	.2368	.2599	.2952	.3325	.3743	.4060	.4449	.4821
2 3/8	.2651	.2911	.3309	.3729	.4203	.4563	.5005	.5429
2 1/2	.2950	.3240	.3686	.4158	.4690	.5095	.5593	.6073
2 5/8	.3264	.3587	.4083	.4609	.5203	.5656	.6215	.6753
2 3/4	.3595	.3952	.4501	.5084	.5744	.6247	.6869	.7470
2 7/8	.3942	.4334	.4939	.5582	.6311	.6867	.7556	.8223
3	.4304	.4734	.5397	.6103	.6904	.7517	.8276	.9012
3 1/4	.5077	.5587	.6375	.7216	.8172	.8905	.9815	1.0699
3 3/8	.5487	.6040	.6895	.7807	.8846	.9643	1.0634	1.1598
3 1/2	.5913	.6511	.7435	.8422	.9547	1.0411	1.1485	1.2532
3 5/8	.6356	.6999	.7995	.9060	1.0274	1.1208	1.2370	1.3503
3 3/4	.6814	.7505	.8576	.9721	1.1029	1.2034	1.3287	1.4510
3 7/8	.7288	.8029	.9177	1.0406	1.1809	1.2890	1.4237	1.5554
4	.7778	.8570	.9798	1.1114	1.2617	1.3775	1.5220	1.6633
4 1/4	.8806	.9706	1.1102	1.2599	1.4313	1.5635	1.7285	1.8902
4 1/2	.9898	1.0913	1.2487	1.4178	1.6116	1.7611	1.9482	2.1316
4 3/4	1.1054	1.2190	1.3954	1.5851	1.8025	1.9706	2.1810	2.3875
5	1.2273	1.3538	1.5503	1.7616	2.0042	2.1919	2.4270	2.6579
5 1/4	1.3556	1.4956	1.7133	1.9475	2.2166	2.4249	2.6861	2.9429
5 1/2	1.4903	1.6445	1.8844	2.1427	2.4397	2.6697	2.9583	3.2424
5 3/4	.....	.....	.....	.....	.....	.....	3.2438	3.5564
6	.....	.....	.....	.....	.....	.....	3.5423	3.8850
6 1/4	.....	.....	.....	.....	.....	.....	3.8541	4.2280
6 1/2	.....	.....	.....	.....	.....	.....	4.1790	4.5856
6 3/4	.....	.....	.....	.....	.....	.....	4.5170	4.9578
7	.....	.....	.....	.....	.....	.....	4.8682	5.3445
7 1/4	.....	.....	.....	.....	.....	.....	5.2326	5.7457
7 1/2	.....	.....	.....	.....	.....	.....	5.6101	6.1614
7 3/4	.....	.....	.....	.....	.....	.....	6.0007	6.5917
8	.....	.....	.....	.....	.....	.....	6.4046	7.0365
8 1/4	.....	.....	.....	.....	.....	.....	6.8215	7.4958
8 1/2	.....	.....	.....	.....	.....	.....	7.2517	7.9696
8 3/4	.....	.....	.....	.....	.....	.....	7.6950	8.4580
9	.....	.....	.....	.....	.....	.....	8.1514	8.9609

Outside Diameter Inches	THICKNESS IN GAGES AND FRACTIONS OF AN INCH							
	5/32"	8 B.W.G.	7 B.W.G.	3/16"	6 B.W.G.	7/32"	5 B.W.G.	4 B.W.G.
5/8	.0224	.0227	.0231	.0233	.....	.....	.....	.....
11/16	.0290	.0295	.0302	.0305	.0310	.0313	.0313	.0316
3/4	.0366	.0373	.0383	.0388	.0395	.0401	.0402	.0406
13/16	.0451	.0461	.0475	.0482	.0493	.0502	.0503	.0511
7/8	.0545	.0558	.0578	.0587	.0603	.0616	.0617	.0629
15/16	.0649	.0666	.0692	.0704	.0725	.0743	.0744	.0761
1	.0762	.0783	.0817	.0831	.0859	.0883	.0885	.0907
1 1/16	.0885	.0911	.0952	.0971	.1005	.1036	.1038	.1068
1 1/8	.1017	.1049	.1098	.1121	.1164	.1202	.1205	.1243

SECTION MODULUS, Z, FOR NEUTRAL AXIS THROUGH CENTER OF SECTION (Continued)

Outside Diameter Inches	THICKNESS IN GAGES AND FRACTIONS OF AN INCH							
	5/32"	8 B.W.G.	7 B.W.G.	3/16"	6 B.W.G.	7/32"	5 B.W.G.	4 B.W.G.
1 5/16	.1159	.1197	.1256	.1283	.1335	.1382	.1385	.1432
1 1/4	.1310	.1354	.1424	.1457	.1518	.1575	.1579	.1635
1 5/16	.1471	.1522	.1604	.1641	.1714	.1781	.1786	.1853
1 3/8	.1642	.1700	.1794	.1838	.1922	.2000	.2006	.2085
1 7/16	.1822	.1888	.1995	.2045	.2143	.2233	.2240	.2332
1 1/2	.2011	.2086	.2207	.2265	.2375	.2479	.2487	.2593
1 5/8	.2419	.2513	.2665	.2737	.2878	.3011	.3021	.3159
1 3/4	.2866	.2980	.3167	.3256	.3431	.3596	.3609	.3783
1 7/8	.3350	.3488	.3713	.3820	.4033	.4238	.4251	.4465
2	.3873	.4035	.4303	.4431	.4684	.4928	.4946	.5206
2 1/8	.4434	.4624	.4937	.5087	.5386	.5674	.5696	.6004
2 1/4	.5034	.5253	.5615	.5789	.6137	.6473	.6499	.6861
2 3/8	.5671	.5922	.6337	.6538	.6938	.7326	.7356	.7776
2 1/2	.6347	.6632	.7103	.7332	.7789	.8233	.8268	.8749
2 5/8	.7062	.7382	.7914	.8172	.8689	.9194	.9233	.9781
2 3/4	.7815	.8173	.8769	.9058	.9640	1.0208	1.0252	1.0871
2 7/8	.8606	.9004	.9667	.9990	1.0640	1.1275	1.1325	1.2019
3	.9435	.9875	1.0610	1.0969	1.1690	1.2396	1.2451	1.3226
3 1/8	1.0303	1.0788	1.1598	1.1993	1.2789	1.3571	1.3632	1.4491
3 1/4	1.1209	1.1740	1.2629	1.3063	1.3939	1.4800	1.4867	1.5814
3 3/8	1.2154	1.2733	1.3704	1.4179	1.5138	1.6082	1.6156	1.7196
3 1/2	1.3136	1.3767	1.4824	1.5341	1.6387	1.7418	1.7499	1.8636
3 5/8	1.4157	1.4841	1.5988	1.6550	1.7686	1.8808	1.8895	2.0134
3 3/4	1.5217	1.5956	1.7196	1.7804	1.9035	2.0251	2.0346	2.1691
3 7/8	1.6315	1.7111	1.8448	1.9104	2.0433	2.1748	2.1851	2.3306
4	1.7451	1.8306	1.9744	2.0450	2.1882	2.3298	2.3409	2.4980
4 1/8	1.8626	1.9542	2.1085	2.1843	2.3380	2.4903	2.5022	2.6712
4 1/4	1.9838	2.0819	2.2470	2.3281	2.4928	2.6561	2.6688	2.8502
4 3/8	2.1090	2.2136	2.3898	2.4765	2.6525	2.8272	2.8409	3.0351
4 1/2	2.2379	2.3494	2.5371	2.6295	2.8173	3.0037	3.0184	3.2258
4 5/8	2.3707	2.4892	2.6889	2.7872	2.9870	3.1856	3.2012	3.4224
4 3/4	2.5073	2.6330	2.8450	2.9494	3.1617	3.3729	3.3895	3.6248
4 7/8	2.6478	2.7809	3.0056	3.1162	3.3414	3.5655	3.5831	3.8330
5	2.7921	2.9329	3.1705	3.2877	3.5261	3.7635	3.7822	4.0471
5 1/4	3.0922	3.2489	3.5137	3.6443	3.9104	4.1756	4.1964	4.4928
5 1/2	3.4076	3.5812	3.8746	4.0194	4.3146	4.6092	4.6323	4.9618
5 3/4	3.7384	3.9296	4.2531	4.4129	4.7388	5.0642	5.0898	5.4542
6	4.0845	4.2942	4.6493	4.8248	5.1829	5.5408	5.5689	5.9700
6 1/4	4.4459	4.6751	5.0632	5.2551	5.6469	6.0388	6.0696	6.5091
6 1/2	4.8227	5.0721	5.4948	5.7038	6.1309	6.5582	6.5919	7.0716
6 3/4	5.2149	5.4854	5.9440	6.1709	6.6347	7.0992	7.1357	7.6574
7	5.6223	5.9148	6.4109	6.6564	7.1585	7.6616	7.7012	8.2666
7 1/4	6.0451	6.3604	6.9140	7.1603	7.7023	8.2455	8.2883	8.8992
7 1/2	6.4833	6.8223	7.3977	7.6826	8.2659	8.8508	8.8969	9.5552
7 3/4	6.9368	7.3003	7.9176	8.2234	8.8495	9.4777	9.5272	10.2345
8	7.4056	7.7945	8.4551	8.7825	9.4530	10.1260	10.1790	10.9371
8 1/4	7.8898	8.3050	9.0104	9.3601	10.0765	10.7958	10.8525	11.6632
8 1/2	8.3893	8.8316	9.5833	9.9560	10.7198	11.4870	11.5475	12.4126
8 3/4	8.9041	9.3744	10.1739	10.5704	11.3831	12.1998	12.2642	13.1853
9	9.4343	9.9335	10.7821	11.2032	12.0664	12.9340	13.0024	13.9815
9 1/4	.....	.....	.....	.....	12.7729	13.6932	13.7659	14.8048
9 1/2	.....	.....	.....	.....	.....	.....	14.5475	15.6479
9 3/4	.....	.....	.....	.....	.....	.....	15.3507	16.5144
10	.....	.....	.....	.....	.....	.....	16.1756	17.4042
10 1/4	.....	.....	.....	.....	.....	.....	.....	18.3173
10 1/2	.....	.....	.....	.....	.....	.....	.....	19.2539

SECTION MODULUS, Z, FOR NEUTRAL AXIS THROUGH CENTER OF SECTION (Continued)

Outside Diameter Inches	THICKNESS IN GAGES AND FRACTIONS OF AN INCH							
	1/4"	3 B.W.G.	9/32"	2 B.W.G.	1 B.W.G.	5/16"	0 B.W.G.	11/32"
11/16	.0317	.....	.....	.....	.....	.....	.....	.....
3/4	.0409	.0410	.0412	.0412	.0413	.0413	.....	.....
13/16	.0515	.0517	.0521	.0522	.0524	.0525	.0526	.0526
7/8	.0635	.0639	.0646	.0647	.0651	.0653	.0656	.0656
15/16	.0770	.0776	.0788	.0789	.0795	.0798	.0804	.0804
1	.0920	.0928	.0945	.0947	.0956	.0962	.0971	.0972
1 1/16	.1085	.1096	.1119	.1122	.1135	.1143	.1157	.1159
1 1/8	.1264	.1279	.1310	.1313	.1331	.1343	.1363	.1365
1 3/16	.1459	.1477	.1517	.1522	.1545	.1561	.1589	.1592
1 1/4	.1668	.1691	.1742	.1747	.1777	.1797	.1834	.1838
1 5/16	.1893	.1921	.1983	.1989	.2026	.2052	.2100	.2105
1 3/8	.2133	.2167	.2240	.2249	.2294	.2326	.2385	.2392
1 7/16	.2388	.2428	.2516	.2525	.2580	.2618	.2691	.2700
1 1/2	.2658	.2704	.2807	.2819	.2883	.2929	.3017	.3028
1 5/8	.3244	.3305	.3442	.3458	.3545	.3608	.3730	.3746
1 3/4	.3891	.3969	.4145	.4166	.4280	.4362	.4526	.4546
1 7/8	.4599	.4695	.4917	.4943	.5087	.5193	.5403	.5430
2	.5368	.5486	.5757	.5789	.5968	.6099	.6363	.6397
2 1/8	.6199	.6339	.6666	.6705	.6921	.7081	.7406	.7447
2 1/4	.7090	.7256	.7644	.7690	.7948	.8140	.8531	.8581
2 3/8	.8042	.8236	.8690	.8744	.9048	.9275	.9739	.9799
2 1/2	.9056	.9279	.9805	.9868	1.0222	1.0486	1.1031	1.1101
2 5/8	1.0131	1.0386	1.0989	1.1061	1.1468	1.1773	1.2405	1.2487
2 3/4	1.1267	1.1557	1.2242	1.2324	1.2789	1.3137	1.3862	1.3957
2 7/8	1.2465	1.2790	1.3564	1.3657	1.4182	1.4578	1.5403	1.5510
3	1.3724	1.4088	1.4955	1.5059	1.5649	1.6095	1.7026	1.7148
3 1/8	1.5044	1.5449	1.6414	1.6530	1.7190	1.7688	1.8733	1.8870
3 1/4	1.6425	1.6873	1.7943	1.8071	1.8804	1.9358	2.0523	2.0676
3 3/8	1.7868	1.8361	1.9540	1.9682	2.0492	2.1105	2.2396	2.2566
3 1/2	1.9371	1.9912	2.1207	2.1362	2.2253	2.2928	2.4353	2.4541
3 5/8	2.0937	2.1527	2.2942	2.3113	2.4087	2.4828	2.6393	2.6600
3 3/4	2.2563	2.3205	2.4746	2.4932	2.5996	2.6804	2.8516	2.8742
3 7/8	2.4251	2.4947	2.6619	2.6821	2.7977	2.8857	3.0723	3.0970
4	2.6000	2.6752	2.8562	2.8780	3.0033	3.0987	3.3012	3.3281
4 1/8	2.7811	2.8621	3.0573	3.0809	3.2162	3.3193	3.5386	3.5677
4 1/4	2.9683	3.0554	3.2653	3.2907	3.4364	3.5476	3.7842	3.8156
4 3/8	3.1616	3.2550	3.4802	3.5075	3.6640	3.7835	4.0382	4.0721
4 1/2	3.3611	3.4609	3.7020	3.7313	3.8990	4.0272	4.3005	4.3369
4 5/8	3.5667	3.6732	3.9308	3.9620	4.1413	4.2784	4.5712	4.6102
4 3/4	3.7784	3.8919	4.1664	4.1997	4.3910	4.5374	4.8502	4.8919
4 7/8	3.9962	4.1169	4.4089	4.4444	4.6480	4.8040	5.1377	5.1820
5	4.2202	4.3483	4.6583	4.6960	4.9124	5.0783	5.4332	5.4806
5 1/8	4.4504	4.5860	4.9146	4.9546	5.1842	5.3602	5.7373	5.7876
5 1/4	4.6866	4.8301	5.1779	5.2202	5.4633	5.6498	6.0496	6.1030
5 1/2	5.1776	5.3373	5.7250	5.7722	6.0436	6.2520	6.6994	6.7592
5 3/4	5.6930	5.8700	6.2997	6.3521	6.6534	6.8849	7.3825	7.4491
6	6.2330	6.4281	6.9021	6.9599	7.2926	7.5485	8.0989	8.1727
6 1/4	6.7976	7.0116	7.5320	7.5955	7.9613	8.2427	8.8488	8.9301
6 1/2	7.3867	7.6205	8.1896	8.2591	8.6594	8.9676	9.6320	9.7212
6 3/4	8.0003	8.2548	8.8748	8.9505	9.3869	9.7232	10.1523	10.5460
7	8.6385	8.9146	9.5876	9.6698	10.1439	10.5094	11.2985	11.4046
7 1/4	9.3012	9.5998	10.3279	10.4169	10.9303	11.3263	12.1819	12.2969
7 1/2	9.9884	10.3104	11.0959	11.1920	11.7462	12.1739	13.0985	13.2229
7 3/4	10.7002	11.0965	11.8915	11.9949	12.5916	13.0522	14.0486	14.1827
8	11.4365	11.8080	12.7148	12.8257	13.4664	13.9611	15.0321	15.1762
8 1/4	12.1974	12.5949	13.5656	13.6844	14.3706	14.9008	16.0489	16.2035
8 1/2	12.9828	13.4072	14.4440	14.5709	15.3043	15.8711	17.0991	17.2645

SECTION MODULUS, Z, FOR NEUTRAL AXIS THROUGH CENTER OF SECTION (Continued)

Outside Diameter Inches	THICKNESS IN GAGES AND FRACTIONS OF AN INCH							
	1/4"	3 B.W.G.	9/32"	2 B.W.G.	1 B.W.G.	5/16"	0 B.W.G.	11/32"
8 3/4	13.7928	14.2449	15.3500	15.4854	16.2674	16.8720	18.1826	18.3593
9	14.6273	15.1081	16.2837	16.4277	17.2600	17.9037	19.2996	19.4878
9 1/4	15.4904	16.0009	17.2494	17.4024	18.2868	18.9709	20.4552	20.6554
9 1/2	16.3742	16.9151	18.2385	18.4008	19.3386	20.0642	21.6392	21.8517
9 3/4	17.2826	17.8548	19.2553	19.4270	20.4198	21.1882	22.8566	23.0818
10	18.2155	18.8200	20.2997	20.4811	21.5304	22.3428	24.1073	24.3455
10 1/4	19.1730	19.8105	21.3716	21.5631	22.6706	23.5282	25.3915	25.6431
10 1/2	20.1550	20.8265	22.4712	22.6730	23.8402	24.7442	26.7090	26.9744
10 3/4	.....	21.8680	23.5984	23.8108	25.0392	25.9909	28.0600	28.3394
11	.....	22.9348	24.7533	24.9764	26.2677	27.2683	29.4443	29.7383
11 1/4	.....	24.0271	25.9357	26.1700	27.5217	28.5764	30.8620	31.1709
11 1/2	.....	25.1448	27.1458	27.3914	28.8131	29.9151	32.3131	32.6372
11 3/4	.....	26.2880	28.3835	28.6407	30.1300	31.2846	33.7975	34.1373
12	.....	27.4566	29.6488	29.9180	31.4764	32.6848	35.3154	35.6712

Outside Diameter Inches	THICKNESS IN GAGES AND FRACTIONS OF AN INCH						
	3/8"	00 B.W.G.	000 B.W.G.	7/16"	0000 B.W.G.	1/2"	9/16"
13/16	.0526	.....	.....	.....	.....	.....	.....
7/8	.0657	.....	.....	.....	.....	.....	.....
15/16	.0807	.0807	.0808	.0808	.....	.....	.....
1	.0977	.0978	.0981	.0981	.0981	.....	.....
1 1/16	.1168	.1169	.1175	.1176	.1177	.....	.....
1 1/8	.1380	.1382	.1392	.1394	.1395	.1397	.....
1 3/16	.1613	.1616	.1633	.1636	.1638	.1642	.....
1 1/4	.1868	.1872	.1897	.1901	.1906	.1914	.....
1 5/16	.2144	.2150	.2185	.2192	.2199	.2212	.....
1 3/8	.2443	.2450	.2497	.2507	.2518	.2538	.2549
1 7/16	.2763	.2772	.2834	.2847	.2862	.2891	.2909
1 1/2	.3106	.3117	.3196	.3213	.3233	.3272	.3300
1 5/8	.3858	.3874	.3994	.4021	.4053	.4120	.4174
1 3/4	.4700	.4722	.4893	.4932	.4979	.5084	.5175
1 7/8	.5632	.5662	.5893	.5947	.6013	.6164	.6305
2	.6655	.6693	.6995	.7067	.7155	.7363	.7566
2 1/8	.7769	.7816	.8199	.8292	.8407	.8680	.8958
2 1/4	.8973	.9032	.9506	.9623	.9767	1.0117	1.0483
2 3/8	1.0269	1.0339	1.0916	1.1059	1.1237	1.1674	1.2142
2 1/2	1.1656	1.1740	1.2429	1.2601	1.2817	1.3351	1.3936
2 5/8	1.3135	1.3233	1.4045	1.4250	1.4507	1.5149	1.5864
2 3/4	1.4705	1.4818	1.5764	1.6004	1.6307	1.7069	1.7927
2 7/8	1.6366	1.6497	1.7587	1.7866	1.8218	1.9109	2.0127
3	1.8120	1.8268	1.9514	1.9834	2.0239	2.1271	2.2462
3 1/8	1.9965	2.0132	2.1545	2.1909	2.2371	2.3554	2.4934
3 1/4	2.1901	2.2089	2.3679	2.4090	2.4613	2.5959	2.7541
3 3/8	2.3930	2.4139	2.5917	2.6378	2.6967	2.8486	3.0286
3 1/2	2.6050	2.6282	2.8259	2.8774	2.9431	3.1135	3.3167
3 5/8	2.8262	2.8518	3.0705	3.1276	3.2006	3.3906	3.6186
3 3/4	3.0566	3.0847	3.3255	3.3885	3.4692	3.6799	3.9341
3 7/8	3.2961	3.3269	3.5909	3.6601	3.7489	3.9814	4.2633
4	3.5449	3.5784	3.8667	3.9425	4.0398	4.2951	4.6063
4 1/8	3.8028	3.8393	4.1529	4.2355	4.3417	4.6210	4.9630
4 1/4	4.0700	4.1094	4.4495	4.5393	4.6548	4.9592	5.3334
4 3/8	4.3463	4.3889	4.7565	4.8537	4.9789	5.3096	5.7176
4 1/2	4.6318	4.6776	5.0739	5.1789	5.3142	5.6723	6.1155
4 5/8	4.9265	4.9757	5.4018	5.5148	5.6606	6.0472	6.5272

SECTION MODULUS, Z, FOR NEUTRAL AXIS THROUGH CENTER OF SECTION (Continued)

Outside Diameter Inches	THICKNESS IN GAGES AND FRACTIONS OF AN INCH						
	3/8"	00 B.W.G.	000 B.W.G.	7/16"	0000 B.W.G.	1/2"	9/16"
4 3/4	5.2304	5.2831	5.6400	5.8614	6.0182	6.4343	6.9526
4 7/8	5.5435	5.5999	6.0887	6.2188	6.3868	6.8336	7.3918
5	5.8658	5.9259	6.4478	6.5869	6.7666	7.2452	7.8447
5 1/8	6.1973	6.2613	6.8173	6.9656	7.1575	7.6691	8.3114
5 1/4	6.5380	6.6059	7.1972	7.3552	7.5595	8.1052	8.7919
5 3/8	6.8879	6.9599	7.5876	7.7554	7.9727	8.5536	9.2862
5 1/2	7.2470	7.3232	7.9883	8.1664	8.3970	9.0142	9.7942
5 3/4	7.9927	8.0778	8.8211	9.0205	9.2790	9.9722	10.8516
6	8.7753	8.8697	9.6956	9.9175	10.2055	10.9792	11.9641
6 1/4	9.5946	9.6989	10.6118	10.8575	11.1765	12.0352	13.1317
6 1/2	10.4508	10.5653	11.5697	11.8403	12.1921	13.1403	14.3545
6 3/4	11.3437	11.4691	12.5693	12.8661	13.2522	14.2944	15.6325
7	12.2735	12.4101	13.6106	13.9348	14.3568	15.4975	16.9656
7 1/4	13.2401	13.3885	14.6936	15.0465	15.2302	16.7498	18.3538
7 1/2	14.2434	14.4041	15.8183	16.2011	16.6998	18.0510	19.7972
7 3/4	15.2836	15.4570	16.9847	17.3986	17.9381	19.4013	21.2959
8	16.3606	16.5472	18.1928	18.6391	19.2209	20.8007	22.8496
8 1/4	17.4744	17.6748	19.4426	19.9225	20.5483	22.2492	24.4586
8 1/2	18.6250	18.8396	20.7342	21.2488	21.9203	23.7467	26.1228
8 3/4	19.8124	20.0417	22.0675	22.6181	23.3368	25.2933	27.8421
9	21.0366	21.2811	23.4425	24.0303	24.7979	26.8889	29.6167
9 1/4	20.3034	22.5637	24.8656	25.4920	26.3104	28.5410	31.4546
9 1/2	23.6016	23.8781	26.3244	26.9905	27.8610	30.2353	33.3400
9 3/4	24.9366	25.2297	27.8249	28.5319	29.4561	31.9786	35.2806
10	26.3084	26.6187	29.3671	30.1163	31.0959	33.7710	37.2765
10 1/4	27.7170	28.0450	30.9511	31.7437	32.7801	35.6125	39.3276
10 1/2	29.1625	29.5086	32.5768	33.4140	34.5091	37.5030	41.4339
10 3/4	30.6447	31.0096	34.2442	35.1272	36.2826	39.4427	43.5954
11	32.1638	32.5479	35.9534	36.8835	38.1006	41.4315	45.8121
11 1/4	33.7197	34.1233	37.7043	38.6826	39.8565	43.4693	48.0841
11 1/2	35.3125	35.7362	39.4969	40.5247	41.8705	45.5563	50.4113
11 3/4	36.9420	37.3864	41.3312	42.4098	43.8222	47.6923	52.7937
12	38.6084	39.0739	43.2073	44.3379	45.8186	49.8774	55.2313
12 1/4	40.3116	40.7987	45.1251	46.3089	47.8595	52.1116	57.7242
12 1/2	42.0516	42.5608	47.0847	48.3228	49.9450	54.3949	60.2723
12 3/4	43.8285	44.3602	49.0859	50.3798	52.0751	56.7273	62.8756
13	.....	.....	.....	52.4796	54.2498	59.1088	65.5341
13 1/4	.....	.....	.....	54.6164	56.4690	61.5394	68.2479
13 1/2	.....	.....	.....	56.8083	58.7329	64.0191	71.0169
13 3/4	.....	.....	.....	.....	.....	66.5479	73.8411

Outside Diameter Inches	THICKNESS IN FRACTIONS OF AN INCH						
	5/8"	11/16"	3/4"	13/16"	7/8"	15/16"	1"
1 1/16	.2915	.....	.....	.....	.....	.....	.....
1 1/2	.3310	.....	.....	.....	.....	.....	.....
1 3/4	.4200	.....	.....	.....	.....	.....	.....
1 7/8	.5226	.....	.....	.....	.....	.....	.....
1 7/8	.6391	.....	.....	.....	.....	.....	.....
2	.7698	.....	.....	.....	.....	.....	.....
2 1/8	.9149	.9274	.9350	.9391	.9411	.9418	.9420
2 1/4	1.0746	1.0926	1.1044	1.1116	1.1155	1.1174	1.1181
2 3/8	1.2489	1.2738	1.2909	1.3021	1.3088	1.3126	1.3143
2 1/2	1.4381	1.4710	1.4947	1.5109	1.5215	1.5279	1.5315

SECTION MODULUS, Z, FOR NEUTRAL AXIS THROUGH CENTER OF SECTION (Concluded)

Outside Diameter Inches	THICKNESS IN FRACTIONS OF AN INCH						
	5/8"	11/16"	3/4"	13/16"	7/8"	15/16"	1"
2 5/8	1.6420	1.6844	1.7158	1.7383	1.7538	1.7639	1.7700
2 3/4	1.8609	1.9141	1.9545	1.9845	2.0060	2.0208	2.0304
2 7/8	2.0948	2.1601	2.2109	2.2496	2.2782	2.2988	2.3129
3	2.3437	2.4225	2.4850	2.5337	2.5708	2.5983	2.6179
3 1/8	2.6077	2.7014	2.7769	2.8370	2.8837	2.9193	2.9457
3 1/4	2.8868	2.9968	3.0868	3.1595	3.2172	3.2621	3.2964
3 3/8	3.1810	3.3087	3.4146	3.5013	3.5713	3.6269	3.6701
3 1/2	3.4903	3.6372	3.7604	3.8625	3.9461	4.0136	4.0672
3 5/8	3.8148	3.9824	4.1242	4.2432	4.3418	4.4225	4.4876
3 3/4	4.1545	4.3442	4.5062	4.6433	4.7583	4.8536	4.9316
3 7/8	4.5094	4.7226	4.9062	5.0630	5.1957	5.3069	5.3992
4	4.8794	5.1178	5.3244	5.5022	5.6541	5.7827	5.8904
4 1/8	5.2648	5.5296	5.7607	5.9611	6.1335	6.2808	6.4055
4 1/4	5.6653	5.9582	6.2153	6.4396	6.6341	6.8014	6.9444
4 3/8	6.0811	6.4035	6.6880	6.9378	7.1557	7.3446	7.5072
4 1/2	6.5121	6.8655	7.1790	7.4556	7.6984	7.9103	8.0939
4 5/8	6.9584	7.3443	7.6882	7.9932	8.2623	8.4985	8.7047
4 3/4	7.4200	7.8399	8.2156	8.5504	8.8474	9.1095	9.3395
4 7/8	7.8968	8.3522	8.7613	9.1275	9.4537	9.7430	9.9984
5	8.3889	8.8813	9.3253	9.7242	10.0812	10.3993	10.6814
5 1/8	8.8963	9.4272	9.9076	10.3408	10.7300	11.0782	11.3885
5 1/4	9.4190	9.9899	10.5082	10.9771	11.4000	11.7799	12.1199
5 3/8	9.9569	10.5694	11.1270	11.6332	12.0913	12.5043	12.8754
5 1/2	10.5102	11.1657	11.7642	12.3092	12.8039	13.2515	13.6552
5 3/4	11.6625	12.4086	13.0935	13.7205	14.2930	14.8143	15.2875
6	12.8761	13.7189	14.4961	15.2111	15.8674	16.4683	17.0169
6 1/4	14.1509	15.0965	15.9720	16.7811	17.5272	18.2136	18.8436
6 1/2	15.4870	16.5413	17.5213	18.4305	19.2724	20.0503	20.7677
6 3/4	16.8842	18.0535	19.1440	20.1594	21.1030	21.9785	22.7892
7	18.3428	19.6331	20.8402	21.9677	23.0192	23.9983	24.9083
7 1/4	19.8626	21.2800	22.6098	23.8556	25.0210	26.1097	27.1250
7 1/2	21.4437	22.9943	24.4528	25.8230	27.1084	28.3127	29.4393
7 3/4	23.0861	24.7760	26.3694	27.8700	29.2814	30.6074	31.8513
8	24.7898	26.6251	28.3594	29.9965	31.5401	32.9938	34.3611
8 1/4	26.5548	28.5416	30.4230	32.2027	33.8844	35.4719	36.9687
8 1/2	28.3811	30.5255	32.5601	34.4884	36.3145	38.0418	39.6741
8 3/4	30.2687	32.5769	34.7706	36.8538	38.8302	40.7035	42.4774
9	32.2176	34.6957	37.0548	39.2989	41.4317	43.4570	45.3785
9 1/4	34.2366	36.8914	39.4227	41.8344	44.1303	46.3143	48.3900
9 1/2	36.3088	39.1456	41.8545	44.4394	46.9040	49.2523	51.4878
9 3/4	38.4422	41.4673	44.3600	47.1241	49.7636	52.2821	54.6835
10	40.6370	43.8565	46.9390	49.8885	52.7088	55.4038	57.9773
10 1/4	42.8931	46.3131	49.5916	52.7326	55.7399	58.6175	61.3690
10 1/2	45.2105	48.8372	52.3178	55.6564	58.8568	61.9230	64.8588
10 3/4	47.5894	51.4287	55.1176	58.6599	62.0596	65.3205	68.4465
11	50.0295	54.0878	57.9910	61.7431	65.3482	68.8099	72.1324
11 1/4	52.5310	56.8143	60.9380	64.9061	68.7226	72.3913	75.9162
11 1/2	55.0939	59.6083	63.9586	68.1488	72.1828	76.0645	79.7982
11 3/4	57.7181	62.4698	67.0528	71.4712	75.7290	79.8300	83.7782
12	60.4037	65.3988	70.2207	74.8734	79.3609	83.6873	87.8563
12 1/4	63.1506	68.3953	73.4621	78.3553	83.0787	87.6365	92.0324
12 1/2	65.9589	71.4592	76.7772	81.9169	86.8824	91.6777	96.3067
12 3/4	68.8286	74.5907	80.1659	85.5583	90.7720	95.8109	100.6791
13	71.7596	77.7896	83.6282	89.2794	94.7474	100.0361	105.1495
13 1/4	74.7520	81.0560	87.1641	93.0803	98.8087	104.3533	109.7181
13 1/2	77.8057	84.3900	90.7736	96.9609	102.9559	108.7625	114.3848
13 3/4	80.9208	87.7914	94.4568	100.9213	107.1889	113.2637	119.1496
14	84.0973	91.2603	98.2136	104.9614	111.5078	117.8569	124.0126

RADIUS OF GYRATION, R, FOR NEUTRAL AXIS THROUGH CENTER OF SECTION

Outside Diameter Inches	THICKNESS IN GAGES							
	24 B.W.G.	23 B.W.G.	22 B.W.G.	21 B.W.G.	20 B.W.G.	19 B.W.G.	18 B.W.G.	17 B.W.G.
1/4	.0809	.0800	.0791	.0779	.0770	.0750	.0731	.0709
5/16	.1030	.1020	.1010	.0998	.0988	.0967	.0947	.0922
3/8	.1250	.1240	.1230	.1217	.1208	.1186	.1165	.1139
7/16	.1471	.1461	.1451	.1438	.1428	.1406	.1384	.1357
1/2	.1691	.1681	.1671	.1658	.1648	.1626	.1603	.1576
9/16	.1912	.1902	.1892	.1879	.1869	.1846	.1823	.1795
5/8	.2133	.2123	.2113	.2099	.2089	.2066	.2043	.2015
11/16	.2354	.2343	.2333	.2320	.2310	.2287	.2264	.2235
3/4	.2575	.2564	.2554	.2541	.2530	.2507	.2484	.2455
13/16	.2795	.2785	.2775	.2761	.2751	.2728	.2704	.2675
7/8	.3016	.3006	.2996	.2982	.2972	.2948	.2925	.2895
15/16	.3237	.3227	.3217	.3203	.3193	.3169	.3146	.3116
1	.3458	.3448	.3437	.3424	.3414	.3390	.3366	.3336
1 1/16	.3679	.3669	.3658	.3645	.3634	.3611	.3587	.3557
1 1/8	.3900	.3890	.3879	.3865	.3855	.3831	.3808	.3777
1 3/16	.4121	.4111	.4100	.4086	.4076	.4052	.4028	.3998
1 1/4	.4342	.4331	.4321	.4307	.4297	.4273	.4249	.4219
1 5/16	.4563	.4552	.4542	.4528	.4518	.4494	.4470	.4440
1 3/8	.4784	.4773	.4763	.4749	.4739	.4715	.4691	.4660
1 7/16	.5005	.4994	.4984	.4970	.4960	.4936	.4912	.4881
1 1/2	.5226	.5215	.5205	.5191	.5181	.5156	.5132	.5102
1 5/8	.5667	.5657	.5647	.5633	.5622	.5598	.5574	.5543
1 3/4	.6109	.6099	.6088	.6075	.6064	.6040	.6016	.5985
1 7/8	.6551	.6541	.6530	.6516	.6506	.6482	.6458	.6427
2	.6993	.6983	.6972	.6958	.6948	.6924	.6900	.6869
2 1/8	.....	.....	.....	.....	.....	.....	.7341	.7310
2 1/4	.....	.....	.....	.....	.....	.....	.7783	.7752
2 3/8	.....	.....	.....	.....	.....	.....	.8225	.8194
2 1/2	.....	.....	.....	.....	.....	.....	.8667	.8636
2 5/8	.....	.....	.....	.....	.....	.....	.9109	.9078
2 3/4	.....	.....	.....	.....	.....	.....	.9551	.9519
2 7/8	.....	.....	.....	.....	.....	.....	.9992	.9961
3	.....	.....	.....	.....	.....	.....	1.0434	1.0403
3 1/8	.....	.....	.....	.....	.....	.....	1.0876	1.0845
3 1/4	.....	.....	.....	.....	.....	.....	1.1318	1.1287
3 3/8	.....	.....	.....	.....	.....	.....	1.1760	1.1729

Outside Diameter Inches	THICKNESS IN GAGES							
	16 B.W.G.	15 B.W.G.	14 B.W.G.	13 B.W.G.	12 B.W.G.	11 B.W.G.	10 B.W.G.	9 B.W.G.
1/4	.0693	.0678	.0659	.0642	.....	.....	.....	.....
5/16	.0904	.0887	.0862	.0839	.0816	.0802	.....	.....
3/8	.1119	.1101	.1073	.1045	.1016	.0996	.0974	.....
7/16	.1336	.1317	.1287	.1256	.1223	.1200	.1172	.....
1/2	.1555	.1534	.1503	.1470	.1435	.1408	.1378	.1350
9/16	.1773	.1752	.1720	.1686	.1649	.1620	.1587	.1556
5/8	.1993	.1971	.1938	.1903	.1864	.1835	.1799	.1765
11/16	.2212	.2190	.2157	.2121	.2081	.2050	.2013	.1977
3/4	.2432	.2410	.2376	.2340	.2298	.2267	.2228	.2191
13/16	.2652	.2630	.2595	.2558	.2516	.2484	.2445	.2406
7/8	.2872	.2850	.2815	.2778	.2735	.2702	.2662	.2623
15/16	.3093	.3070	.3035	.2997	.2954	.2921	.2880	.2839
1	.3313	.3290	.3255	.3217	.3173	.3140	.3098	.3057
1 1/16	.3534	.3511	.3475	.3437	.3393	.3359	.3316	.3275
1 1/8	.3754	.3731	.3695	.3657	.3612	.3578	.3535	.3493

RADIUS OF GYRATION, R, FOR NEUTRAL AXIS THROUGH CENTER OF SECTION (Continued)

Outside Diameter Inches	THICKNESS IN GAGES							
	16 B.W.G.	15 B.W.G.	14 B.W.G.	13 B.W.G.	12 B.W.G.	11 B.W.G.	10 B.W.G.	9 B.W.G.
1 3/16	.3975	.3952	.3916	.3877	.3832	.3797	.3754	.3712
1 1/4	.4195	.4172	.4136	.4097	.4052	.4017	.3974	.3931
1 5/16	.4416	.4393	.4356	.4317	.4272	.4237	.4193	.4150
1 3/8	.4637	.4613	.4577	.4537	.4492	.4457	.4413	.4369
1 7/16	.4857	.4834	.4797	.4758	.4712	.4677	.4632	.4589
1 1/2	.5078	.5055	.5018	.4978	.4933	.4897	.4852	.4808
1 5/8	.5520	.5496	.5459	.5419	.5373	.5337	.5292	.5248
1 3/4	.5961	.5938	.5901	.5860	.5814	.5778	.5733	.5688
1 7/8	.6403	.6379	.6342	.6302	.6255	.6219	.6173	.6128
2	.6845	.6821	.6873	.6743	.6696	.6660	.6614	.6568
2 1/4	.7728	.7704	.7767	.7626	.7579	.7542	.7496	.7450
2 3/8	.8170	.8146	.8108	.8068	.8020	.7983	.7937	.7891
2 1/2	.8612	.8588	.8550	.8509	.8462	.8425	.8378	.8332
2 5/8	.9053	.9029	.8992	.8951	.8903	.8866	.8819	.8773
2 3/4	.9495	.9471	.9433	.9392	.9345	.9308	.9261	.9214
2 7/8	.9937	.9913	.9875	.9834	.9786	.9749	.9702	.9655
3	1.0379	1.0355	1.0317	1.0276	1.0228	1.0191	1.0143	1.0096
3 1/4	1.1263	1.1238	1.1200	1.1159	1.1111	1.1074	1.1026	1.0979
3 3/8	1.1704	1.1680	1.1642	1.1601	1.1553	1.1515	1.1468	1.1421
3 1/2	1.2146	1.2122	1.2084	1.2043	1.1995	1.1957	1.1910	1.1862
3 5/8	1.2588	1.2564	1.2526	1.2484	1.2436	1.2399	1.2351	1.2304
3 3/4	1.3030	1.3006	1.2968	1.2926	1.2878	1.2841	1.2793	1.2745
3 7/8	1.3472	1.3448	1.3409	1.3368	1.3320	1.3282	1.3234	1.3187
4	1.3914	1.3889	1.3851	1.3810	1.3762	1.3724	1.3676	1.3628
4 1/4	1.4797	1.4773	1.4735	1.4693	1.4645	1.4607	1.4559	1.4512
4 1/2	1.5681	1.5657	1.5619	1.5577	1.5529	1.5491	1.5443	1.5395
4 3/4	1.6565	1.6541	1.6502	1.6461	1.6412	1.6375	1.6326	1.6278
5	1.7449	1.7424	1.7386	1.7345	1.7296	1.7258	1.7210	1.7162
5 1/4	1.8333	1.8308	1.8270	1.8228	1.8180	1.8142	1.8093	1.8045
5 1/2	1.9217	1.9192	1.9154	1.9112	1.9063	1.9025	1.8977	1.8929
5 3/4	.....	.....	.....	.....	.....	.....	1.9861	1.9812
6	.....	.....	.....	.....	.....	.....	2.0744	2.0696
6 1/4	.....	.....	.....	.....	.....	.....	2.1628	2.1580
6 1/2	.....	.....	.....	.....	.....	.....	2.2512	2.2463
6 3/4	.....	.....	.....	.....	.....	.....	2.3395	2.3347
7	.....	.....	.....	.....	.....	.....	2.4279	2.4231
7 1/4	.....	.....	.....	.....	.....	.....	2.5163	2.5114
7 1/2	.....	.....	.....	.....	.....	.....	2.6047	2.5998
7 3/4	.....	.....	.....	.....	.....	.....	2.6930	2.6882
8	.....	.....	.....	.....	.....	.....	2.7814	2.7765
8 1/4	.....	.....	.....	.....	.....	.....	2.8698	2.8649
8 1/2	.....	.....	.....	.....	.....	.....	2.9582	2.9533
8 3/4	.....	.....	.....	.....	.....	.....	3.0465	3.0417
9	.....	.....	.....	.....	.....	.....	3.1349	3.1300

Outside Diameter Inches	THICKNESS IN GAGES AND FRACTIONS OF AN INCH							
	5/32"	8 B.W.G.	7 B.W.G.	3/16"	6 B.W.G.	7/32"	5 B.W.G.	4 B.W.G.
5/8	.1746	.1727	.1697	.1682	.....	.....	.....	.....
1 1/16	.1957	.1937	.1903	.1887	.1857	.1828	.1826	.1798
3/4	.2170	.2148	.2113	.2096	.2062	.2031	.2028	.1996
1 3/16	.2385	.2362	.2325	.2307	.2271	.2237	.2234	.2198
7/8	.2600	.2577	.2538	.2519	.2481	.2445	.2442	.2404
1 5/16	.2816	.2792	.2752	.2733	.2694	.2656	.2653	.2612
1	.3033	.3009	.2968	.2948	.2907	.2868	.2865	.2822
1 1/16	.3251	.3226	.3184	.3163	.3122	.3081	.3078	.3034

RADIUS OF GYRATION, R, FOR NEUTRAL AXIS THROUGH CENTER OF SECTION (Continued)

Outside Diameter Inches	THICKNESS IN GAGES AND FRACTIONS OF AN INCH							
	5/32"	8 B.W.G.	7 B.W.G.	3/16"	6 B.W.G.	7/32"	5 B.W.G.	4 B.W.G.
1 1/8	.3469	.3443	.3401	.3380	.3337	.3296	.3292	.3246
1 5/16	.3687	.3661	.3618	.3597	.3553	.3511	.3507	.3460
1 1/4	.3906	.3880	.3836	.3814	.3770	.3727	.3723	.3675
1 5/16	.4125	.4098	.4054	.4032	.3987	.3943	.3940	.3891
1 3/8	.4344	.4317	.4272	.4250	.4205	.4160	.4156	.4107
1 7/16	.4563	.4536	.4491	.4468	.4423	.4377	.4374	.4323
1 1/2	.4782	.4755	.4710	.4687	.4641	.4595	.4591	.4540
1 5/8	.5222	.5194	.5148	.5125	.5078	.5031	.5027	.4975
1 3/4	.5661	.5634	.5587	.5563	.5516	.5468	.5465	.5411
1 7/8	.6101	.6073	.6026	.6002	.5954	.5908	.5902	.5848
2	.6542	.6513	.6466	.6442	.6393	.6344	.6341	.6286
2 1/8	.6982	.6954	.6906	.6882	.6833	.6783	.6779	.6724
2 1/4	.7423	.7394	.7346	.7322	.7272	.7223	.7219	.7163
2 3/8	.7863	.7835	.7786	.7762	.7712	.7662	.7658	.7602
2 1/2	.8304	.8276	.8227	.8202	.8152	.8102	.8098	.8041
2 5/8	.8745	.8716	.8667	.8643	.8593	.8542	.8538	.8481
2 3/4	.9186	.9157	.9108	.9084	.0933	.8982	.8978	.8921
2 7/8	.9628	.9599	.9549	.9524	.9474	.9423	.9419	.9361
3	1.0069	1.0040	.9990	.9965	.9914	.9863	.9859	.9801
3 1/8	1.0510	1.0481	1.0431	1.0406	1.0355	1.0304	1.0300	1.0241
3 1/4	1.0952	1.0922	1.0872	1.0847	1.0796	1.0744	1.0740	1.0682
3 3/8	1.1393	1.1364	1.1313	1.1288	1.1237	1.1185	1.1181	1.1122
3 1/2	1.1834	1.1805	1.1755	1.1730	1.1678	1.1626	1.1622	1.1563
3 5/8	1.2276	1.2246	1.2196	1.2171	1.2119	1.2067	1.2063	1.2004
3 3/4	1.2717	1.2688	1.2637	1.2612	1.2561	1.2508	1.2504	1.2445
3 7/8	1.3159	1.3129	1.3079	1.3054	1.3002	1.2949	1.2945	1.2886
4	1.3600	1.3571	1.3520	1.3495	1.3443	1.3391	1.3386	1.3327
4 1/8	1.4042	1.4012	1.3962	1.3936	1.3884	1.3832	1.3828	1.3768
4 1/4	1.4484	1.4454	1.4403	1.4378	1.4326	1.4273	1.4269	1.4209
4 3/8	1.4925	1.4896	1.4845	1.4819	1.4767	1.4714	1.4710	1.4650
4 1/2	1.5367	1.5337	1.5286	1.5261	1.5209	1.5156	1.5152	1.5091
4 5/8	1.5809	1.5779	1.5728	1.5702	1.5650	1.5597	1.5593	1.5533
4 3/4	1.6250	1.6220	1.6169	1.6144	1.6092	1.6039	1.6034	1.5974
4 7/8	1.6692	1.6662	1.6611	1.6586	1.6533	1.6480	1.6476	1.6415
5	1.7134	1.7104	1.7053	1.7027	1.6975	1.6921	1.6917	1.6857
5 1/4	1.8017	1.7987	1.7936	1.7910	1.7858	1.7804	1.7800	1.7740
5 1/2	1.8901	1.8871	1.8819	1.8794	1.8741	1.8688	1.8683	1.8623
5 3/4	1.9784	1.9754	1.9703	1.9677	1.9624	1.9571	1.9566	1.9506
6	2.0668	2.0638	2.0586	2.0560	2.0508	2.0454	2.0450	2.0389
6 1/4	2.1551	2.1521	2.1470	2.1444	2.1391	2.1337	2.1333	2.1272
6 1/2	2.2435	2.2405	2.2353	2.2327	2.2274	2.2221	2.2216	2.2155
6 3/4	2.3318	2.3288	2.3237	2.3211	2.3158	2.3104	2.3100	2.3038
7	2.4202	2.4172	2.4120	2.4094	2.4041	2.3987	2.3983	2.3922
7 1/4	2.5086	2.5056	2.5038	2.4978	2.4925	2.4871	2.4866	2.4805
7 1/2	2.5969	2.5939	2.5887	2.5862	2.5808	2.5754	2.5750	2.5688
7 3/4	2.6853	2.6823	2.6771	2.6745	2.6692	2.6638	2.6633	2.6572
8	2.7737	2.7707	2.7655	2.7629	2.7575	2.7521	2.7517	2.7455
8 1/4	2.8621	2.8590	2.8538	2.8512	2.8459	2.8405	2.8400	2.8339
8 1/2	2.9504	2.9474	2.9422	2.9396	2.9343	2.9288	2.9284	2.9222
8 3/4	3.0388	3.0358	3.0306	3.0280	3.0226	3.0172	3.0168	3.0106
9	3.1272	3.1241	3.1189	3.1163	3.1110	3.1056	3.1051	3.0989
9 1/4	.....	.....	.....	.....	3.1998	3.1944	3.1939	3.1877
9 1/2	.....	.....	.....	.....	.....	.....	3.2823	3.2761
9 3/4	.....	.....	.....	.....	.....	.....	3.3707	3.3645
10	.....	.....	.....	.....	.....	.....	3.4590	3.4528
10 1/4	.....	.....	.....	.....	.....	.....	.....	3.5412
10 1/2	.....	.....	.....	.....	.....	.....	.....	3.6296

RADIUS OF GYRATION, R, FOR NEUTRAL AXIS THROUGH CENTER OF SECTION (Continued)

Outside Diameter Inches	THICKNESS IN GAGES AND FRACTIONS OF AN INCH							
	1/4"	3 B.W.G.	9/32"	2 B.W.G.	1 B.W.G.	5/16"	0 B.W.G.	11/32"
11/16	.1781	.....	.....	.....	.....	.....	.....	.....
3/4	.1976	.1962	.1932	.1929	.1912	.1900	.....	.....
13/16	.2176	.2160	.2125	.2121	.2099	.2084	.2058	.2055
7/8	.2379	.2362	.2322	.2318	.2292	.2275	.2241	.2237
15/16	.2586	.2567	.2524	.2519	.2491	.2470	.2430	.2425
1	.2795	.2775	.2728	.2723	.2692	.2670	.2624	.2619
1 1/16	.3005	.2984	.2935	.2929	.2897	.2872	.2823	.2816
1 1/8	.3217	.3195	.3144	.3138	.3103	.3077	.3024	.3017
1 3/16	.3430	.3408	.3354	.3348	.3312	.3284	.3228	.3221
1 1/4	.3644	.3621	.3566	.3559	.3522	.3493	.3434	.3426
1 5/16	.3859	.3835	.3779	.3772	.3733	.3704	.3642	.3634
1 3/8	.4074	.4050	.3992	.3985	.3945	.3915	.3851	.3843
1 7/16	.4290	.4266	.4207	.4200	.4159	.4128	.4062	.4053
1 1/2	.4506	.4482	.4422	.4414	.4373	.4341	.4273	.4264
1 5/8	.4941	.4915	.4853	.4846	.4803	.4770	.4699	.4690
1 3/4	.5376	.5350	.5287	.5279	.5235	.5201	.5127	.5118
1 7/8	.5812	.5786	.5721	.5713	.5668	.5633	.5558	.5548
2	.6250	.6223	.6157	.6149	.6103	.6067	.5990	.5980
2 1/8	.6687	.6660	.6594	.6585	.6538	.6502	.6424	.6413
2 1/4	.7126	.7098	.7031	.7023	.6975	.6938	.6859	.6848
2 3/8	.7564	.7537	.7469	.7460	.7412	.7375	.7294	.7283
2 1/2	.8003	.7975	.7907	.7898	.7850	.7812	.7730	.7719
2 5/8	.8443	.8415	.8345	.8337	.8288	.8250	.8167	.8156
2 3/4	.8882	.8854	.8784	.8776	.8726	.8688	.8605	.8593
2 7/8	.9322	.9294	.9224	.9215	.9165	.9126	.9042	.9031
3	.9762	.9734	.9663	.9654	.9604	.9565	.9481	.9469
3 1/8	1.0203	1.0174	1.0103	1.0094	1.0044	1.0004	.9919	.9908
3 1/4	1.0643	1.0614	1.0543	1.0534	1.0483	1.0444	1.0358	1.0346
3 3/8	1.1083	1.1054	1.0983	1.0974	1.0923	1.0883	1.0797	1.0785
3 1/2	1.1524	1.1495	1.1423	1.1414	1.1363	1.1323	1.1236	1.1225
3 5/8	1.1965	1.1935	1.1863	1.1854	1.1803	1.1763	1.1676	1.1664
3 3/4	1.2405	1.2376	1.2304	1.2295	1.2243	1.2203	1.2115	1.2104
3 7/8	1.2846	1.2817	1.2744	1.2735	1.2683	1.2643	1.2555	1.2543
4	1.3287	1.3258	1.3185	1.3176	1.3124	1.3084	1.2995	1.2983
4 1/8	1.3728	1.3699	1.3626	1.3617	1.3564	1.3524	1.3435	1.3423
4 1/4	1.4169	1.4140	1.4066	1.4057	1.4005	1.3964	1.3876	1.3864
4 3/8	1.4610	1.4581	1.4507	1.4498	1.4446	1.4405	1.4316	1.4304
4 1/2	1.5051	1.5022	1.4948	1.4939	1.4887	1.4846	1.4756	1.4744
4 5/8	1.5493	1.5463	1.5389	1.5380	1.5327	1.5286	1.5197	1.5185
4 3/4	1.5934	1.5904	1.5830	1.5821	1.5768	1.5727	1.5637	1.5625
4 7/8	1.6375	1.6345	1.6271	1.6262	1.6209	1.6168	1.6078	1.6066
5	1.6817	1.6786	1.6712	1.6703	1.6650	1.6609	1.6519	1.6507
5 1/8	1.7258	1.7228	1.7154	1.7144	1.7091	1.7050	1.6960	1.6947
5 1/4	1.7699	1.7669	1.7595	1.7586	1.7533	1.7491	1.7401	1.7388
5 3/8	1.8141	1.8110	1.8036	1.8027	1.7974	1.7932	1.7841	1.7829
5 1/2	1.8582	1.8552	1.8477	1.8468	1.8415	1.8373	1.8282	1.8270
5 3/4	1.9465	1.9435	1.9360	1.9351	1.9297	1.9256	1.9164	1.9152
6	2.0348	2.0318	2.0243	2.0234	2.0180	2.0138	2.0047	2.0034
6 1/4	2.1231	2.1201	2.1126	2.1116	2.1063	2.1021	2.0929	2.0917
6 1/2	2.2114	2.2084	2.2009	2.1999	2.1945	2.1904	2.1812	2.1799
6 3/4	2.2997	2.2967	2.2892	2.2882	2.2828	2.2786	2.2694	2.2682
7	2.3881	2.3850	2.3775	2.3765	2.3711	2.3669	2.3577	2.3564
7 1/4	2.4764	2.4733	2.4658	2.4648	2.4594	2.4552	2.4460	2.4447
7 1/2	2.5647	2.5617	2.5541	2.5532	2.5477	2.5435	2.5342	2.5330
7 3/4	2.6531	2.6500	2.6424	2.6415	2.6361	2.6318	2.6225	2.6213
8	2.7414	2.7383	2.7308	2.7298	2.7244	2.7201	2.7108	2.7096
8 1/4	2.8298	2.8267	2.8191	2.8181	2.8127	2.8085	2.7991	2.7979

RADIUS OF GYRATION, R, FOR NEUTRAL AXIS THROUGH CENTER OF SECTION (Continued)

Outside Diameter Inches	THICKNESS IN GAGES AND FRACTIONS OF AN INCH							
	1/4"	3 B.W.G.	9/32"	2 B.W.G.	1 B.W.G.	5/16"	0 B.W.G.	11/32"
8 1/2	2.9181	2.9150	2.9074	2.9065	2.9010	2.8968	2.8874	2.8862
8 3/4	3.0065	3.0034	2.9958	2.9948	2.9894	2.9851	2.9758	2.9745
9	3.0948	3.0917	3.0841	3.0832	3.0777	3.0734	3.0641	3.0628
9 1/4	3.1836	3.1805	3.1729	3.1720	3.1665	3.1622	3.1529	3.1516
9 1/2	3.2720	3.2689	3.2612	3.2603	3.2548	3.2506	3.2412	3.2399
9 3/4	3.3603	3.3572	3.3496	3.3487	3.3432	3.3389	3.3295	3.3283
10	3.4487	3.4456	3.4380	3.4370	3.4315	3.4273	3.4179	3.4166
10 1/4	3.5371	3.5340	3.5263	3.5254	3.5199	3.5156	3.5062	3.5049
10 1/2	3.6254	3.6224	3.6147	3.6137	3.6083	3.6040	3.5946	3.5933
10 3/4	.....	3.7107	3.7031	3.7021	3.6966	3.6923	3.6829	3.6816
11	.....	3.7991	3.7914	3.7905	3.7850	3.7807	3.7713	3.7700
11 1/4	.....	3.8875	3.8798	3.8789	3.8733	3.8691	3.8596	3.8583
11 1/2	.....	3.9759	3.9682	3.9672	3.9617	3.9574	3.9481	3.9467
11 3/4	.....	4.0643	4.0565	4.0556	4.0501	4.0458	4.0363	4.0351
12	.....	4.1526	4.1449	4.1440	4.1385	4.1342	4.1247	4.1234

Outside Diameter Inches	THICKNESS IN GAGES AND FRACTIONS OF AN INCH						
	3/8"	00 B.W.G.	000 B.W.G.	7/16"	0000 B.W.G.	1/2"	9/16"
13/16	.2037	.....	.....	.....	.....	.....	.....
7/8	.2209	.....	.....	.....	.....	.....	.....
15/16	.2390	.2385	.2353	.2348	.....	.....	.....
1	.2576	.2570	.2527	.2519	.2510	.....	.....
1 1/16	.2768	.2761	.2708	.2697	.2684	.....	.....
1 1/8	.2964	.2956	. 2895	.2881	.2864	.2829	.....
1 3/16	.3163	.3155	.3086	.3069	.3049	.3005	.....
1 1/4	.3365	.3356	.3281	.3262	.3239	.3186	.....
1 5/16	.3569	.3560	.3479	.3458	.3433	.3372	.....
1 3/8	.3775	.3765	.3679	.3657	.3630	.3563	.3493
1 7/16	.3983	.3972	.3882	.3859	.3829	.3756	.3677
1 1/2	.4192	.4181	.4086	.4062	.4031	.3952	.3865
1 5/8	.4614	.4602	.4500	.4474	.4440	.4352	.4250
1 3/4	.5038	.5026	.4919	.4891	.4855	.4759	.4645
1 7/8	.5466	.5453	.5342	.5312	.5274	.5172	.5048
2	.5896	.5883	.5767	.5736	.5696	.5590	.5451
2 1/8	.6327	.6314	.6195	.6163	.6122	.6011	.5871
2 1/4	.6760	.6746	.6625	.6592	.6549	.6434	.6288
2 3/8	.7194	.7180	.7056	.7022	.6978	.6860	.6709
2 1/2	.7629	.7614	.7488	.7454	.7409	.7288	.7132
2 5/8	.8064	.8050	.7921	.7887	.7841	.7718	.7558
2 3/4	.8500	.8486	.8356	.8320	.8274	.8149	.7985
2 7/8	.8937	.8922	.8791	.8755	.8708	.8580	.8414
3	.9375	.9360	.9227	.9190	.9143	.9013	.8844
3 1/8	.9812	.9797	.9663	.9626	.9578	.9447	.9275
3 1/4	1.0250	1.0235	1.0100	1.0063	1.0014	.9882	.9707
3 3/8	1.0689	1.0673	1.0537	1.0500	1.0451	1.0317	1.0140
3 1/2	1.1127	1.1112	1.0975	1.0937	1.0888	1.0752	1.0574
3 5/8	1.1566	1.1551	1.1413	1.1375	1.1325	1.1189	1.1008
3 3/4	1.2005	1.1990	1.1851	1.1813	1.1763	1.1625	1.1443
3 7/8	1.2445	1.2429	1.2289	1.2251	1.2201	1.2062	1.1879
4	1.2884	1.2868	1.2728	1.2689	1.2639	1.2500	1.2315
4 1/8	1.3324	1.3308	1.3167	1.3128	1.3077	1.2937	1.2751
4 1/4	1.3764	1.3748	1.3606	1.3567	1.3516	1.3375	1.3188
4 3/8	1.4204	1.4188	1.4045	1.4006	1.3955	1.3813	1.3625
4 1/2	1.4644	1.4628	1.4485	1.4446	1.4394	1.4252	1.4062
4 5/8	1.5084	1.5068	1.4925	1.4885	1.4833	1.4690	1.4500

RADIUS OF GYRATION, R, FOR NEUTRAL AXIS THROUGH CENTER OF SECTION (Continued)

Outside Diameter Inches	THICKNESS IN GAGES AND FRACTIONS OF AN INCH						
	3/8"	00 B.W.G.	000 B.W.G.	7/16"	0000 B.W.G.	1/2"	9/16"
4 3/4	1.5524	1.5508	1.5364	1.5325	1.5273	1.5129	1.4938
4 7/8	1.5965	1.5948	1.5804	1.5765	1.5712	1.5568	1.5376
5	1.6405	1.6389	1.6244	1.6204	1.6152	1.6007	1.5814
5 1/8	1.6846	1.6829	1.6684	1.6644	1.6592	1.6447	1.6253
5 1/4	1.7286	1.7270	1.7125	1.7084	1.7032	1.6886	1.6691
5 3/8	1.7727	1.7711	1.7565	1.7525	1.7472	1.7326	1.7130
5 1/2	1.8168	1.8151	1.8005	1.7965	1.7912	1.7765	1.7569
5 3/4	1.9049	1.9033	1.8886	1.8846	1.8792	1.8645	1.8448
6	1.9931	1.9915	1.9767	1.9727	1.9673	1.9525	1.9327
6 1/4	2.0813	2.0797	2.0649	2.0608	2.0554	2.0406	2.0206
6 1/2	2.1695	2.1679	2.1530	2.1489	2.1436	2.1286	2.1086
6 3/4	2.2577	2.2561	2.2412	2.2371	2.2311	2.2167	2.1966
7	2.3460	2.3443	2.3294	2.3253	2.3199	2.3048	2.2846
7 1/4	2.4342	2.4326	2.4176	2.4135	2.4081	2.3930	2.3727
7 1/2	2.5225	2.5208	2.5058	2.5017	2.4963	2.4811	2.4608
7 3/4	2.6108	2.6091	2.5941	2.5899	2.5845	2.5693	2.5489
8	2.6991	2.6974	2.6823	2.6782	2.6727	2.6575	2.6370
8 1/4	2.7873	2.7857	2.7706	2.7664	2.7609	2.7457	2.7252
8 1/2	2.8756	2.8739	2.8588	2.8547	2.8492	2.8339	2.8133
8 3/4	2.9639	2.9622	2.9471	2.9429	2.9374	2.9221	2.9015
9	3.0522	3.0505	3.0354	3.0312	3.0257	3.0103	2.9897
9 1/4	3.1410	3.1393	3.1241	3.1199	3.1144	3.0990	3.0783
9 1/2	3.2293	3.2276	3.2124	3.2082	3.2027	3.1873	3.1665
9 3/4	3.3176	3.3159	3.3007	3.2965	3.2910	3.2756	3.2548
10	3.4060	3.4043	3.3890	3.3848	3.3793	3.3638	3.3430
10 1/4	3.4943	3.4926	3.4774	3.4731	3.4676	3.4521	3.4313
10 1/2	3.5826	3.5809	3.5657	3.5614	3.5559	3.5404	3.5195
10 3/4	3.6701	3.6693	3.6540	3.6498	3.6442	3.6287	3.6078
11	3.7593	3.7576	3.7423	3.7381	3.7325	3.7170	3.6960
11 1/4	3.8477	3.8459	3.8307	3.8264	3.8208	3.8053	3.7843
11 1/2	3.9360	3.9343	3.9190	3.9147	3.9091	3.8936	3.8726
11 3/4	4.0244	4.0227	4.0073	4.0031	3.9975	3.9819	3.9609
12	4.1127	4.1110	4.0957	4.0914	4.0858	4.0702	4.0492
12 1/4	4.2011	4.1994	4.1840	4.1797	4.1741	4.1585	4.1375
12 1/2	4.2894	4.2877	4.2723	4.2681	4.2625	4.2469	4.2258
12 3/4	4.3778	4.3761	4.3607	4.3564	4.3508	4.3352	4.3141
13	.....	.....	.....	4.4448	4.4392	4.4235	4.4024
13 1/4	.....	.....	.....	4.5329	4.5275	4.5118	4.4907
13 1/2	.....	.....	.....	4.6215	4.6159	4.6002	4.5790
13 3/4	.....	.....	.....	.....	.....	4.6885	4.6673

Outside Diameter Inches	THICKNESS IN FRACTIONS OF AN INCH						
	5/8"	11/16"	3/4"	13/16"	7/8"	15/16"	1"
1 7/16	.3624	.....	.....	.....	.....	.....	.....
1 1/2	.3801	.....	.....	.....	.....	.....	.....
1 5/8	.4169	.....	.....	.....	.....	.....	.....
1 3/4	.4550	.....	.....	.....	.....	.....	.....
1 7/8	.4941	.....	.....	.....	.....	.....	.....
2	.5340	.....	.....	.....	.....	.....	.....
2 1/8	.5745	.5633	.5537	.5457	.5394	.5349	.5321
2 1/4	.6155	.6036	.5929	.5837	.5762	.5702	.5659
2 3/8	.6569	.6442	.6327	.6226	.6139	.6067	.6011
2 1/2	.6987	.6853	.6731	.6621	.6525	.6442	.6373
2 5/8	.7408	.7268	.7139	.7022	.6917	.6825	.6745
2 3/4	.7831	.7686	.7551	.7428	.7315	.7214	.7126

RADIUS OF GYRATION, R, FOR NEUTRAL AXIS THROUGH CENTER OF SECTION (Concluded)

Outside Diameter Inches	THICKNESS IN FRACTIONS OF AN INCH						
	5/8"	11/16"	3/4"	13/16"	7/8"	15/16"	1"
2 3/8	.8256	.8106	.7967	.7837	.7718	.7609	.7513
3	.8682	.8529	.8385	.8250	.8125	.8010	.7905
3 1/8	.9110	.8954	.8805	.8665	.8535	.8414	.8303
3 1/4	.9540	.9380	.9228	.9084	.8948	.8822	.8705
3 3/8	.9970	.9807	.9652	.9504	.9364	.9233	.9110
3 1/2	1.0402	1.0236	1.0077	.9926	.9782	.9647	.9519
3 5/8	1.0834	1.0666	1.0504	1.0350	1.0203	1.0063	.9931
3 3/4	1.1267	1.1097	1.0933	1.0775	1.0625	1.0481	1.0345
3 7/8	1.1701	1.1528	1.1362	1.1202	1.1048	1.0901	1.0761
4	1.2135	1.1961	1.1792	1.1629	1.1473	1.1323	1.1180
4 1/8	1.2570	1.2394	1.2223	1.2058	1.1899	1.1746	1.1600
4 1/4	1.3005	1.2827	1.2655	1.2488	1.2326	1.2171	1.2022
4 3/8	1.3441	1.3261	1.3087	1.2918	1.2755	1.2597	1.2445
4 1/2	1.3877	1.3696	1.3520	1.3350	1.3184	1.3024	1.2869
4 5/8	1.4313	1.4131	1.3954	1.3781	1.3614	1.3452	1.3295
4 3/4	1.4750	1.4567	1.4388	1.4214	1.4045	1.3880	1.3721
4 7/8	1.5187	1.5003	1.4823	1.4647	1.4476	1.4310	1.4149
5	1.5625	1.5439	1.5258	1.5081	1.4908	1.4740	1.4577
5 1/8	1.6062	1.5876	1.5693	1.5515	1.5341	1.5171	1.5006
5 1/4	1.6500	1.6312	1.6129	1.5949	1.5774	1.5603	1.5436
5 3/8	1.6938	1.6750	1.6565	1.6384	1.6207	1.6035	1.5866
5 1/2	1.7376	1.7187	1.7001	1.6819	1.6641	1.6467	1.6298
5 3/4	1.8253	1.8062	1.7875	1.7691	1.7511	1.7334	1.7161
6	1.9131	1.8939	1.8750	1.8564	1.8381	1.8202	1.8027
6 1/4	2.0009	1.9816	1.9625	1.9437	1.9253	1.9072	1.8895
6 1/2	2.0888	2.0693	2.0501	2.0312	2.0126	1.9943	1.9764
6 3/4	2.1767	2.1571	2.1378	2.1187	2.1000	2.0815	2.0634
7	2.2647	2.2450	2.2255	2.2063	2.1875	2.1688	2.1505
7 1/4	2.3526	2.3328	2.3133	2.2940	2.2750	2.2562	2.2378
7 1/2	2.4407	2.4208	2.4011	2.3817	2.3626	2.3437	2.3251
7 3/4	2.5287	2.5087	2.4890	2.4695	2.4502	2.4312	2.4125
8	2.6168	2.5967	2.5769	2.5573	2.5379	2.5188	2.5000
8 1/4	2.7048	2.6847	2.6648	2.6451	2.6257	2.6065	2.5875
8 1/2	2.7929	2.7728	2.7528	2.7330	2.7135	2.6942	2.6751
8 3/4	2.8811	2.8608	2.8408	2.8209	2.8013	2.7819	2.7627
9	2.9692	2.9489	2.9288	2.9089	2.8892	2.8697	2.8504
9 1/4	3.0578	3.0374	3.0173	2.9973	2.9775	2.9579	2.9385
9 1/2	3.1459	3.1256	3.1053	3.0853	3.0654	3.0458	3.0263
9 3/4	3.2341	3.2137	3.1934	3.1733	3.1534	3.1337	3.1141
10	3.3223	3.3018	3.2815	3.2614	3.2414	3.2216	3.2020
10 1/4	3.4105	3.3900	3.3698	3.3494	3.3294	3.3095	3.2898
10 1/2	3.4988	3.4782	3.4578	3.4375	3.4175	3.3975	3.3777
10 3/4	3.5870	3.5664	3.5459	3.5256	3.5055	3.4855	3.4657
11	3.6752	3.6546	3.6341	3.6137	3.5935	3.5735	3.5536
11 1/4	3.7635	3.7428	3.7222	3.7018	3.6816	3.6615	3.6416
11 1/2	3.8517	3.8310	3.8104	3.7900	3.7698	3.7496	3.7296
11 3/4	3.9400	3.9192	3.8986	3.8781	3.8578	3.8376	3.8176
12	4.0282	4.0075	3.9868	3.9663	3.9459	3.9257	3.9056
12 1/4	4.1165	4.0957	4.0750	4.0545	4.0341	4.0138	3.9937
12 1/2	4 2048	4.1840	4 1632	4 1427	4.1222	4 1019	4 0817
12 3/4	4.2931	4.2722	4.2515	4.2308	4.2104	4.1900	4.1698
13	4.3814	4.3605	4.3397	4.3191	4.2985	4.2781	4.2579
13 1/4	4.4697	4.4488	4.4280	4.4073	4.3867	4.3663	4.3460
13 1/2	4.5579	4.5370	4.5162	4.4955	4.4749	4.4544	4.4340
13 3/4	4.6463	4.6253	4.6044	4.5837	4.5631	4.5426	4.5222
14	4.7345	4.7136	4.6927	4.6719	4.6513	4.6308	4.6104

WEIGHTS OF SOLID ROUND STEEL BARS

BASED ON 1 CUBIC INCH STEEL = .2833 POUND

Diameter in Inches	Weight in Pounds		Cross Sectional Area	Circumference
	One Inch	One Foot	Square Inches	Inches
1/8	.0035	.0417	.0123	.3927
1/4	.0139	.1669	.0491	.7854
3/8	.0313	.3755	.1104	1.1781
1/2	.0556	.6675	.1964	1.5708
5/8	.0869	1.0430	.3068	1.9635
3/4	.1252	1.5019	.4418	2.3562
7/8	.1704	2.0442	.6013	2.7489
1	.2225	2.6700	.7854	3.1416
1 1/8	.2816	3.3793	.9940	3.5343
1 1/4	.3477	4.1719	1.2272	3.9270
1 3/8	.4207	5.0480	1.4849	4.3197
1 1/2	.5006	6.0076	1.7672	4.7124
1 5/8	.5875	7.0506	2.0739	5.1051
1 3/4	.6814	8.1770	2.4053	5.4978
1 7/8	.7822	9.3869	2.7612	5.8905
2	.8900	10.6801	3.1416	6.2832
2 1/8	1.0047	12.0569	3.5466	6.6759
2 1/4	1.1264	13.5171	3.9761	7.0686
2 3/8	1.2551	15.0607	4.4301	7.4613
2 1/2	1.3906	16.6877	4.9088	7.8540
2 5/8	1.5332	18.3982	5.4119	8.2467
2 3/4	1.6827	20.1922	5.9396	8.6394
2 7/8	1.8391	22.0695	6.4918	9.0321
3	2.0025	24.0304	7.0686	9.4248
3 1/8	2.1729	26.0746	7.6699	9.8175
3 1/4	2.3502	28.2020	8.2958	10.2102
3 3/8	2.5345	30.4134	8.9462	10.6029
3 1/2	2.7257	32.7080	9.6212	10.9956
3 5/8	2.9239	35.0860	10.3206	11.3883
3 3/4	3.1289	37.5474	11.0447	11.7810
3 7/8	3.3410	40.0923	11.7933	12.1737
4	3.5601	42.7206	12.5664	12.5664
4 1/8	3.7860	45.4324	13.3641	12.9591
4 1/4	4.0190	48.2276	14.1863	13.3518
4 3/8	4.2589	51.1062	15.0330	13.7445
4 1/2	4.5057	54.0683	15.9044	14.1372
4 5/8	4.7595	57.1138	16.8002	14.5299
4 3/4	5.0202	60.2428	17.7206	14.9226
4 7/8	5.2879	63.4552	18.6655	15.3153
5	5.5626	66.7510	19.6350	15.7080
5 1/8	5.8442	70.1303	20.6290	16.1007

WEIGHTS OF SOLID ROUND STEEL BARS (Concluded)
BASED ON 1 CUBIC INCH STEEL = .2833 POUND

Diameter in Inches	Weight in Pounds		Cross Sectional Area	Circumference
	One Inch	One Foot	Square Inches	Inches
5 1/4	6.1327	73.5930	21.6476	16.4934
5 3/8	6.4283	77.1391	22.6907	16.8861
5 1/2	6.7307	80.7687	23.7584	17.2788
5 5/8	7.0401	84.4812	24.8505	17.6715
5 3/4	7.3565	88.2782	25.9673	18.0642
5 7/8	7.6798	92.1581	27.1086	18.4569
6	8.0101	96.1214	28.2744	18.8495
6 1/8	8.3474	100.1682	29.4648	19.2423
6 1/4	8.6915	104.2984	30.6797	19.6350
6 3/8	9.0427	108.5121	31.9191	20.0277
6 1/2	9.4008	112.8092	33.1832	20.4204
6 5/8	9.7658	117.1897	34.4717	20.8131
6 3/4	10.1378	121.6537	35.7848	21.2058
6 7/8	10.5168	126.2011	37.1224	21.5984
7	10.9027	130.8319	38.4848	21.9911
7 1/8	11.2955	135.5462	39.8713	22.3838
7 1/4	11.6953	140.3440	41.2826	22.7765
7 3/8	12.1021	145.2251	42.7184	23.1692
7 1/2	12.5158	150.1897	44.1788	23.5619
7 5/8	12.9365	155.2378	45.6636	23.9546
7 3/4	13.3641	160.3690	47.1731	24.3473
7 7/8	13.7987	165.5842	48.7071	24.7400
8	14.2402	170.8826	50.2656	25.1327
8 1/8	14.6887	176.2643	51.8487	25.5254
8 1/4	15.1441	181.7296	53.4563	25.9181
8 3/8	15.6065	187.2782	55.0884	26.3108
8 1/2	16.0759	192.9104	56.7452	26.7035
8 5/8	16.5522	198.6259	58.4264	27.0962
8 3/4	17.0354	204.4249	60.1322	27.4889
8 7/8	17.5256	210.3073	61.8625	27.8816
9	18.0228	216.2732	63.6174	28.2743
9 1/8	18.5269	222.3225	65.3968	28.6670
9 1/4	19.0379	228.4553	67.2008	29.0597
9 3/8	19.5551	234.6614	69.0293	29.4524
9 1/2	20.0809	240.9711	70.8824	29.8451
9 5/8	20.6128	247.3541	72.7599	30.2378
9 3/4	21.1517	253.8207	74.6621	30.6305
9 7/8	21.6975	260.3705	76.5888	31.0232
10	22.2503	267.0039	78.5400	31.4159

METRIC SYSTEM

Since the metric system was first adopted in France, 1799, its use has become general throughout the world with the exception of the United States and Great Britain, although it is now legal in these countries. For scientific purposes the metric system is used almost exclusively.

The unit of length—the fundamental unit of the system—is the *meter*, which was legally established in the United States in 1866 as being equivalent to 39.37".

The unit of weight is the *gram*, or 1/1000 of the weight of a liter of water at 4 °C.

The unit of capacity is the *liter*, whose volume equals that of a cube with sides of 1/10 meter.

All other units of the metric system are multiples or decimals of these three units and are designated by the prefixes:

Milli.....meaning $\frac{1}{1000}$ or .001

Centi.....meaning $\frac{1}{100}$ or .01

Deci.....meaning $\frac{1}{10}$ or .1

Deka.....meaning 10
Hecto.....meaning 100
Kilo.....meaning 1000

Following are tables of metric units and their corresponding English equivalents.

U. S. System			Metrical System		
MEASURES OF LENGTH					
12 inches	=	1 foot	1 meter (m)	=	39.37 inches 3.2808 feet 1.0936 yards
3 feet	=	1 yard			
2 yards	=	1 fathom	1 centimeter (cm)	=	0.3937 inch
5½ yards	=	1 rod	1 millimeter (mm)	=	0.03937 inch
1760 yards 5280 feet 320 rods	=	1 statute mile	1 kilometer (km)	=	3280.8 feet 1093.6 yards 0.6214 statute mile
6080 feet	=	1 nautical mile or knot	2.54 centimeters	=	1 inch
3 nautical miles	=	1 league	0.3048 meter	=	1 foot
			0.9144 meter	=	1 yard
			1.609 kilometers	=	1 statute mile
MEASURES OF SURFACE					
144 square inches	=	1 square foot	1 square meter	=	10.7638 sq. ft. 1.1959 sq. yds.
9 square feet	=	1 square yard			
30¼ square yards	=	1 square rod	1 sq. centimeter	=	0.155 sq. in.
43,560 square feet	=	1 acre	1 sq. millimeter	=	0.00155 sq. in.
640 acres	=	1 square mile	1 hectare	=	2.47 acres
			1 sq. kilometer	=	247.11 acres

6.45 sq. centimeters 645 sq. millimeters	=	1 sq. inch
0.0929 sq. meter	=	1 sq. foot
0.836 sq. meter	=	1 sq. yard
0.405 hectare	=	1 acre
2.5899 sq. kilometers	=	1 sq. mile

METRIC SYSTEM (Continued)

U. S. System		Metrical System

MEASURES OF VOLUME

Liquid Measures

4 gills	= 1 pint			
2 pints	= 1 quart			
4 quarts	= 1 gallon	1 liter (lr)	=	1.057 U. S. liquid quarts
1 U. S. gallon	= 231 cu. in.	1 cubic decimeter	=	0.2642 U. S. liquid gallon
1 British gallon	= 277.274 cu. in. = 1.200 U. S. gal.			2.202 lbs. water at 62°F.

Dry Measure

2 pints	= 1 quart			
8 quarts	= 1 peck			
4 pecks	= 1 bushel	1 liter	=	0.908 U. S. quart
1 Standard U. S. bushel	= 2150.42 cu. in. = 1.2445 cu. ft.	1.101 liters	=	1 U. S. quart
1 British Imperial bushel	= 2218.19 cu. in. = 1.2837 cu. ft.			

CUBIC MEASURES

Cubic Measures

1728 cubic inches	= 1 cubic foot	1 cubic meter	=	35.314 cu. ft. = 1.308 cu. yds.
27 cubic feet	= 1 cubic yard	1 cubic centimeter	=	0.061 cu. inch
		1 milliliter		
		1 cubic decimeter	=	61.023 cu. in. = 0.035 cu. foot

16.387 cu. centimeters	=	1 cubic inch
28.32 cu. decimeters	=	1 cubic foot
0.028 cubic meter		
0.765 cubic meter	=	1 cubic yard

MEASURES OF WEIGHT

Avoirdupois

437.5 grains	= 1 ounce, oz.	1 gram (gm)	=	15.432 grains = 0.035 avoir. ounce = 0.032 troy ounce
1 ounce avoir.	= 0.912 troy ounce	1 kilogram (kg)	=	2.2046 avoir. lb. = 2.679 troy pounds
16 ounces = 7000 grains	= 1 pound, lb.	1000 kilograms or 1 metric ton	=	2204.6 pounds = 0.984 long ton = 1.102 short tons
1 pound avoir.	= 1.217 troy pounds	0.065 gram	=	1 grain
28 pounds	= 1 quarter, qr.	28.35 grams	=	1 avoir. ounce
4 quarters or 112 lbs.	= 1 hundredweight, cwt.	31.10 grams	=	1 troy ounce
20 cwt. or 2240 lbs.	= 1 gross or long ton	0.454 kilogram	=	1 avoir. pound
2000 lbs.	= 1 net or short ton	0.373 kilogram	=	1 troy pound
2204.6 lbs.	= 1 metric ton	1.016 metric tons	=	1 gross or long ton
		0.907 metric ton	=	1 net or short ton

Apothecaries

20 grains	= 1 scruple			**Troy**
3 scruples	= 1 drachm	24 grains	=	1 pennyweight, dwt.
8 drachms	= 1 ounce = 480 grains	20 pennyweight or 480 grains	=	1 ounce, oz.
12 ounces	= 1 pound = 5760 grains	1 ounce troy	=	1.097 avoir. ounces
		12 ounces or 5760 grains	=	1 pound, lb.
		1 pound troy	=	0.822 avoir. pound

METRIC SYSTEM (Concluded)

COMPOUND UNITS OF MEASURE

Metric to U. S. System

1 gram per sq. millimeter	=	1.422 lbs. per sq. inch
1 kilogram per sq. millimeter	=	1422.33 lbs. per sq. inch
1 kilogram per sq. centimeter	=	14.223 lbs. per sq. inch
1 gram per liter	=	0.06244 lb. per cubic foot 58.415 grains per U. S. gallon

U. S. to Metric System

1 pound per sq. inch	=	0.0703 kilogram per sq. centimeter
1 pound per sq. inch	=	0.703 gram per sq. millimeter
1 grain per U. S. gallon	=	0.017118 gram per liter 1.7118 parts per 100,000

Shipping Measure

40 cubic feet	=	1 U. S. shipping ton
42 cubic feet	=	1 British shipping ton

Circular Measure

60 seconds, ″	=	1 minute,
60 minutes, ′	=	1 degree, °
90 degrees, °	=	1 quadrant
4 quadrants or 360 degrees	=	1 circumference

MEASURES OF WORK, POWER AND HEAT

Foot-Pound: The unit of work or energy; equal to the work performed in raising one pound avoirdupois, one foot in height against the force of gravity.

1 kilogram-meter	=	7.233 foot-pounds
1 foot-pound	=	.1382 kilogram-meter

Horse Power: Measurement of the rate of work. The unit of horse power is 33,000 foot-pounds per minute, or 550 foot-pounds per second.

1 force de cheval	=	.9863 horse power

British Thermal Unit: (B.T.U.) is 1/180 of the amount of heat required to raise the temperature of one pound of water from 32°F. to 212°F. This heat unit is in general use in English speaking countries.

Calorie: (cal) is 1/100 of the heat required to raise the temperature of one gram of water from 0° to 100°C.

1 B.T.U.	=	0.252 calories
1 calorie	=	3.968 B.T.U.
1 B.T.U. per sq. foot	=	2.7126 calories per sq. meter
1 calorie per sq. meter	=	0.3686 B.T.U. per sq. foot

METRIC CONVERSION TABLES

MILLIMETERS TO DECIMALS OF AN INCH

Millimeters	Inches	Millimeters	Inches	Millimeters	Inches	Millimeters	Inches	Millimeters	Inches
1	.03937	21	.82677	41	1.61417	61	2.40157	81	3.18897
2	.07874	22	.86614	42	1.65354	62	2.44094	82	3.22834
3	.11811	23	.90551	43	1.69291	63	2.48031	83	3.26771
4	.15748	24	.94488	44	1.73228	64	2.51968	84	3.30708
5	.19685	25	.98425	45	1.77165	65	2.55905	85	3.34645
6	.23622	26	1.02362	46	1.81102	66	2.59842	86	3.38582
7	.27559	27	1.06299	47	1.85039	67	2.63779	87	3.42519
8	.31496	28	1.10236	48	1.88976	68	2.67716	88	3.46456
9	.35433	29	1.14173	49	1.92913	69	2.71653	89	3.50393
10	.39370	30	1.18110	50	1.96850	70	2.75590	90	3.54330
11	.43307	31	1.22047	51	2.00787	71	2.79527	91	3.58267
12	.47244	32	1.25984	52	2.04724	72	2.83464	92	3.62204
13	.51181	33	1.29921	53	2.08661	73	2.87401	93	3.66141
14	.55118	34	1.33858	54	2.12598	74	2.91338	94	3.70078
15	.59055	35	1.37795	55	2.16535	75	2.95275	95	3.74015
16	.62992	36	1.41732	56	2.20472	76	2.99212	96	3.77952
17	.66929	37	1.45669	57	2.24409	77	3.03149	97	3.81889
18	.70866	38	1.49606	58	2.28346	78	3.07086	98	3.85826
19	.74803	39	1.53543	59	2.32283	79	3.11023	99	3.89763
20	.78740	40	1.57480	60	2.36220	80	3.14960	100	3.93700

HUNDREDTHS OF AN INCH TO MILLIMETERS

Hundredths of an Inch	Millimeters	Hundredths of an Inch	Millimeters	Hundredths of an Inch	Millimeters	Hundredths of an Inch	Millimeters	Hundredths of an Inch	Millimeters
1	.254	21	5.334	41	10.414	61	15.494	81	20.574
2	.508	22	5.588	42	10.668	62	15.748	82	20.828
3	.762	23	5.842	43	10.922	63	16.002	83	21.082
4	1.016	24	6.096	44	11.176	64	16.256	84	21.336
5	1.270	25	6.350	45	11.430	65	16.510	85	21.590
6	1.524	26	6.604	46	11.684	66	16.764	86	21.844
7	1.778	27	6.858	47	11.938	67	17.018	87	22.098
8	2.032	28	7.112	48	12.192	68	17.272	88	22.352
9	2.286	29	7.366	49	12.446	69	17.526	89	22.606
10	2.540	30	7.620	50	12.700	70	17.780	90	22.860
11	2.794	31	7.874	51	12.954	71	18.034	91	23.114
12	3.048	32	8.128	52	13.208	72	18.288	92	23.368
13	3.302	33	8.382	53	13.462	73	18.542	93	23.622
14	3.556	34	8.636	54	13.716	74	18.796	94	23.876
15	3.810	35	8.890	55	13.970	75	19.050	95	24.130
16	4.064	36	9.144	56	14.224	76	19.304	96	24.384
17	4.318	37	9.398	57	14.478	77	19.558	97	24.638
18	4.572	38	9.652	58	14.732	78	19.812	98	24.892
19	4.826	39	9.906	59	14.986	79	20.066	99	25.146
20	5.080	40	10.160	60	15.240	80	20.320	100	25.400

METRIC CONVERSION TABLES (Continued)

POUNDS TO KILOGRAMS

Pounds	Kilograms	Pounds	Kilograms	Pounds	Kilograms	Pounds	Kilograms	Pounds	Kilograms
1	.4536	21	9.5254	41	18.5973	61	27.6691	81	36.7410
2	.9072	22	9.9790	42	19.0509	62	28.1227	82	37.1946
3	1.3608	23	10.4326	43	19.5045	63	28.5763	83	37.6482
4	1.8144	24	10.8862	44	19.9581	64	29.0299	84	38.1018
5	2.2680	25	11.3398	45	20.4117	65	29.4835	85	38.5554
6	2.7216	26	11.7934	46	20.8653	66	29.9371	86	39.0089
7	3.1751	27	12.2470	47	21.3188	67	30.3907	87	39.4625
8	3.6287	28	12.7006	48	21.7724	68	30.8443	88	39.9161
9	4.0823	29	13.1542	49	22.2260	69	31.2979	89	40.3697
10	4.5359	30	13.6078	50	22.6796	70	31.7515	90	40.8233
11	4.9895	31	14.0614	51	23.1332	71	32.2051	91	41.2769
12	5.4431	32	14.5150	52	23.5868	72	32.6587	92	41.7305
13	5.8967	33	14.9686	53	24.0404	73	33.1122	93	42.1841
14	6.3503	34	15.4221	54	24.4940	74	33.5658	94	42.6377
15	6.8039	35	15.8757	55	24.9476	75	34.0194	95	43.0913
16	7.2575	36	16.3293	56	25.4012	76	34.4730	96	43.5449
17	7.7111	37	16.7829	57	25.8548	77	34.9266	97	43.9985
18	8.1647	38	17.2365	58	26.3084	78	35.3802	98	44.4521
19	8.6183	39	17.6901	59	26.7620	79	35.8338	99	44.9057
20	9.0718	40	18.1437	60	27.2155	80	36.2874	100	45.3592

KILOGRAMS TO POUNDS

Kilograms	Pounds	Kilograms	Pounds	Kilograms	Pounds	Kilograms	Pounds	Kilograms	Pounds
1	2.2046	21	46.2971	41	9.0390	61	13.4482	81	17.8574
2	4.4092	22	48.5017	42	9.2594	62	13.6687	82	18.0779
3	6.6139	23	50.7063	43	9.4799	63	13.8891	83	18.2984
4	8.8185	24	52.9109	44	9.7003	64	14.1096	84	18.5188
5	11.0231	25	55.1156	45	9.9208	65	14.3300	85	18.7393
6	13.2277	26	57.3202	46	10.1413	66	14.5505	86	18.9598
7	15.4324	27	59.5248	47	10.3617	67	14.7710	87	19.1802
8	17.6370	28	61.7294	48	10.5822	68	14.9914	88	19.4007
9	19.8416	29	63.9340	49	10.8026	69	15.2119	89	19.6211
10	22.0462	30	66.1387	50	11.0231	70	15.4324	90	19.8416
11	24.2508	31	68.3433	51	11.2436	71	15.6528	91	20.0621
12	26.4555	32	70.5479	52	11.4640	72	15.8733	92	20.2825
13	28.6601	33	72.7525	53	11.6845	73	16.0937	93	20.5030
14	30.8647	34	74.9572	54	11.9050	74	16.3142	94	20.7234
15	33.0693	35	77.1618	55	12.1254	75	16.5347	95	20.9439
16	35.2740	36	79.3664	56	12.3459	76	16.7551	96	21.1644
17	37.4786	37	81.5710	57	12.5663	77	16.9756	97	21.3848
18	39.6832	38	83.7756	58	12.7868	78	17.1961	98	21.6053
19	41.8878	39	85.9803	59	13.0073	79	17.4165	99	21.8258
20	44.0924	40	88.1849	60	13.2277	80	17.6370	100	22.0462

METRIC CONVERSION TABLES (Concluded)

POUNDS PER SQUARE INCH TO KILOGRAMS PER SQUARE MILLIMETER

Pounds per Sq. Inch	Kilos per Sq. Mm.	Pounds per Sq. Inch	Kilos per Sq. Mm.	Pounds per Sq. Inch	Kilos per Sq. Mm.	Pounds per Sq. Inch	Kilos per Sq. Mm.	Pounds per Sq. Inch	Kilos per Sq. Mm.
100	.0703	14000	9.8429	36000	25.3104	58000	40.7779	80000	56.2453
200	.1406	15000	10.5460	37000	26.0135	59000	41.4809	81000	56.9484
300	.2109	16000	11.2491	38000	26.7165	60000	42.1840	82000	57.6515
400	.2812	17000	11.9521	39000	27.4196	61000	42.8871	83000	58.3545
500	.3515	18000	12.6552	40000	28.1227	62000	43.5901	84000	59.0576
600	.4218	19000	13.3583	41000	28.8257	63000	44.2932	85000	59.7607
700	.4921	20000	14.0613	42000	29.5288	64000	44.9963	86000	60.4637
800	.5625	21000	14.7644	43000	30.2319	65000	45.6993	87000	61.1668
900	.6328	22000	15.4675	44000	30.9349	66000	46.4024	88000	61.8699
1000	.7031	23000	16.1705	45000	31.6380	67000	47.1055	89000	62.5729
2000	1.4061	24000	16.8736	46000	32.3411	68000	47.8085	90000	63.2760
3000	2.1092	25000	17.5767	47000	33.0441	69000	48.5116	91000	63.9791
4000	2.8123	26000	18.2797	48000	33.7472	70000	49.2147	92000	64.6822
5000	3.5153	27000	18.9828	49000	34.4503	71000	49.9177	93000	65.3852
6000	4.2184	28000	19.6859	50000	35.1533	72000	50.6208	94000	66.0883
7000	4.9215	29000	20.3889	51000	35.8564	73000	51.3239	95000	66.7914
8000	5.6246	30000	21.0920	52000	36.5595	74000	52.0269	96000	67.4944
9000	6.3276	31000	21.7951	53000	37.2625	75000	52.7300	97000	68.1975
10000	7.0301	32000	22.4981	54000	37.9656	76000	53.4331	98000	68.9006
11000	7.7338	33000	23.2012	55000	38.6687	77000	54.1361	99000	69.6036
12000	8.4368	34000	23.9043	56000	39.3717	78000	54.8392	100000	70.3067
13000	9.1399	35000	24.6073	57000	40.0748	79000	55.5423	.....	.....

KILOGRAMS PER SQUARE MILLIMETER TO POUNDS PER SQUARE INCH

Kilos per Sq. Mm.	Pounds per Sq. Inch	Kilos per Sq. Mm.	Pounds per Sq. Inch	Kilos per Sq. Mm.	Pounds per Sq. Inch	Kilos per Sq. Mm.	Pounds per Sq. Inch	Kilos per Sq. Mm.	Pounds per Sq. Inch
1	1422	21	29869	41	58316	61	86763	81	115210
2	2845	22	31291	42	59738	62	88185	82	116632
3	4267	23	32714	43	61161	63	89607	83	118054
4	5689	24	34136	44	62583	64	91030	84	119477
5	7112	25	35558	45	64005	65	92452	85	120899
6	8534	26	36981	46	65428	66	93874	86	122321
7	9956	27	38403	47	66850	67	95297	87	123744
8	11379	28	39826	48	68272	68	96719	88	125166
9	12801	29	41248	49	69695	69	98141	89	126588
10	14223	30	42670	50	71117	70	99564	90	128011
11	15646	31	44093	51	72539	71	100986	91	129433
12	17068	32	45515	52	73962	72	102408	92	130855
13	18490	33	46937	53	75384	73	103831	93	132278
14	19913	34	48360	54	76806	74	105253	94	133700
15	21335	35	49782	55	78229	75	106675	95	135122
16	22757	36	51204	56	79651	76	108098	96	136545
17	24180	37	52627	57	81073	77	109520	97	137969
18	25602	38	54049	58	82496	78	110943	98	139389
19	27024	39	55471	59	83918	79	112365	99	140812
20	28447	40	56894	60	85340	80	113787	100	142234

HARDNESS CONVERSION TABLE

(Approximate)

Rockwell B	Brinell Number	Scleroscope	Rockwell C	Brinell Number	Scleroscope
1/16" Ball 100 kg. Load	10 mm. Ball 3000 kg. Load	Models C and D	120° Cone 150 kg. Load	10 mm. Ball 3000 kg. Load	Models C and D
40	80	15	10	175	28
42	82	15	12	184	29
44	85	16	14	193	30
46	87	16	16	202	31
48	89	16	18	216	33
50	92	16	20	228	35
52	95	17	22	234	37
54	97	17	24	246	39
56	100	17	26	259	41
58	102	18	28	273	43
60	105	18	30	288	45
62	108	18	32	304	48
64	112	18	34	322	50
66	115	19	36	342	52
68	119	19	38	363	56
70	124	20	40	385	59
72	128	20	42	416	63
74	132	20	44	433	65
76	137	21	46	452	67
78	142	21	48	473	70
80	148	22	50	494	72
82	154	23	52	516	74
84	160	24	54	540	76
86	167	25	56	564	79
88	175	28	58	591	81
90	184	29	60	620	83
92	193	30	62	655	85
94	202	31	64	680	88
96	216	33	66	723	92
98	228	35	68	770	94
100	234	37	70	820	98

TEMPERATURE CONVERSION TABLE

Fahrenheit to Centigrade

TEMPERATURE CENTIGRADE = 5/9 (TEMPERATURE FAHRENHEIT − 32)

F°	C°	F°	C°	F°	C°	F°	C°	F°	C°
−459.4	−273.00	410	210.00	910	487.77	1410	765.55	1910	1043.33
−400	−240.00	420	215.55	920	493.33	1420	771.11	1920	1048.88
−300	−184.44	430	221.11	930	498.88	1430	776.66	1930	1054.44
−200	−128.88	440	226.66	940	504.44	1440	782.22	1940	1060.00
−100	− 73.33	450	232.22	950	510.00	1450	787.77	1950	1065.55
− 50	− 45.55	460	237.77	960	515.55	1460	793.33	1960	1071.11
− 40	− 40.00	470	243.33	970	521.11	1470	798.88	1970	1076.66
− 30	− 34.44	480	248.88	980	526.66	1480	804.44	1980	1082.22
− 10	− 23.33	490	254.44	990	532.22	1490	810.00	1990	1087.77
0	− 17.77	500	260.00	1000	537.77	1500	815.55	2000	1093.33
10	− 12.22	510	265.55	1010	543.33	1510	821.11	2010	1098.88
20	− 6.66	520	271.11	1020	548.88	1520	826.66	2020	1104.44
30	− 1.11	530	276.66	1030	554.44	1530	832.22	2030	1110.00
40	4.44	540	282.22	1040	560.00	1540	837.77	2040	1115.55
50	10.00	550	287.77	1050	565.55	1550	843.33	2050	1121.11
60	15.55	560	293.33	1060	571.11	1560	848.88	2060	1126.66
70	21.11	570	298.88	1070	576.66	1570	854.44	2070	1132.22
80	26.66	580	304.44	1080	582.22	1580	860.00	2080	1137.77
90	32.22	590	310.00	1090	587.77	1590	865.55	2090	1143.33
100	37.77	600	315.55	1100	593.33	1600	871.11	2100	1148.88
110	43.33	610	321.11	1110	598.88	1610	876.66	2110	1154.44
120	48.88	620	326.66	1120	604.44	1620	882.22	2120	1160.00
130	54.44	630	332.22	1130	610.00	1630	887.77	2130	1165.55
140	60.00	640	337.77	1140	615.55	1640	893.33	2140	1171.11
150	65.55	650	343.33	1150	621.11	1650	898.88	2150	1176.66
160	71.11	660	348.88	1160	626.66	1660	904.44	2160	1182.22
170	76.66	670	354.44	1170	632.22	1670	910.00	2170	1187.77
180	82.22	680	360.00	1180	637.77	1680	915.55	2180	1193.33
190	87.77	690	365.55	1190	643.33	1690	921.11	2190	1198.99
200	93.33	700	371.11	1200	648.88	1700	926.66	2200	1204.44
210	98.88	710	376.66	1210	654.44	1710	932.22	2250	1232.22
220	104.44	720	382.22	1220	660.00	1720	937.77	2300	1260.00
230	110.00	730	387.77	1230	665.55	1730	943.33	2350	1287.77
240	115.55	740	393.33	1240	671.11	1740	948.88	2400	1315.55
250	121.11	750	398.88	1250	676.66	1750	954.44	2450	1343.33
260	126.66	760	404.44	1260	682.22	1760	960.00	2500	1371.11
270	132.22	770	410.00	1270	687.77	1770	965.55	2550	1398.88
280	137.77	780	415.55	1280	693.33	1780	971.11	2600	1426.66
290	143.33	790	421.11	1290	698.88	1790	976.66	2650	1454.44
300	148.88	800	426.66	1300	704.44	1800	982.22	2700	1482.22
310	154.44	810	432.22	1310	710.00	1810	987.77	2750	1510.00
320	160.00	820	437.77	1320	715.55	1820	993.33	2800	1537.77
330	165.55	830	443.33	1330	721.11	1830	998.88	2850	1565.55
340	171.11	840	448.88	1340	726.66	1840	1004.44	2900	1593.33
350	176.66	850	454.44	1350	732.22	1850	1010.00	2950	1621.11
360	182.22	860	460.00	1360	737.77	1860	1015.55	3000	1648.88
370	187.77	870	465.55	1370	743.33	1870	1021.11	3050	1676.66
380	193.33	880	471.11	1380	748.88	1880	1026.66	3100	1704.44
390	198.88	890	476.66	1390	754.44	1890	1032.22	3150	1732.22
400	204.44	900	482.22	1400	760.00	1900	1037.77	3200	1760.00

TEMPERATURE CONVERSION TABLE (Concluded)

Centigrade to Fahrenheit

TEMPERATURE FAHRENHEIT = 9/5 TEMPERATURE CENTIGRADE + 32

C°	F°	C°	F°	C°	F°	C°	F°	C°	F°
−273	−459.4	185	365	435	815	770	1418	1270	2318
−250	−418	190	374	440	824	780	1436	1280	2336
−200	−328	195	383	445	833	790	1454	1290	2354
−175	−283	200	392	450	842	800	1472	1300	2372
−150	−238	205	401	455	851	810	1490	1310	2390
−125	−193	210	410	460	860	820	1508	1320	2408
−100	−148	215	419	465	869	830	1526	1330	2426
− 75	−103	220	428	470	878	840	1544	1340	2444
− 50	− 58	225	437	475	887	850	1562	1350	2462
− 40	− 40	230	446	480	896	860	1580	1360	2480
− 30	− 22	235	455	485	905	870	1598	1370	2498
− 20	− 4	240	464	490	914	880	1616	1380	2516
− 10	14	245	473	495	923	890	1634	1390	2534
0	32	250	482	500	932	900	1652	1400	2552
5	41	255	491	505	941	910	1670	1410	2570
10	50	260	500	510	950	920	1688	1420	2588
15	59	265	509	515	959	930	1706	1430	2606
20	68	270	518	520	968	940	1724	1440	2624
25	77	275	527	525	977	950	1742	1450	2642
30	86	280	536	530	986	960	1760	1460	2660
35	95	285	545	535	995	970	1778	1470	2678
40	104	290	554	540	1004	980	1796	1480	2696
45	113	295	563	545	1013	990	1814	1490	2714
50	122	300	572	550	1022	1000	1832	1500	2732
55	131	305	581	555	1031	1010	1850	1510	2750
60	140	310	590	560	1040	1020	1868	1520	2768
65	149	315	599	565	1049	1030	1886	1530	2786
70	158	320	608	570	1058	1040	1904	1540	2804
75	167	325	617	575	1067	1050	1922	1550	2822
80	176	330	626	580	1076	1060	1940	1560	2840
85	185	335	635	585	1085	1070	1958	1570	2858
90	194	340	644	590	1094	1080	1976	1580	2876
95	203	345	653	595	1103	1090	1994	1590	2894
100	212	350	662	600	1112	1100	2012	1600	2912
105	221	355	671	610	1130	1110	2030	1610	2930
110	230	360	680	620	1148	1120	2048	1620	2948
115	239	365	689	630	1166	1130	2066	1630	2966
120	248	370	698	640	1184	1140	2084	1640	2984
125	257	375	707	650	1202	1150	2102	1650	3002
130	266	380	716	660	1220	1160	2120	1660	3020
135	275	385	725	670	1238	1170	2138	1670	3038
140	284	390	734	680	1256	1180	2156	1680	3056
145	293	395	743	690	1274	1190	2174	1690	3074
150	302	400	752	700	1292	1200	2192	1700	3092
155	311	405	761	710	1310	1210	2210	1720	3128
160	320	410	770	720	1328	1220	2228	1740	3164
165	329	415	779	730	1346	1230	2246	1760	3200
170	338	420	788	740	1364	1240	2264	1780	3236
175	347	425	797	750	1382	1250	2282	1800	3272
180	356	430	806	760	1400	1260	2300	2000	3632

FUNCTIONS OF NUMBERS, 1 to 49

No.	Square	Cube	Square Root	Cube Root	No. = Diameter	
					Circum.	Area
1	1	1	1.0000	1.0000	3.142	0.7854
2	4	8	1.4142	1.2599	6.283	3.1416
3	9	27	1.7321	1.4422	9.425	7.0686
4	16	64	2.0000	1.5874	12.566	12.5664
5	25	125	2.2361	1.7100	15.708	19.6350
6	36	216	2.4495	1.8171	18.850	28.2743
7	49	343	2.6458	1.9129	21.991	38.4845
8	64	512	2.8284	2.0000	25.133	50.2655
9	81	729	3.0000	2.0801	28.274	63.6173
10	100	1000	3.1623	2.1544	31.416	78.5398
11	121	1331	3.3166	2.2240	34.558	95.0332
12	144	1728	3.4641	2.2894	37.699	113.097
13	169	2197	3.6056	2.3513	40.841	132.732
14	196	2744	3.7417	2.4101	43.982	153.938
15	225	3375	3.8730	2.4662	47.124	176.715
16	256	4096	4.0000	2.5198	50.265	201.062
17	289	4913	4.1231	2.5713	53.407	226.980
18	324	5832	4.2426	2.6207	56.549	254.469
19	361	6859	4.3589	2.6684	59.690	283.529
20	400	8000	4.4721	2.7144	62.832	314.159
21	441	9261	4.5826	2.7589	65.973	346.361
22	484	10648	4.6904	2.8020	69.115	380.133
23	529	12167	4.7958	2.8439	72.257	415.476
24	576	13824	4.8990	2.8845	75.398	452.389
25	625	15625	5.0000	2.9240	78.540	490.874
26	676	17576	5.0990	2.9625	81.681	530.929
27	729	19683	5.1962	3.0000	84.823	572.555
28	784	21952	5.2915	3.0366	87.965	615.752
29	841	24389	5.3852	3.0723	91.106	660.520
30	900	27000	5.4772	3.1072	94.248	706.858
31	961	29791	5.5678	3.1414	97.389	754.768
32	1024	32768	5.6569	3.1748	100.53	804.248
33	1089	35937	5.7446	3.2075	103.67	855.299
34	1156	39304	5.8310	3.2396	106.81	907.920
35	1225	42875	5.9161	3.2711	109.96	962.113
36	1296	46656	6.0000	3.3019	113.10	1017.88
37	1369	50653	6.0828	3.3322	116.24	1075.21
38	1444	54872	6.1644	3.3620	119.38	1134.11
39	1521	59319	6.2450	3.3912	122.52	1194.59
40	1600	64000	6.3246	3.4200	125.66	1256.64
41	1681	68921	6.4031	3.4482	128.81	1320.25
42	1764	74088	6.4807	3.4760	131.95	1385.44
43	1849	79507	6.5574	3.5034	135.09	1452.20
44	1936	85184	6.6332	3.5303	138.23	1520.53
45	2025	91125	6.7082	3.5569	141.37	1590.43
46	2116	97336	6.7823	3.5830	144.51	1661.90
47	2209	103823	6.8557	3.6088	147.65	1734.94
48	2304	110592	6.9282	3.6342	150.80	1809.56
49	2401	117649	7.0000	3.6593	153.94	1885.74

FUNCTIONS OF NUMBERS, 50 to 99

No.	Square	Cube	Square Root	Cube Root	No. = Diameter	
					Circum.	Area
50	2500	125000	7.0711	3.6840	157.08	1963.50
51	2601	132651	7.1414	3.7084	160.22	2042.82
52	2704	140608	7.2111	3.7325	163.36	2123.72
53	2809	148877	7.2801	3.7563	166.50	2206.18
54	2916	157464	7.3485	3.7798	169.65	2290.22
55	3025	166375	7.4162	3.8030	172.79	2375.83
56	3136	175616	7.4833	3.8259	175.93	2463.01
57	3249	185193	7.5498	3.8485	179.07	2551.76
58	3364	195112	7.6158	3.8709	182.21	2642.08
59	3481	205379	7.6811	3.8930	185.35	2733.97
60	3600	216000	7.7460	3.9149	188.50	2827.43
61	3721	226981	7.8102	3.9365	191.64	2922.47
62	3844	238328	7.8740	3.9579	194.78	3019.07
63	3969	250047	7.9373	3.9791	197.92	3117.25
64	4096	262144	8.0000	4.0000	201.06	3216.99
65	4225	274625	8.0623	4.0207	204.20	3318.31
66	4356	287496	8.1240	4.0412	207.35	3421.19
67	4489	300763	8.1854	4.0615	210.49	3525.65
68	4624	314432	8.2462	4.0817	213.63	3631.68
69	4761	328509	8.3066	4.1016	216.77	3739.28
70	4900	343000	8.3666	4.1213	219.91	3848.45
71	5041	357911	8.4261	4.1408	223.05	3959.19
72	5184	373248	8.4853	4.1602	226.19	4071.50
73	5329	389017	8.5440	4.1793	229.34	4185.39
74	5476	405224	8.6023	4.1983	232.48	4300.84
75	5625	421875	8.6603	4.2172	235.62	4417.86
76	5776	438976	8.7178	4.2358	238.76	4536.46
77	5929	456533	8.7750	4.2543	241.90	4656.63
78	6084	474552	8.8318	4.2727	245.04	4778.36
79	6241	493039	8.8882	4.2908	248.19	4901.67
80	6400	512000	8.9443	4.3089	251.33	5026.55
81	6561	531441	9.0000	4.3267	254.47	5153.00
82	6724	551368	9.0554	4.3445	257.61	5281.02
83	6889	571787	9.1104	4.3621	260.75	5410.61
84	7056	592704	9.1652	4.3795	263.89	5541.77
85	7225	614125	9.2195	4.3968	267.04	5674.50
86	7396	636056	9.2736	4.4140	270.18	5808.80
87	7569	658503	9.3274	4.4310	273.32	5944.68
88	7744	681472	9.3808	4.4480	276.46	6082.12
89	7921	704969	9.4340	4.4647	279.60	6221.14
90	8100	729000	9.4868	4.4814	282.74	6361.73
91	8281	753571	9.5394	4.4979	285.88	6503.88
92	8464	778688	9.5917	4.5144	289.03	6647.61
93	8649	804357	9.6437	4.5307	292.17	6792.91
94	8836	830584	9.6954	4.5468	295.31	6939.78
95	9025	857375	9.7468	4.5629	298.45	7088.22
96	9216	884736	9.7980	4.5789	301.59	7238.23
97	9409	912673	9.8489	4.5947	304.73	7389.81
98	9604	941192	9.8995	4.6104	307.88	7542.96
99	9801	970299	9.9499	4.6261	311.02	7697.69

FUNCTIONS OF NUMBERS, 100 to 149

No.	Square	Cube	Square Root	Cube Root	No. = Diameter	
					Circum.	Area
100	10000	1000000	10.0000	4.6416	314.16	7853.98
101	10201	1030301	10.0499	4.6570	317.30	8011.85
102	10404	1061208	10.0995	4.6723	320.44	8171.28
103	10609	1092727	10.1489	4.6875	323.58	8332.29
104	10816	1124864	10.1980	4.7027	326.73	8494.87
105	11025	1157625	10.2470	4.7177	329.87	8659.01
106	11236	1191016	10.2956	4.7326	333.01	8824.73
107	11449	1225043	10.3441	4.7475	336.15	8992.02
108	11664	1259712	10.3923	4.7622	339.29	9160.88
109	11881	1295029	10.4403	4.7769	342.43	9331.32
110	12100	1331000	10.4881	4.7914	345.58	9503.32
111	12321	1367631	10.5357	4.8059	348.72	9676.89
112	12544	1404928	10.5830	4.8203	351.86	9852.03
113	12769	1442897	10.6301	4.8346	355.00	10028.7
114	12996	1481544	10.6771	4.8488	358.14	10207.0
115	13225	1520875	10.7238	4.8629	361.28	10386.9
116	13456	1560896	10.7703	4.8770	364.42	10568.3
117	13689	1601613	10.8167	4.8910	367.57	10751.3
118	13924	1643032	10.8628	4.9049	370.71	10935.9
119	14161	1685159	10.9087	4.9187	373.85	11122.0
120	14400	1728000	10.9545	4.9324	376.99	11309.7
121	14641	1771561	11.0000	4.9461	380.13	11499.0
122	14884	1815848	11.0454	4.9597	383.27	11689.9
123	15129	1860867	11.0905	4.9732	386.42	11882.3
124	15376	1906624	11.1355	4.9866	389.56	12076.3
125	15625	1953125	11.1803	5.0000	392.70	12271.8
126	15876	2000376	11.2250	5.0133	395.84	12469.0
127	16129	2048383	11.2694	5.0265	398.98	12667.7
128	16384	2097152	11.3137	5.0397	402.12	12868.0
129	16641	2146689	11.3578	5.0528	405.27	13069.8
130	16900	2197000	11.4018	5.0658	408.41	13273.2
131	17161	2248091	11.4455	5.0788	411.55	13478.2
132	17424	2299968	11.4891	5.0916	414.69	13684.8
133	17689	2352637	11.5326	5.1045	417.83	13892.9
134	17956	2406104	11.5758	5.1172	420.97	14102.6
135	18225	2460375	11.6190	5.1299	424.12	14313.9
136	18496	2515456	11.6619	5.1426	427.26	14526.7
137	18769	2571353	11.7047	5.1551	430.40	14741.1
138	19044	2628072	11.7473	5.1676	433.54	14957.1
139	19321	2685619	11.7898	5.1801	436.68	15174.7
140	19600	2744000	11.8322	5.1925	439.82	15393.8
141	19881	2803221	11.8743	5.2048	442.96	15614.5
142	20164	2863288	11.9164	5.2171	446.11	15836.8
143	20449	2924207	11.9583	5.2293	449.25	16060.6
144	20736	2985984	12.0000	5.2415	452.39	16286.0
145	21025	3048625	12.0416	5.2536	455.53	16513.0
146	21316	3112136	12.0830	5.2656	458.67	16741.5
147	21609	3176523	12.1244	5.2776	461.81	16971.7
148	21904	3241792	12.1655	5.2896	464.96	17203.4
149	22201	3307949	12.2066	5.3015	468.10	17436.6

FUNCTIONS OF NUMBERS, 150 to 199

No.	Square	Cube	Square Root	Cube Root	No. = Diameter	
					Circum.	Area
150	22500	3375000	12.2474	5.3133	471.24	17671.5
151	22801	3442951	12.2882	5.3251	474.38	17907.9
152	23104	3511808	12.3288	5.3368	477.52	18145.8
153	23409	3581577	12.3693	5.3485	480.66	18385.4
154	23716	3652264	12.4097	5.3601	483.81	18626.5
155	24025	3723875	12.4499	5.3717	486.95	18869.2
156	24336	3796416	12.4900	5.3832	490.09	19113.4
157	24649	3869893	12.5300	5.3947	493.23	19359.3
158	24964	3944312	12.5698	5.4061	496.37	19606.7
159	25281	4019679	12.6095	5.4175	499.51	19855.7
160	25600	4096000	12.6491	5.4288	502.65	20106.2
161	25921	4173281	12.6886	5.4401	505.80	20358.3
162	26244	4251528	12.7279	5.4514	508.94	20612.0
163	26569	4330747	12.7671	5.4626	512.08	20867.2
164	26896	4410944	12.8062	5.4737	515.22	21124.1
165	27225	4492125	12.8452	5.4848	518.36	21382.5
166	27556	4574296	12.8841	5.4959	521.50	21642.4
167	27889	4657463	12.9228	5.5069	524.65	21904.0
168	28224	4741632	12.9615	5.5178	527.79	22167.1
169	28561	4826809	13.0000	5.5288	530.93	22431.8
170	28900	4913000	13.0384	5.5397	534.07	22698.0
171	29241	5000211	13.0767	5.5505	537.21	22965.8
172	29584	5088448	13.1149	5.5613	540.35	23235.2
173	29929	5177717	13.1529	5.5721	543.50	23506.2
174	30276	5268024	13.1909	5.5828	546.64	23778.7
175	30625	5359375	13.2288	5.5934	549.78	24052.8
176	30976	5451776	13.2665	5.6041	552.92	24328.5
177	31329	5545233	13.3041	5.6147	556.06	24605.7
178	31684	5639752	13.3417	5.6252	559.20	24884.6
179	32041	5735339	13.3791	5.6357	562.35	25164.9
180	32400	5832000	13.4164	5.6462	565.49	25446.9
181	32761	5929741	13.4536	5.6567	568.63	25730.4
182	33124	6028568	13.4907	5.6671	571.77	26015.5
183	33489	6128487	13.5277	5.6774	574.91	26302.2
184	33856	6229504	13.5647	5.6877	578.05	26590.4
185	34225	6331625	13.6015	5.6980	581.19	26880.3
186	34596	6434856	13.6382	5.7083	584.34	27171.6
187	34969	6539203	13.6748	5.7185	587.48	27464.6
188	35344	6644672	13.7113	5.7287	590.62	27759.1
189	35721	6751269	13.7477	5.7388	593.76	28055.2
190	36100	6859000	13.7840	5.7489	596.90	28352.9
191	36481	6967871	13.8203	5.7590	600.04	28652.1
192	36864	7077888	13.8564	5.7690	603.19	28952.9
193	37249	7189057	13.8924	5.7790	606.33	29255.3
194	37636	7301384	13.9284	5.7890	609.47	29559.2
195	38025	7414875	13.9642	5.7989	612.61	29864.8
196	38416	7529536	14.0000	5.8088	615.75	30171.9
197	38809	7645373	14.0357	5.8186	618.89	30480.5
198	39204	7762392	14.0712	5.8285	622.04	30790.7
199	39601	7880599	14.1067	5.8383	625.18	31102.6

FUNCTIONS OF NUMBERS, 200 to 249

No.	Square	Cube	Square Root	Cube Root	No. = Diameter	
					Circum.	Area
200	40000	8000000	14.1421	5.8480	628.32	31415.9
201	40401	8120601	14.1774	5.8578	631.46	31730.9
202	40804	8242408	14.2127	5.8675	634.60	32047.4
203	41209	8365427	14.2478	5.8771	637.74	32365.5
204	41616	8489664	14.2829	5.8868	640.88	32685.1
205	42025	8615125	14.3178	5.8964	644.03	33006.4
206	42436	8741816	14.3527	5.9059	647.17	33329.2
207	42849	8869743	14.3875	5.9155	650.31	33653.5
208	43264	8998912	14.4222	5.9250	653.45	33979.5
209	43681	9129329	14.4568	5.9345	656.59	34307.0
210	44100	9261000	14.4914	5.9439	659.73	34636.1
211	44521	9393931	14.5258	5.9533	662.88	34966.7
212	44944	9528128	14.5602	5.9627	666.02	35298.9
213	45369	9663597	14.5945	5.9721	669.16	35632.7
214	45796	9800344	14.6287	5.9814	672.30	35968.1
215	46225	9938375	14.6629	5.9907	675.44	36305.0
216	46656	10077696	14.6969	6.0000	678.58	36643.5
217	47089	10218313	14.7309	6.0092	681.73	36983.6
218	47524	10360232	14.7648	6.0185	684.87	37325.3
219	47961	10503459	14.7986	6.0277	688.01	37668.5
220	48400	10648000	14.8324	6.0368	691.15	38013.3
221	48841	10793861	14.8661	6.0459	694.29	38359.6
222	49284	10941048	14.8997	6.0550	697.43	38707.6
223	49729	11089567	14.9332	6.0641	700.58	39057.1
224	50176	11239424	14.9666	6.0732	703.72	39408.1
225	50625	11390625	15.0000	6.0822	706.86	39760.8
226	51076	11543176	15.0333	6.0912	710.00	40115.0
227	51529	11697083	15.0665	6.1002	713.14	40470.8
228	51984	11852352	15.0997	6.1091	716.28	40828.1
229	52441	12008989	15.1327	6.1180	719.42	41187.1
230	52900	12167000	15.1658	6.1269	722.57	41547.6
231	53361	12326391	15.1987	6.1358	725.71	41909.6
232	53824	12487168	15.2315	6.1446	728.85	42273.3
233	54289	12649337	15.2643	6.1534	731.99	42638.5
234	54756	12812904	15.2971	6.1622	735.13	43005.3
235	55225	12977875	15.3297	6.1710	738.27	43373.6
236	55696	13144256	15.3623	6.1797	741.42	43743.5
237	56169	13312053	15.3948	6.1885	744.56	44115.0
238	56644	13481272	15.4272	6.1972	747.70	44488.1
239	57121	13651919	15.4596	6.2058	750.84	44862.7
240	57600	13824000	15.4919	6.2145	753.98	45238.9
241	58081	13997521	15.5242	6.2231	757.12	45616.7
242	58564	14172488	15.5563	6.2317	760.27	45996.1
243	59049	14348907	15.5885	6.2403	763.41	46377.0
244	59536	14526784	15.6205	6.2488	766.55	46759.5
245	60025	14706125	15.6525	6.2573	769.69	47143.5
246	60516	14886936	15.6844	6.2658	772.83	47529.2
247	61009	15069223	15.7162	6.2743	775.97	47916.4
248	61504	15252992	15.7480	6.2828	779.12	48305.1
249	62001	15438249	15.7797	6.2912	782.26	48695.5

FUNCTIONS OF NUMBERS, 250 to 299

No.	Square	Cube	Square Root	Cube Root	No. = Diameter	
					Circum.	Area
250	62500	15625000	15.8114	6.2996	785.40	49087.4
251	63001	15813251	15.8430	6.3080	788.54	49480.9
252	63504	16003008	15.8745	6.3164	791.68	49875.9
253	64009	16194277	15.9060	6.3247	794.82	50272.6
254	64516	16387064	15.9374	6.3330	797.96	50670.7
255	65025	16581375	15.9687	6.3413	801.11	51070.5
256	65536	16777216	16.0000	6.3496	804.25	51471.9
257	66049	16974593	16.0312	6.3579	807.39	51874.8
258	66564	17173512	16.0624	6.3661	810.53	52279.2
259	67081	17373979	16.0935	6.3743	813.67	52685.3
260	67600	17576000	16.1245	6.3825	816.81	53092.9
261	68121	17779581	16.1555	6.3907	819.96	53502.1
262	68644	17984728	16.1864	6.3988	823.10	53912.9
263	69169	18191447	16.2173	6.4070	826.24	54325.2
264	69696	18399744	16.2481	6.4151	829.38	54739.1
265	70225	18609625	16.2788	6.4232	832.52	55154.6
266	70756	18821096	16.3095	6.4312	835.66	55571.6
267	71289	19034163	16.3401	6.4393	838.81	55990.2
268	71824	19248832	16.3707	6.4473	841.95	56410.4
269	72361	19465109	16.4012	6.4553	845.09	56832.2
270	72900	19683000	16.4317	6.4633	848.23	57255.5
271	73441	19902511	16.4621	6.4713	851.37	57680.4
272	73984	20123648	16.4924	6.4792	854.51	58106.9
273	74529	20346417	16.5227	6.4872	857.65	58534.9
274	75076	20570824	16.5529	6.4951	860.80	58964.6
275	75625	20796875	16.5831	6.5030	863.94	59395.7
276	76176	21024576	16.6132	6.5108	867.08	59828.5
277	76729	21253933	16.6433	6.5187	870.22	60262.8
278	77284	21484952	16.6733	6.5265	873.36	60698.7
279	77841	21717639	16.7033	6.5343	876.50	61136.2
280	78400	21952000	16.7332	6.5421	879.65	61575.2
281	78961	22188041	16.7631	6.5499	882.79	62015.8
282	79524	22425768	16.7929	6.5577	885.93	62458.0
283	80089	22665187	16.8226	6.5654	889.07	62901.8
284	80656	22906304	16.8523	6.5731	892.21	63347.1
285	81225	23149125	16.8819	6.5808	895.35	63794.0
286	81796	23393656	16.9115	6.5885	898.50	64242.4
287	82369	23639903	16.9411	6.5962	901.64	64692.5
288	82944	23887872	16.9706	6.6039	904.78	65144.1
289	83521	24137569	17.0000	6.6115	907.92	65597.2
290	84100	24389000	17.0294	6.6191	911.06	66052.0
291	84681	24642171	17.0587	6.6267	914.20	66508.3
292	85264	24897088	17.0880	6.6343	917.35	66966.2
293	85849	25153757	17.1172	6.6419	920.49	67425.6
294	86436	25412184	17.1464	6.6494	923.63	67886.7
295	87025	25672375	17.1756	6.6569	926.77	68349.3
296	87616	25934336	17.2047	6.6644	929.91	68813.4
297	88209	26198073	17.2337	6.6719	933.05	69279.2
298	88804	26463592	17.2627	6.6794	936.19	69746.5
299	89401	26730899	17.2916	6.6869	939.34	70215.4

FUNCTIONS OF NUMBERS, 300 to 349

No.	Square	Cube	Square Root	Cube Root	No. = Diameter	
					Circum.	Area
300	90000	27000000	17.3205	6.6943	942.48	70685.8
301	90601	27270901	17.3494	6.7018	945.62	71157.9
302	91204	27543608	17.3781	6.7092	948.76	71631.5
303	91809	27818127	17.4069	6.7166	951.90	72106.6
304	92416	28094464	17.4356	6.7240	955.04	72583.4
305	93025	28372625	17.4642	6.7313	958.19	73061.7
306	93636	28652616	17.4929	6.7387	961.33	73541.5
307	94249	28934443	17.5214	6.7460	964.47	74023.0
308	94864	29218112	17.5499	6.7533	967.61	74506.0
309	95481	29503629	17.5784	6.7606	970.75	74990.6
310	96100	29791000	17.6068	6.7679	973.89	75476.8
311	96721	30080231	17.6352	6.7752	977.04	75964.5
312	97344	30371328	17.6635	6.7824	980.18	76453.8
313	97969	30664297	17.6918	6.7897	983.32	76944.7
314	98596	30959144	17.7200	6.7969	986.46	77437.1
315	99225	31255875	17.7482	6.8041	989.60	77931.1
316	99856	31554496	17.7764	6.8113	992.74	78426.7
317	100489	31855013	17.8045	6.8185	995.88	78923.9
318	101124	32157432	17.8326	6.8256	999.03	79422.6
319	101761	32461759	17.8606	6.8328	1002.2	79922.9
320	102400	32768000	17.8885	6.8399	1005.3	80424.8
321	103041	33076161	17.9165	6.8470	1008.5	80928.2
322	103684	33386248	17.9444	6.8541	1011.6	81433.2
323	104329	33698267	17.9722	6.8612	1014.7	81939.8
324	104976	34012224	18.0000	6.8683	1017.9	82448.0
325	105625	34328125	18.0278	6.8753	1021.0	82957.7
326	106276	34645976	18.0555	6.8824	1024.2	83469.0
327	106929	34965783	18.0831	6.8894	1027.3	83981.8
328	107584	35287552	18.1108	6.8964	1030.4	84496.3
329	108241	35611289	18.1384	6.9034	1033.6	85012.3
330	108900	35937000	18.1659	6.9104	1036.7	85529.9
331	109561	36264691	18.1934	6.9174	1039.9	86049.0
332	110224	36594368	18.2209	6.9244	1043.0	86569.7
333	110889	36926037	18.2483	6.9313	1046.2	87092.0
334	111556	37259704	18.2757	6.9382	1049.3	87615.9
335	112225	37595375	18.3030	6.9451	1052.4	88141.3
336	112896	37933056	18.3303	6.9521	1055.6	88668.3
337	113569	38272753	18.3576	6.9589	1058.7	89196.9
338	114244	38614472	18.3848	6.9658	1061.9	89727.0
339	114921	38958219	18.4120	6.9727	1065.0	90258.7
340	115600	39304000	18.4391	6.9795	1068.1	90792.0
341	116281	39651821	18.4662	6.9864	1071.3	91326.9
342	116964	40001688	18.4932	6.9932	1074.4	91863.3
343	117649	40353607	18.5203	7.0000	1077.6	92401.3
344	118336	40707584	18.5472	7.0068	1080.7	92940.9
345	119025	41063625	18.5742	7.0136	1083.8	93482.0
346	119716	41421736	18.6011	7.0203	1087.0	94024.7
347	120409	41781923	18.6279	7.0271	1090.1	94569.0
348	121104	42144192	18.6548	7.0338	1093.3	95114.9
349	121801	42508549	18.6815	7.0406	1096.4	95662.3

FUNCTIONS OF NUMBERS, 350 to 399

No.	Square	Cube	Square Root	Cube Root	No. = Diameter	
					Circum.	Area
350	122500	42875000	18.7083	7.0473	1099.6	96211.3
351	123201	43243551	18.7350	7.0540	1102.7	96761.8
352	123904	43614208	18.7617	7.0607	1105.8	97314.0
353	124609	43986977	18.7883	7.0674	1109.0	97867.7
354	125316	44361864	18.8149	7.0740	1112.1	98423.0
355	126025	44738875	18.8414	7.0807	1115.3	98979.8
356	126736	45118016	18.8680	7.0873	1118.4	99538.2
357	127449	45499293	18.8944	7.0940	1121.5	100098
358	128164	45882712	18.9209	7.1006	1124.7	100660
359	128881	46268279	18.9473	7.1072	1127.8	101223
360	129600	46656000	18.9739	7.1138	1131.0	101788
361	130321	47045881	19.0000	7.1204	1134.1	102354
362	131044	47437928	19.0263	7.1269	1137.3	102922
363	131769	47832147	19.0526	7.1335	1140.4	103491
364	132496	48228544	19.0788	7.1400	1143.5	104062
365	133225	48627125	19.1050	7.1466	1146.7	104635
366	133956	49027896	19.1311	7.1531	1149.8	105209
367	134689	49430863	19.1572	7.1596	1153.0	105785
368	135424	49836032	19.1833	7.1661	1156.1	106362
369	136161	50243409	19.2094	7.1726	1159.2	106941
370	136900	50653000	19.2354	7.1791	1162.4	107521
371	137641	51064811	19.2614	7.1855	1165.5	108103
372	138384	51478848	19.2873	7.1920	1168.7	108687
373	139129	51895117	19.3132	7.1984	1171.8	109272
374	139876	52313624	19.3391	7.2048	1175.0	109858
375	140625	52734375	19.3649	7.2112	1178.1	110447
376	141376	53157376	19.3907	7.2177	1181.2	111036
377	142129	53582633	19.4165	7.2240	1184.4	111628
378	142884	54010152	19.4422	7.2304	1187.5	112221
379	143641	54439939	19.4679	7.2368	1190.7	112815
380	144400	54872000	19.4936	7.2432	1193.8	113411
381	145161	55306341	19.5192	7.2495	1196.9	114009
382	145924	55742968	19.5448	7.2558	1200.1	114608
383	146689	56181887	19.5704	7.2622	1203.2	115209
384	147456	56623104	19.5959	7.2685	1206.4	115812
385	148225	57066625	19.6214	7.2748	1209.5	116416
386	148996	57512456	19.6469	7.2811	1212.7	117021
387	149769	57960603	19.6723	7.2874	1215.8	117628
388	150544	58411072	19.6977	7.2936	1218.9	118237
389	151321	58863869	19.7231	7.2999	1222.1	118847
390	152100	59319000	19.7484	7.3061	1225.2	119459
391	152881	59776471	19.7737	7.3124	1228.4	120072
392	153664	60236288	19.7990	7.3186	1231.5	120687
393	154449	60698457	19.8242	7.3248	1234.6	121304
394	155236	61162984	19.8494	7.3310	1237.8	121922
395	156025	61629875	19.8746	7.3372	1240.9	122542
396	156816	62099136	19.8997	7.3434	1244.1	123163
397	157609	62570773	19.9249	7.3496	1247.2	123786
398	158404	63044792	19.9499	7.3558	1250.4	124410
399	159201	63521199	19.9750	7.3619	1253.5	125036

FUNCTIONS OF NUMBERS, 400 to 449

No.	Square	Cube	Square Root	Cube Root	No. = Diameter	
					Circum.	Area
400	160000	64000000	20.0000	7.3681	1256.6	125664
401	160801	64481201	20.0250	7.3742	1259.8	126293
402	161604	64964808	20.0499	7.3803	1262.9	126923
403	162409	65450827	20.0749	7.3864	1266.1	127556
404	163216	65939264	20.0998	7.3925	1269.2	128190
405	164025	66430125	20.1246	7.3986	1272.3	128825
406	164836	66923416	20.1494	7.4047	1275.5	129462
407	165649	67419143	20.1742	7.4108	1278.6	130100
408	166464	67917312	20.1990	7.4169	1281.8	130741
409	167281	68417929	20.2237	7.4229	1284.9	131382
410	168100	68921000	20.2485	7.4290	1288.1	132025
411	168921	69426531	20.2731	7.4350	1291.2	132670
412	169744	69934528	20.2978	7.4410	1294.3	133317
413	170569	70444997	20.3224	7.4470	1297.5	133965
414	171396	70957944	20.3470	7.4530	1300.6	134614
415	172225	71473375	20.3715	7.4590	1303.8	135265
416	173056	71991296	20.3961	7.4650	1306.9	135918
417	173889	72511713	20.4206	7.4710	1310.0	136572
418	174724	73034632	20.4450	7.4770	1313.2	137228
419	175561	73560059	20.4695	7.4829	1316.3	137885
420	176400	74088000	20.4939	7.4889	1319.5	138544
421	177241	74618461	20.5183	7.4948	1322.6	139205
422	178084	75151448	20.5426	7.5007	1325.8	139867
423	178929	75686967	20.5670	7.5067	1328.9	140531
424	179776	76225024	20.5913	7.5126	1332.0	141196
425	180625	76765625	20.6155	7.5185	1335.2	141863
426	181476	77308776	20.6398	7.5244	1338.3	142531
427	182329	77854483	20.6640	7.5302	1341.5	143201
428	183184	78402752	20.6882	7.5361	1344.6	143872
429	184041	78953589	20.7123	7.5420	1347.7	144545
430	184900	79507000	20.7364	7.5478	1350.9	145220
431	185761	80062991	20.7605	7.5537	1354.0	145896
432	186624	80621568	20.7846	7.5595	1357.2	146574
433	187489	81182737	20.8087	7.5654	1360.3	147254
434	188356	81746504	20.8327	7.5712	1363.5	147934
435	189225	82312875	20.8567	7.5770	1366.6	148617
436	190096	82881856	20.8806	7.5828	1369.7	149301
437	190969	83453453	20.9045	7.5886	1372.9	149987
438	191844	84027672	20.9284	7.5944	1376.0	150674
439	192721	84604519	20.9523	7.6001	1379.2	151363
440	193600	85184000	20.9762	7.6059	1382.3	152053
441	194481	85766121	21.0000	7.6117	1385.4	152745
442	195364	86350888	21.0238	7.6174	1388.6	153439
443	196249	86938307	21.0476	7.6232	1391.7	154134
444	197136	87528384	21.0713	7.6289	1394.9	154830
445	198025	88121125	21.0950	7.6346	1398.0	155528
446	198916	88716536	21.1187	7.6403	1401.2	156228
447	199809	89314623	21.1424	7.6460	1404.3	156930
448	200704	89915392	21.1660	7.6517	1407.4	157633
449	201601	90518849	21.1896	7.6574	1410.6	158337

FUNCTIONS OF NUMBERS, 450 to 499

No.	Square	Cube	Square Root	Cube Root	No. = Diameter	
					Circum.	Area
450	202500	91125000	21.2132	7.6631	1413.7	159043
451	203401	91733851	21.2368	7.6688	1416.9	159751
452	204304	92345408	21.2603	7.6744	1420.0	160460
453	205209	92959677	21.2838	7.6801	1423.1	161171
454	206116	93576664	21.3073	7.6857	1426.3	161883
455	207025	94196375	21.3307	7.6914	1429.4	162597
456	207936	94818816	21.3542	7.6970	1432.6	163313
457	208849	95443993	21.3776	7.7026	1435.7	164030
458	209764	96071912	21.4009	7.7082	1438.8	164748
459	210681	96702579	21.4243	7.7138	1442.0	165468
460	211600	97336000	21.4476	7.7194	1445.1	166190
461	212521	97972181	21.4709	7.7250	1448.3	166914
462	213444	98611128	21.4942	7.7306	1451.4	167639
463	214369	99252847	21.5174	7.7362	1454.6	168365
464	215296	99897344	21.5407	7.7418	1457.7	169093
465	216225	100544625	21.5639	7.7473	1460.8	169823
466	217156	101194696	21.5870	7.7529	1464.0	170554
467	218089	101847563	21.6102	7.7584	1467.1	171287
468	219024	102503232	21.6333	7.7639	1470.3	172021
469	219961	103161709	21.6564	7.7695	1473.4	172757
470	220900	103823000	21.6795	7.7750	1476.5	173494
471	221841	104487111	21.7025	7.7805	1479.7	174234
472	222784	105154048	21.7256	7.7860	1482.8	174974
473	223729	105823817	21.7486	7.7915	1486.0	175716
474	224676	106496424	21.7715	7.7970	1489.1	176460
475	225625	107171875	21.7945	7.8025	1492.3	177205
476	226576	107850176	21.8174	7.8079	1495.4	177952
477	227529	108531333	21.8403	7.8134	1498.5	178701
478	228484	109215352	21.8632	7.8188	1501.7	179451
479	229441	109902239	21.8861	7.8243	1504.8	180203
480	230400	110592000	21.9089	7.8297	1508.0	180956
481	231361	111284641	21.9317	7.8352	1511.1	181711
482	232324	111980168	21.9545	7.8406	1514.2	182467
483	233289	112678587	21.9773	7.8460	1517.4	183225
484	234256	113379904	22.0000	7.8514	1520.5	183984
485	235225	114084125	20.0227	7.8568	1523.7	184745
486	236196	114791256	22.0454	7.8622	1526.8	185508
487	237169	115501303	22.0681	7.8676	1530.0	186272
488	238144	116214272	22.0907	7.8730	1533.1	187038
489	239121	116930169	22.1133	7.8784	1536.2	187805
490	240100	117649000	22.1359	7.8837	1539.4	188574
491	241081	118370771	22.1585	7.8891	1542.5	189345
492	242064	119095488	22.1811	7.8944	1545.7	190117
493	243049	119823157	22.2036	7.8998	1548.8	190890
494	244036	120553784	22.2261	7.9051	1551.9	191665
495	245025	121287375	22.2486	7.9105	1555.1	192442
496	246016	122023936	22.2711	7.9158	1558.2	193221
497	247009	122763473	22.2935	7.9211	1561.4	194000
498	248004	123505992	22.3159	7.9264	1564.5	194782
499	249001	124251499	22.3383	7.9317	1567.7	195565

FUNCTIONS OF NUMBERS, 500 to 549

No.	Square	Cube	Square Root	Cube Root	No. = Diameter	
					Circum.	Area
500	250000	125000000	22.3607	7.9370	1570.8	196350
501	251001	125751501	22.3830	7.9423	1573.9	197136
502	252004	126506008	22.4054	7.9476	1577.1	197923
503	253009	127263527	22.4277	7.9528	1580.2	198713
504	254016	128024064	22.4499	7.9581	1583.4	199504
505	255025	128787625	22.4722	7.9634	1586.5	200296
506	256036	129554216	22.4944	7.9686	1589.6	201090
507	257049	130323843	22.5167	7.9739	1592.8	201886
508	258064	131096512	22.5389	7.9791	1595.9	202683
509	259081	131872229	22.5610	7.9843	1599.1	203482
510	260100	132651000	22.5832	7.9896	1602.2	204282
511	261121	133432831	22.6053	7.9948	1605.4	205084
512	262144	134217728	22.6274	8.0000	1608.5	205887
513	263169	135005697	22.6495	8.0052	1611.6	206692
514	264196	135796744	22.6716	8.0104	1614.8	207499
515	265225	136590875	22.6936	8.0156	1617.9	208307
516	266256	137388096	22.7156	8.0208	1621.1	209117
517	267289	138188413	22.7376	8.0260	1624.2	209928
518	268324	138991832	22.7596	8.0311	1627.3	210741
519	269361	139798359	22.7816	8.0363	1630.5	211556
520	270400	140608000	22.8035	8.0415	1633.6	212372
521	271441	141420761	22.8254	8.0466	1636.8	213189
522	272484	142236648	22.8473	8.0517	1639.9	214008
523	273529	143055667	22.8692	8.0569	1643.1	214829
524	274576	143877824	22.8910	8.0620	1646.2	215651
525	275625	144703125	22.9129	8.0671	1649.3	216475
526	276676	145531576	22.9347	8.0723	1652.5	217301
527	277729	146363183	22.9565	8.0774	1655.6	218128
528	278784	147197952	22.9783	8.0825	1658.8	218956
529	279841	148035889	23.0000	8.0876	1661.9	219787
530	280900	148877000	23.0217	8.0927	1665.0	220618
531	281961	149721291	23.0434	8.0978	1668.2	221452
532	283024	150568768	23.0651	8.1028	1671.3	222287
533	284089	151419437	23.0868	8.1079	1674.5	223123
534	285156	152273304	23.1084	8.1130	1677.6	223961
535	286225	153130375	23.1301	8.1180	1680.8	224801
536	287296	153990656	23.1517	8.1231	1683.9	225642
537	288369	154854153	23.1733	8.1281	1687.0	226484
538	289444	155720872	23.1948	8.1332	1690.2	227329
539	290521	156590819	23.2164	8.1382	1693.3	228175
540	291600	157464000	23.2379	8.1433	1696.5	229022
541	292681	158340421	23.2594	8.1483	1699.6	229871
542	293764	159220088	23.2809	8.1533	1702.7	230722
543	294849	160103007	23.3024	8.1583	1705.9	231574
544	295936	160989184	23.3238	8.1633	1709.0	232428
545	297025	161878625	23.3452	8.1683	1712.2	233283
546	298116	162771336	23.3666	8.1733	1715.3	234140
547	299209	163667323	23.3880	8.1783	1718.5	234998
548	300304	164566592	23.4094	8.1833	1721.6	235858
549	301401	165469149	23.4307	8.1882	1724.7	236720

FUNCTIONS OF NUMBERS, 550 to 599

No.	Square	Cube	Square Root	Cube Root	No. = Diameter	
					Circum.	Area
550	302500	166375000	23.4521	8.1932	1727.9	237583
551	303601	167284151	23.4734	8.1982	1731.0	238448
552	304704	168196608	23.4947	8.2031	1734.2	239314
553	305809	169112377	23.5160	8.2081	1737.3	240182
554	306916	170031464	23.5372	8.2130	1740.4	241051
555	308025	170953875	23.5584	8.2180	1743.6	241922
556	309136	171879616	23.5797	8.2229	1746.7	242795
557	310249	172808693	23.6008	8.2278	1749.9	243669
558	311364	173741112	23.6220	8.2327	1753.0	244545
559	312481	174676879	23.6432	8.2377	1756.2	245422
560	313600	175616000	23.6643	8.2426	1759.3	246301
561	314721	176558481	23.6854	8.2475	1762.4	247181
562	315844	177504328	23.7065	8.2524	1765.6	248063
563	316969	178453547	23.7276	8.2573	1768.7	248947
564	318096	179406144	23.7487	8.2621	1771.9	249832
565	319225	180362125	23.7697	8.2670	1775.0	250719
566	320356	181321496	23.7908	8.2719	1778.1	251607
567	321489	182284263	23.8118	8.2768	1781.3	252497
568	322624	183250432	23.8328	8.2816	1784.4	253388
569	323761	184220009	23.8537	8.2865	1787.6	254281
570	324900	185193000	23.8747	8.2913	1790.7	255176
571	326041	186169411	23.8956	8.2962	1793.8	256072
572	327184	187149248	23.9165	8.3010	1797.0	256970
573	328329	188132517	23.9374	8.3059	1800.1	257869
574	329476	189119224	23.9583	8.3107	1803.3	258770
575	330625	190109375	23.9792	8.3155	1806.4	259672
576	331776	191102976	24.0000	8.3203	1809.6	260576
577	332929	192100033	24.0208	8.3251	1812.7	261482
578	334084	193100552	24.0416	8.3300	1815.8	262389
579	335241	194104539	24.0624	8.3348	1819.0	263298
580	336400	195112000	24.0832	8.3396	1822.1	264208
581	337561	196122941	24.1039	8.3443	1825.3	265120
582	338724	197137368	24.1247	8.3491	1828.4	266033
583	339889	198155287	24.1454	8.3539	1831.6	266948
584	341056	199176704	24.1661	8.3587	1834.7	267865
585	342225	200201625	24.1868	8.3634	1837.8	268783
586	343396	201230056	24.2074	8.3682	1841.0	269703
587	344569	202262003	24.2281	8.3730	1844.1	270624
588	345744	203297472	24.2487	8.3777	1847.3	271547
589	346921	204336469	24.2693	8.3825	1850.4	272471
590	348100	205379000	24.2899	8.3872	1853.5	273397
591	349281	206425071	24.3105	8.3919	1856.7	274325
592	350464	207474688	24.3311	8.3967	1859.8	275254
593	351649	208527857	24.3516	8.4014	1863.0	276184
594	352836	209584584	24.3721	8.4061	1866.1	277117
595	354025	210644875	24.3926	8.4108	1869.2	278051
596	355216	211708736	24.4131	8.4155	1872.4	278986
597	356409	212776173	24.4336	8.4202	1875.5	279923
598	357604	213847192	24.4540	8.4249	1878.7	280862
599	358801	214921799	24.4745	8.4296	1881.8	281802

FUNCTIONS OF NUMBERS, 600 to 649

No.	Square	Cube	Square Root	Cube Root	No. = Diameter	
					Circum.	Area
600	360000	216000000	24.4949	8.4343	1885.0	282743
601	361201	217081801	24.5153	8.4390	1888.1	283687
602	362404	218167208	24.5357	8.4437	1891.2	284631
603	363609	219256227	24.5561	8.4484	1894.4	285578
604	364816	220348864	24.5764	8.4530	1897.5	286526
605	366025	221445125	24.5967	8.4577	1900.7	287475
606	367236	222545016	24.6171	8.4623	1903.8	288426
607	368449	223648543	24.6374	8.4670	1906.9	289379
608	369664	224755712	24.6577	8.4716	1910.1	290333
609	370881	225866529	24.6779	8.4763	1913.2	291289
610	372100	226981000	24.6982	8.4809	1916.4	292247
611	373321	228099131	24.7184	8.4856	1919.5	293206
612	374544	229220928	24.7386	8.4902	1922.7	294166
613	375769	230346397	24.7588	8.4948	1925.8	295128
614	376996	231475544	24.7790	8.4994	1928.9	296092
615	378225	232608375	24.7992	8.5040	1932.1	297057
616	379456	233744896	24.8193	8.5086	1935.2	298024
617	380689	234885113	24.8395	8.5132	1938.4	298992
618	381924	236029032	24.8596	8.5178	1941.5	299962
619	383161	237176659	24.8797	8.5224	1944.6	300934
620	384400	238328000	24.8998	8.5270	1947.8	301907
621	385641	239483061	24.9199	8.5316	1950.9	302882
622	386884	240641848	24.9399	8.5362	1954.1	303858
623	388129	241804367	24.9600	8.5408	1957.2	304836
624	389376	242970624	24.9800	8.5453	1960.4	305815
625	390625	244140625	25.0000	8.5499	1963.5	306796
626	391876	245314376	25.0200	8.5544	1966.6	307779
627	393129	246491883	25.0400	8.5590	1969.8	308763
628	394384	247673152	25.0599	8.5635	1972.9	309748
629	395641	248858189	25.0799	8.5681	1976.1	310736
630	396900	250047000	25.0998	8.5726	1979.2	311725
631	398161	251239591	25.1197	8.5772	1982.3	312715
632	399424	252435968	25.1396	8.5817	1985.5	313707
633	400689	253636137	25.1595	8.5862	1988.6	314700
634	401956	254840104	25.1794	8.5907	1991.8	315696
635	403225	256047875	25.1992	8.5952	1994.9	316692
636	404496	257259456	25.2190	8.5997	1998.1	317690
637	405769	258474853	25.2389	8.6043	2001.2	318690
638	407044	259694072	25.2587	8.6088	2004.3	319692
639	408321	260917119	25.2784	8.6132	2007.5	320695
640	409600	262144000	25.2982	8.6177	2010.6	321699
641	410881	263374721	25.3180	8.6222	2013.8	322705
642	412164	264609288	25.3377	8.6267	2016.9	323713
643	413449	265847707	25.3574	8.6312	2020.0	324722
644	414736	267089984	25.3772	8.6357	2023.2	325733
645	416025	268336125	25.3969	8.6401	2026.3	326745
646	417316	269586136	25.4165	8.6446	2029.5	327759
647	418609	270840023	25.4362	8.6490	2032.6	328775
648	419904	272097792	25.4558	8.6535	2035.8	329792
649	421201	273359449	25.4755	8.6579	2038.9	330810

FUNCTIONS OF NUMBERS, 650 to 699

No.	Square	Cube	Square Root	Cube Root	No. = Diameter	
					Circum.	Area
650	422500	274625000	25.4951	8.6624	2042.0	331831
651	423801	275894451	25.5147	8.6668	2045.2	332853
652	425104	277167808	25.5343	8.6713	2048.3	333876
653	426409	278445077	25.5539	8.6757	2051.5	334901
654	427716	279726264	25.5734	8.6801	2054.6	335927
655	429025	281011375	25.5930	8.6845	2057.7	336955
656	430336	282300416	25.6125	8.6890	2060.9	337985
657	431649	283593393	25.6320	8.6934	2064.0	339016
658	432964	284890312	25.6515	8.6978	2067.2	340049
659	434281	286191179	25.6710	8.7022	2070.3	341084
660	435600	287496000	25.6905	8.7066	2073.5	342119
661	436921	288804781	25.7099	8.7110	2076.6	343157
662	438244	290117528	25.7294	8.7154	2079.7	344196
663	439569	291434247	25.7488	8.7198	2082.9	345237
664	440896	292754944	25.7682	8.7241	2086.0	346279
665	442225	294079625	25.7876	8.7285	2089.2	347323
666	443556	295408296	25.8070	8.7329	2092.3	348368
667	444889	296740963	25.8263	8.7373	2095.4	349415
668	446224	298077632	25.8457	8.7416	2098.6	350464
669	447561	299418309	25.8650	8.7460	2101.7	351514
670	448900	300763000	25.8844	8.7503	2104.9	352565
671	450241	302111711	25.9037	8.7547	2108.0	353618
672	451584	303464448	25.9230	8.7590	2111.2	354673
673	452929	304821217	25.9422	8.7634	2114.3	355730
674	454276	306182024	25.9615	8.7677	2117.4	356788
675	455625	307546875	25.9808	8.7721	2120.6	357847
676	456976	308915776	26.0000	8.7764	2123.7	358908
677	458329	310288733	26.1092	8.7807	2126.9	359971
678	459684	311665752	26.0384	8.7850	2130.0	361035
679	461041	313046839	26.0576	8.7893	2133.1	362101
680	462400	314432000	26.0768	8.7937	2136.3	363168
681	463761	315821241	26.0960	8.7980	2139.4	364237
682	465124	317214568	26.1151	8.8023	2142.6	365308
683	466489	318611987	26.1343	8.8066	2145.7	366380
684	467856	320013504	26.1534	8.8109	2148.8	367453
685	469225	321419125	26.1725	8.8152	2152.0	368528
686	470596	322828856	26.1916	8.8194	2155.1	369605
687	471969	324242703	26.2107	8.8237	2158.3	370684
688	473344	325660672	26.2298	8.8280	2161.4	371764
689	474721	327082769	26.2488	8.8323	2164.6	372845
690	476100	328509000	26.2679	8.8366	2167.7	373928
691	477481	329939371	26.2869	8.8408	2170.8	375013
692	478864	331373888	26.3059	8.8451	2174.0	376099
693	480249	332812557	26.3249	8.8493	2177.1	377187
694	481636	334255384	26.3439	8.8536	2180.3	378276
695	483025	335702375	26.3629	8.8578	2183.4	379367
696	484416	337153536	26.3818	8.8621	2186.5	380459
697	485809	338608873	26.4008	8.8663	2189.7	381553
698	487204	340068392	26.4197	8.8706	2192.8	382649
699	488601	341532099	26.4386	8.8748	2196.0	383746

FUNCTIONS OF NUMBERS, 700 to 749

No.	Square	Cube	Square Root	Cube Root	No. = Diameter	
					Circum.	Area
700	490000	343000000	26.4575	8.8790	2199.1	384845
701	491401	344472101	26.4764	8.8833	2202.3	385945
702	492804	345948408	26.4953	8.8875	2205.4	387047
703	494209	347428927	26.5141	8.8917	2208.5	388151
704	495616	348913664	26.5330	8.8959	2211.7	389256
705	497025	350402625	26.5518	8.9001	2214.8	390363
706	498436	351895816	26.5707	8.9043	2218.0	391471
707	499849	353393243	26.5895	8.9085	2221.1	392580
708	501264	354894912	26.6083	8.9127	2224.2	393692
709	502681	356400829	26.6271	8.9169	2227.4	394805
710	504100	357911000	26.6458	8.9211	2230.5	395919
711	505521	359425431	26.6646	8.9253	2233.7	397035
712	506944	360944128	26.6833	8.9295	2236.8	398153
713	508369	362467097	26.7021	8.9337	2240.0	399272
714	509796	363994344	26.7208	8.9378	2243.1	400393
715	511225	365525875	26.7395	8.9420	2246.2	401515
716	512656	367061696	26.7582	8.9462	2249.4	402639
717	514089	368601813	26.7769	8.9503	2252.5	403765
718	515524	370146232	26.7955	8.9545	2255.7	404892
719	516961	371694959	26.8142	8.9587	2258.8	406020
720	518400	373248000	26.8328	8.9628	2261.9	407150
721	519841	374805361	26.8514	8.9670	2265.1	408282
722	521284	376367048	26.8701	8.9711	2268.2	409415
723	522729	377933067	26.8887	8.9752	2271.4	410550
724	524176	379503424	26.9072	8.9794	2274.5	411687
725	525625	381078125	26.9258	8.9835	2277.7	412825
726	527076	382657176	26.9444	8.9876	2280.8	413965
727	528529	384240583	26.9629	8.9918	2283.9	415106
728	529984	385828352	26.9815	8.9959	2287.1	416248
729	531441	387420489	27.0000	9.0000	2290.2	417393
730	532900	389017000	27.0185	9.0041	2293.4	418539
731	534361	390617891	27.0370	9.0082	2296.5	419686
732	535824	392223168	27.0555	9.0123	2299.6	420835
733	537289	393832837	27.0740	9.0164	2302.8	421986
734	538756	395446904	27.0924	9.0205	2305.9	423138
735	540225	397065375	27.1109	9.0246	2309.1	424293
736	541696	398688256	27.1293	9.0287	2312.2	425447
737	543169	400315553	27.1477	9.0328	2315.4	426604
738	544644	401947272	27.1662	9.0369	2318.5	427762
739	546121	403583419	27.1846	9.0410	2321.6	428922
740	547600	405224000	27.2029	9.0450	2324.8	430084
741	549081	406869021	27.2213	9.0491	2327.9	431247
742	550564	408518488	27.2397	9.0532	2331.1	432412
743	552049	410172407	27.2580	9.0572	2334.2	433578
744	553536	411830784	27.2764	9.0613	2337.3	434746
745	555025	413493625	27.2947	9.0654	2340.5	435916
746	556516	415160936	27.3130	9.0694	2343.6	437087
747	558009	416832723	27.3313	9.0735	2346.8	438259
748	559504	418508992	27.3496	9.0775	2349.9	439433
749	561001	420189749	27.3679	9.0816	2353.1	440609

FUNCTIONS OF NUMBERS, 750 to 799

No.	Square	Cube	Square Root	Cube Root	No. = Diameter	
					Circum.	Area
750	562500	421875000	27.3861	9.0856	2356.2	441786
751	564001	423564751	27.4044	9.0896	2359.3	442965
752	565504	425259008	27.4226	9.0937	2362.5	444146
753	567009	426957777	27.4408	9.0977	2365.6	445328
754	568516	428661064	27.4591	9.1017	2368.8	446511
755	570025	430368875	27.4773	9.1057	2371.9	447697
756	571536	432081216	27.4955	9.1098	2375.0	448883
757	573049	433798093	27.5136	9.1138	2378.2	450072
758	574564	435519512	27.5318	9.1178	2381.3	451262
759	576081	437245479	27 5500	9.1218	2384.5	452453
760	577600	438976000	27.5681	9.1258	2387.6	453646
761	579121	440711081	27.5862	8.1298	2390.8	454841
762	580644	442450728	27.6043	9.1338	2393.9	456037
763	582169	444194947	27.6225	9.1378	2397.0	457234
764	583696	445943744	27.6405	9.1418	2400.2	458434
765	585225	447697125	27.6586	9.1458	2403.3	459635
766	586756	449455096	27.6767	9.1498	2406.5	460837
767	588289	451217663	27.6948	9.1537	2409.6	462041
768	589824	452984832	27.7128	9.1577	2412.7	463247
769	591361	454756609	27.7308	9.1617	2415.9	464454
770	592900	456533000	27.7489	9.1657	2419.0	465663
771	594441	458314011	27.7669	9.1696	2422.2	466873
772	595984	460099648	27.7849	9.1736	2425.3	468085
773	597529	461889917	27.8029	9.1775	2428.5	469298
774	599076	463684824	27.8209	9.1815	2431.6	470513
775	600625	465484375	27.8388	9.1855	2434.7	471730
776	602176	467288576	27.8568	9.1894	2437.9	472948
777	603729	469097433	27.8747	9.1933	2441.0	474168
778	605284	470910952	27.8927	9.1973	2444.2	475389
779	606841	472729139	27.9106	9.2012	2447.3	476612
780	608400	474552000	27.9285	9.2052	2450.4	477836
781	609961	476379541	27.9464	9.2091	2453.6	479062
782	611524	478211768	27.9643	9.2130	2456.7	480290
783	613089	480048687	27.9821	9.2170	2459.9	481519
784	614656	481890304	28.0000	9.2209	2463.0	482750
785	616225	483736625	28.0179	9.2248	2466.2	483982
786	617796	485587656	28.0357	9.2287	2469.3	485216
787	619369	487443403	28.0535	9.2326	2472.4	486451
788	620944	489303872	28.0713	9.2365	2475.6	487688
789	622521	491169069	28.0891	9.2404	2478.7	488927
790	624100	493039000	28.1069	9.2443	2481.9	490167
791	625681	494913671	28.1247	9.2482	2485.0	491409
792	627264	496793088	28.1425	9.2521	2488.1	492652
793	628849	498677257	28.1603	9.2560	2491.3	493897
794	630436	500566184	28.1780	9.2599	2494.4	495143
795	632025	502459875	28.1957	9.2638	2497.6	496391
796	633616	504358336	28.2135	9.2677	2500.7	497641
797	635209	506261573	23.2312	9.2716	2503.8	498892
798	636804	508169592	28.2489	9.2754	2507.0	500145
799	638401	510082399	28.2666	9.2793	2510.1	501399

FUNCTIONS OF NUMBERS, 800 to 849

No.	Square	Cube	Square Root	Cube Root	No. = Diameter	
					Circum.	Area
800	640000	512000000	28.2843	9.2832	2513.3	502655
801	641601	513922401	28.3019	9.2870	2516.4	503912
802	643204	515849608	28.3196	9.2909	2519.6	505171
803	644809	517781627	28.3373	9.2948	2522.7	506432
804	646416	519718464	28.3549	9.2986	2525.8	507694
805	648025	521660125	28.3725	9.3025	2529.0	508958
806	649636	523606616	28.3901	9.3063	2532.1	510223
807	651249	525557943	28.4077	9.3102	2535.3	511490
808	652864	527514112	28.4253	9.3140	2538.4	512758
809	654481	529475129	28.4429	9.3179	2541.5	514028
810	656100	531441000	28.4605	9.3217	2544.7	515300
811	657721	533411731	28.4781	9.3255	2547.8	516573
812	659344	535387328	28.4956	9.3294	2551.0	517848
813	660969	537367797	28.5132	9.3332	2554.1	519124
814	662596	539353144	28.5307	9.3370	2557.3	520402
815	664225	541343375	28.5482	9.3408	2560.4	521681
816	665856	543338496	28.5657	9.3447	2563.5	522962
817	667489	545338513	28.5832	9.3485	2566.7	524245
818	669124	547343432	28.6007	9.3523	2569.8	525529
819	670761	549353259	28.6182	9.3561	2573.0	526814
820	672400	551368000	28.6356	9.3599	2576.1	528102
821	674041	553387661	28.6531	9.3637	2579.2	529391
822	675684	555412248	28.6705	9.3675	2582.4	530681
823	677329	557441767	28.6880	9.3713	2585.5	531973
824	678976	559476224	28.7054	9.3751	2588.7	533267
825	680625	561515625	28.7228	9.3789	2591.8	534562
826	682276	563559976	28.7402	9.3827	2595.0	535858
827	683929	565609283	28.7576	9.3865	2598.1	537157
828	685584	567663552	28.7750	9.3902	2601.2	538456
829	687241	569722789	28.7924	9.3940	2604.4	539758
830	688900	571787000	28.8097	9.3978	2607.5	541061
831	690561	573856191	28.8271	9.4016	2610.7	542365
832	692224	575930368	28.8444	9.4053	2613.8	543671
833	693889	578009537	28.8617	9.4091	2616.9	544979
834	695556	580093704	28.8791	9.4129	2620.1	546288
835	697225	582182875	28.8964	9.4166	2623.2	547599
836	698896	584277056	28.9137	9.4204	2626.4	548912
837	700569	586376253	28.9310	9.4241	2629.5	550226
838	702244	588480472	28.9482	9.4279	2632.7	551541
839	703921	590589719	28.9655	9.4316	2635.8	552858
840	705600	592704000	28.9828	9.4354	2638.9	554177
841	707281	594823321	29.0000	9.4391	2642.1	555497
842	708964	596947688	29.0172	9.4429	2645.2	556819
843	710649	599077107	29.0345	9.4466	2648.4	558142
844	712336	601211584	29.0517	9.4503	2651.5	559467
845	714025	603351125	29.0689	9.4541	2654.6	560794
846	715716	605495736	29.0861	9.4578	2657.8	562122
847	717409	607645423	29.1033	9.4615	2660.9	563452
848	719104	609800192	29.1204	9.4652	2664.1	564783
849	720801	611960049	29.1376	9.4690	2667.2	566116

FUNCTIONS OF NUMBERS, 850 to 899

No.	Square	Cube	Square Root	Cube Root	No. = Diameter	
					Circum.	Area
850	722500	614125000	29.1548	9.4727	2670.4	567450
851	724201	616295051	29.1719	9.4764	2673.5	568786
852	725904	618470208	29.1890	9.4801	2676.6	570124
853	727609	620650477	29.2062	9.4838	2679.8	571463
854	729316	622835864	29.2233	9.4875	2682.9	572803
855	731025	625026375	29.2404	9.4912	2686.1	574146
856	732736	627222016	29.2575	9.4949	2689.2	575490
857	734449	629422793	29.2746	9.4986	2692.3	576835
858	736164	631628712	29.2916	9.5023	2695.5	578182
859	737881	633839779	29.3087	9.5060	2698.6	579530
860	739600	636056000	29.3258	9.5097	2701.8	580880
861	741321	638277381	29.3428	9.5134	2704.9	582232
862	743044	640503928	29.3598	9.5171	2708.1	583585
863	744769	642735647	29.3769	9.5207	2711.2	584940
864	746496	644972544	29.3939	9.5244	2714.3	586297
865	748225	647214625	29.4109	9.5281	2717.5	587655
866	749956	649461896	29.4279	9.5317	2720.6	589014
867	751689	651714363	29.4449	9.5354	2723.8	590375
868	753424	653972032	29.4618	9.5391	2726.9	591738
869	755161	656234909	29.4788	9.5427	2730.0	593102
870	756900	658503000	29.4958	9.5464	2733.2	594468
871	758641	660776311	29.5127	9.5501	2736.3	595835
872	760384	663054848	29.5296	9.5537	2739.5	597204
873	762129	665338617	29.5466	9.5574	2742.6	598575
874	763876	667627624	29.5635	9.5610	2745.8	599947
875	765625	669921875	29.5804	9.5647	2748.9	601320
876	767376	672221376	29.5973	9.5683	2752.0	602696
877	769129	674526133	29.6142	9.5719	2755.2	604073
878	770884	676836152	29.6311	9.5756	2758.3	605451
879	772641	679151439	29.6479	9.5792	2761.5	606831
880	774400	681472000	29.6648	9.5828	2764.6	608212
881	776161	683797841	29.6816	9.5865	2767.7	609595
882	777924	686128968	29.6985	9.5901	2770.9	610980
883	779689	688465387	29.7153	9.5937	2774.0	612366
884	781456	690807104	29.7321	9.5973	2777.2	613754
885	783225	693154125	29.7489	9.6010	2780.3	615143
886	784996	695506456	29.7658	9.6046	2783.5	616534
887	786769	697864103	29.7825	9.6082	2786.6	617927
888	788544	700227072	29.7993	9.6118	2789.7	619321
889	790321	702595369	29.8161	9.6154	2792.9	620717
890	792100	704969000	29.8329	9.6190	2796.0	622114
891	793881	707347971	29.8496	9.6226	2799.2	623513
892	795664	709732288	29.8664	9.6262	2802.3	624913
893	797449	712121957	29.8831	9.6298	2805.4	626315
894	799236	714516984	29.8998	9.6334	2808.6	627718
895	801025	716917375	29.9166	9.6370	2811.7	629124
896	802816	719323136	29.9333	9.6406	2814.9	630530
897	804609	721734273	29.9500	9.6442	2818.0	631938
898	806404	724150792	29.9666	9.6477	2821.2	633348
899	808201	726572699	29.9833	9.6513	2824.3	634760

FUNCTIONS OF NUMBERS, 900 to 949

No.	Square	Cube	Square Root	Cube Root	No. = Diameter	
					Circum.	Area
900	810000	729000000	30.0000	9.6549	2827.4	636173
901	811801	731432701	30.0167	9.6585	2830.6	637587
902	813604	733870808	30.0333	9.6620	2833.7	639003
903	815409	736314327	30.0500	9.6656	2836.9	640421
904	817216	738763264	30.0666	9.6692	2840.0	641840
905	819025	741217625	30.0832	9.6727	2843.1	643261
906	820836	743677416	30.0998	9.6763	2846.3	644683
907	822649	746142643	30.1164	9.6799	2849.4	646107
908	824464	748613312	30.1330	9.6834	2852.6	647533
909	826281	751089429	30.1496	9.6870	2855.7	648960
910	828100	753571000	30.1662	9.6905	2858.8	650388
911	829921	756058031	30.1828	9.6941	2862.0	651818
912	831744	758550528	30.1993	9.6976	2865.1	653250
913	833569	761048497	30.2159	9.7012	2868.3	654684
914	835396	763551944	30.2324	9.7047	2871.4	656118
915	837225	766060875	30.2490	9.7082	2874.6	657555
916	839056	768575296	30.2655	9.7118	2877.7	658993
917	840889	771095213	30.2820	9.7153	2880.8	660433
918	842724	773620632	30.2985	9.7188	2884.0	661874
919	844561	776151559	30.3150	9.7224	2887.1	663317
920	846400	778688000	30.3315	9.7259	2890.3	664761
921	848241	781229961	30.3480	9.7294	2893.4	666207
922	850084	783777448	30.3645	9.7329	2896.5	667654
923	851929	786330467	30.3809	9.7364	2899.7	669103
924	853776	788889024	30.3974	9.7400	2902.8	670554
925	855625	791453125	30.4138	9.7435	2906.0	672006
926	857476	794022776	30.4302	9.7470	2909.1	673460
927	859329	796597983	30.4467	9.7505	2912.3	674915
928	861184	799178752	30.4631	9.7540	2915.4	676372
929	863041	801765089	30.4795	9.7575	2918.5	677831
930	864900	804357000	30.4959	9.7610	2921.7	679291
931	866761	806954491	30.5123	9.7645	2924.8	680752
932	868624	809557568	30.5287	9.7680	2928.0	682216
933	870489	812166237	30.5450	9.7715	2931.1	683680
934	872356	814780504	30.5614	9.7750	2934.2	685147
935	874225	817400375	30.5778	9.7785	2937.4	686615
936	876096	820025856	30.5941	9.7819	2940.5	688084
937	877969	822656953	30.6105	9.7854	2943.7	689555
938	879844	825293672	30.6268	9.7889	2946.8	691028
639	881721	827936019	30.6431	9.7924	2950.0	692502
940	883600	830584000	30.6594	9.7959	2953.1	693978
941	885481	833237621	30.6757	9.7993	2956.2	695455
942	887364	835896888	30.6920	9.8028	2959.4	696934
943	889249	838561807	30.7083	9.8063	2962.5	698415
944	891136	841232384	30.7246	9.8097	2965.7	699897
945	893025	843908625	30.7409	9.8132	2968.8	701380
946	894916	846590536	30.7571	9.8167	2971.9	702865
947	896809	849278123	30.7734	9.8201	2975.1	704352
948	898704	851971392	30.7896	9.8236	2978.2	705840
949	900601	854670349	30.8058	9.8270	2981.4	707330

FUNCTIONS OF NUMBERS, 950 to 999

No.	Square	Cube	Square Root	Cube Root	No. = Diameter	
					Circum.	Area
950	902500	857375000	30.8221	9.8305	2984.5	708822
951	904401	860085351	30.8383	9.8339	2987.7	710315
952	906304	862801408	30.8545	9.8374	2990.8	711809
953	908209	865523177	30.8707	9.8408	2993.9	713306
954	910116	868250664	30.8869	9.8443	2997.1	714803
955	912025	870983875	30.9031	9.8477	3000.2	716303
956	913936	873722816	30.9192	9.8511	3003.4	717804
957	915849	876467493	30.9354	9.8546	3006.5	719306
958	917764	879217912	30.9516	9.8580	3009.6	720810
959	919681	881974079	30.9677	9.8614	3012.8	722316
960	921600	884736000	30.9839	9.8648	3015.9	723823
961	923521	887503681	31.0000	9.8683	3019.1	725332
962	925444	890277128	31.0161	9.8717	3022.2	726842
963	927369	893056347	31.0322	9.8751	3025.4	728354
964	929296	895841344	31.0483	9.8785	3028.5	729867
965	931225	898632125	31.0644	9.8819	3031.6	731382
966	933156	901428696	31.0805	9.8854	3034.8	732899
967	935089	904231063	31.0966	9.8888	3037.9	734417
968	937024	907039232	31.1127	9.8922	3041.1	735937
969	938961	909853209	31.1288	9.8956	3044.2	737458
970	940900	912673000	31.1448	9.8990	3047.3	738981
971	942841	915498611	31.1609	9.9024	3050.5	740506
972	944784	918330048	31.1769	9.9058	3053.6	742032
973	946729	921167317	31.1929	9.9092	3056.8	743559
974	948676	924010424	31.2090	9.9126	3059.9	745088
975	950625	926859375	31.2250	9.9160	3063.1	746619
976	952576	929714176	31.2410	9.9194	3066.2	748151
977	954529	932574833	31.2570	9.9227	3069.3	749685
978	956484	935441352	31.2730	9.9261	3072.5	751221
979	958441	938313739	31.2890	9.9295	3075.6	752758
980	960400	941192000	31.3050	9.9329	3078.8	754296
981	962361	944076141	31.3209	9.9363	3081.9	755837
982	964324	946966168	31.3369	9.9396	3085.0	757378
983	966289	949862087	31.3528	9.9430	3088.2	758922
984	968256	952763904	31.3688	9.9464	3091.3	760466
985	970225	955671625	31.3847	9.9497	3094.5	762013
986	972196	958585256	31.4006	9.9531	3097.6	763561
987	974169	961504803	31.4166	9.9565	3100.8	765111
988	976144	964430272	31.4325	9.9598	3103.9	766662
989	978121	967361669	31.4484	9.9632	3107.0	768214
990	980100	970299000	31.4643	9.9666	3110.2	769769
991	982081	973242271	31.4802	9.9699	3113.3	771325
992	984064	976191488	31.4960	9.9733	3116.5	772882
993	986049	979146657	31.5119	9.9766	3119.6	774441
994	988036	982107784	31.5278	9.9800	3122.7	776002
995	990025	985074875	31.5436	9.9833	3125.9	777564
996	992016	988047936	31.5595	9.9866	3129.0	779128
997	994009	991026973	31.5753	9.9900	3132.2	780693
998	996004	994011992	31.5911	9.9933	3135.3	782260
999	998001	997002999	31.6070	9.9967	3138.5	783828

COMPARATIVE TABLE OF STANDARD GAGES

Gage Number	THICKNESS IN DECIMALS OF AN INCH					
	Birmingham Wire (B.W.G.) also known as Stubbs Iron Wire	American Wire or Browne & Sharpe	United States Steel Wire formerly Washburn & Moen	Trenton Iron Company	British Imperial Standard Wire (S.W.G.)	Standard Birmingham Sheet and Hoop (B.G.)
0000000	.....	.....	.4900	.....	.500	.....
000000	.....	.580000	.4615	.....	.464	.....
00000	.....	.516500	.4305	.450	.432	.....
0000	.454	.460000	.3938	.400	.400	.....
000	.425	.409642	.3625	.360	.372	.5000
00	.380	.364796	.3310	.330	.348	.4452
0	.340	.324861	.3065	.305	.324	.3964
1	.300	.289297	.2830	.285	.300	.3532
2	.284	.257627	.2625	.265	.276	.3147
3	.259	.229423	.2437	.245	.252	.2804
4	.238	.204307	.2253	.225	.232	.2500
5	.220	.181940	.2070	.205	.212	.2225
6	.203	.162023	.1920	.190	.192	.1981
7	.180	.144285	.1770	.175	.176	.1764
8	.165	.128490	.1620	.160	.160	.1570
9	.148	.114423	.1483	.145	.144	.1398
10	.134	.101897	.1350	.130	.128	.1250
11	.120	.090742	.1205	.1175	.116	.1113
12	.109	.080808	.1055	.105	.104	.0991
13	.095	.071962	.0915	.0925	.092	.0882
14	.083	.064084	.0800	.0806	.080	.0785
15	.072	.057068	.0720	.070	.072	.0699
16	.065	.050821	.0625	.061	.064	.0625
17	.058	.045257	.0540	.0525	.056	.0556
18	.049	.040303	.0475	.045	.048	.0495
19	.042	.035890	.0410	.040	.040	.0440
20	.035	.031961	.0348	.035	.036	.0392
21	.032	.028462	.03175	.031	.032	.0349
22	.028	.025346	.0286	.028	.028	.03125
23	.025	.022572	.0258	.025	.024	.02782
24	.022	.020101	.0230	.0225	.022	.02476
25	.020	.017900	.0204	.020	.020	.02204
26	.018	.015941	.0181	.018	.018	.01961
27	.016	.014195	.0173	.017	.0164	.01745
28	.014	.012641	.0162	.016	.0148	.015625
29	.013	.011257	.0150	.015	.0136	.0139
30	.012	.010025	.0140	.014	.0124	.0123
31	.010	.008928	.0132	.013	.0116	.0110
32	.009	.007950	.0128	.012	.0108	.0098
33	.008	.007080	.0118	.011	.0100	.0087
34	.007	.006305	.0104	.010	.0092	.0077
35	.005	.005615	.0095	.0095	.0084	.0069
36	.004	.005000	.0090	.009	.0076	.0061
37	.....	.004453	.0085	.0085	.0068	.0054
38	.....	.003965	.0080	.008	.0060	.0048
39	.....	.003531	.0075	.0075	.0052	.....
40	.....	.003144	.0070	.007	.0048	.....

DECIMALS OF AN INCH AND OF A FOOT

Fractions of Inch or Foot		Inch Equivalents to Foot Fractions	Fractions of Inch or Foot		Inch Equivalents to Foot Fractions	Fractions of Inch or Foot		Inch Equivalents to Foot Fractions	Fractions of Inch or Foot		Inch Equivalents to Foot Fractions
	.0052	1/16		.2552	3 1/16		.5052	6 1/16		.7552	9 1/16
	.0104	1/8		.2604	3 1/8		.5104	6 1/8		.7604	9 1/8
1/64	.015625	3/16	17/64	.265625	3 3/16	33/64	.515625	6 3/16	49/64	.765625	9 3/16
	.0208	1/4		.2708	3 1/4		.5208	6 1/4		.7708	9 1/4
	.0260	5/16		.2760	3 5/16		.5260	6 5/16		.7760	9 5/16
1/32	.03125	3/8	9/32	.28125	3 3/8	17/32	.53125	6 3/8	25/32	.78125	9 3/8
	.0365	7/16		.2865	3 7/16		.5365	6 7/16		.7865	9 7/16
	.0417	1/2		.2917	3 1/2		.5417	6 1/2		.7917	9 1/2
3/64	.046875	9/16	19/64	.296875	3 9/16	35/64	.546875	6 9/16	51/64	.796875	9 9/16
	.0521	5/8		.3021	3 5/8		.5521	6 5/8		.8021	9 5/8
	.0573	11/16		.3073	3 11/16		.5573	6 11/16		.8073	9 11/16
1/16	.0625	3/4	5/16	.3125	3 3/4	9/16	.5625	6 3/4	13/16	.8125	9 3/4
	.0677	13/16		.3177	3 13/16		.5677	6 13/16		.8177	9 13/16
	.0729	7/8		.3229	3 7/8		.5729	6 7/8		.8229	9 7/8
5/64	.078125	5/16	21/64	.328125	3 15/16	37/64	.578125	6 15/16	53/64	.828125	9 15/16
	.0833	1		.3333	4		.5833	7		.8333	10
	.0885	1 1/16		.3385	4 1/16		.5885	7 1/16		.8385	10 1/16
3/32	.09375	1 1/8	11/32	.34375	4 1/8	19/32	.59375	7 1/8	27/32	.84375	10 1/8
	.0990	1 3/16		.3490	4 3/16		.5990	7 3/16		.8490	10 3/16
	.1042	1 1/4		.3542	4 1/4		.6042	7 1/4		.8542	10 1/4
7/64	.109375	1 5/16	23/64	.359375	4 5/16	39/64	.609375	7 5/16	55/64	.859375	10 5/16
	.1146	1 3/8		.3646	4 3/8		.6146	7 3/8		.8646	10 3/8
	.1198	1 7/16		.3698	4 7/16		.6198	7 7/16		.8698	10 7/16
1/8	.1250	1 1/2	3/8	.3750	4 1/2	5/8	.6250	7 1/2	7/8	.8750	10 1/2
	.1302	1 9/16		.3802	4 9/16		.6302	7 9/16		.8802	10 9/16
	.1354	1 5/8		.3854	4 5/8		.6354	7 5/8		.8854	10 5/8
9/64	.140625	1 11/16	25/64	.390625	4 11/16	41/64	.640625	7 11/16	57/64	.890625	10 11/16
	.1458	1 3/4		.3958	4 3/4		.6458	7 3/4		.8958	10 3/4
	.1510	1 13/16		.4010	4 13/16		.6510	7 13/16		.9010	10 13/16
5/32	.15625	1 7/8	13/32	.40625	4 7/8	21/32	.65625	7 7/8	29/32	.90625	10 7/8
	.1615	1 15/16		.4115	4 15/16		.6615	7 15/16		.9115	10 15/16
	.1667	2		.4167	5		.6667	8		.9167	11
11/64	.171875	2 1/16	27/64	.421875	5 1/16	43/64	.671875	8 1/16	59/64	.921875	11 1/16
	.1771	2 1/8		.4271	5 1/8		.6771	8 1/8		.9271	11 1/8
	.1823	2 5/16		.4323	5 5/16		.6823	8 5/16		.9323	11 5/16
3/16	.1875	2 1/4	7/16	.4375	5 1/4	11/16	.6875	8 1/4	15/16	.9375	11 1/4
	.1927	2 5/16		.4427	5 5/16		.6927	8 5/16		.9427	11 5/16
	.1979	2 3/8		.4479	5 3/8		.6979	8 3/8		.9479	11 3/8
13/64	.203125	2 7/16	29/64	.453125	5 7/16	45/64	.703125	8 7/16	61/64	.953125	11 7/16
	.2083	2 1/2		.4583	5 1/2		.7083	8 1/2		.9583	11 1/2
	.2135	2 9/16		.4635	5 9/16		.7135	8 9/16		.9635	11 9/16
7/32	.21875	2 5/8	15/32	.46875	5 5/8	23/32	.71875	8 5/8	31/32	.96875	11 5/8
	.2240	2 11/16		.4740	5 11/16		.7240	8 11/16		.9740	11 11/16
	.2292	2 3/4		.4792	5 3/4		.7292	8 3/4		.9792	11 3/4
15/64	.234375	2 13/16	31/64	.484375	5 13/16	47/64	.734375	8 13/16	63/64	.984375	11 13/16
	.2396	2 7/8		.4896	5 7/8		.7396	8 7/8		.9896	11 7/8
	.2448	2 15/16		.4948	5 15/16		.7448	8 15/16		.9948	11 15/16
1/4	.2500	3	1/2	.5000	6	3/4	.7500	9	1	1.0000	12

TRADE CUSTOMS

Unless otherwise specified quotations are for prompt acceptance and are subject to change without notice.

All sales, contracts and orders become effective only when approved and accepted in writing by the Seller's home office.

The acceptance of any order or specification, and terms of payment, on all sales and orders are subject to the approval of the Treasurer of the Seller. The Seller may decline to make deliveries, except for cash, whenever the Seller for any reason shall have any doubt as to the Buyer's responsibility and shall so advise the Buyer, whereupon the Buyer shall have the privilege of satisfying the Seller of his responsibility, and when Seller is so satisfied, then deliveries shall be made or renewed as per terms expressed.

The total quantity of material in each individual shipment will govern the prices charged for the materials specified under orders and contracts, which prices shall be the proper prices for the quantity and delivery involved in accordance with the general schedule of prices upon which the computations shown are based.

Each Month's shipments to be treated as a separate and independent contract, but if Buyer fails to fulfill terms of payment under any contract Seller may either defer further shipments until payment is made or may cancel the contract.

The Seller shall not be liable for non-performance of orders or contracts in whole or in part if such non-performance is the result of fires, strikes, differences with employes, casualties, delays in transportation, shortage of cars or other causes beyond the Seller's reasonable control, nor shall these exemptions be limited or waived by any other terms of orders or contracts, whether printed or written.

All materials are carefully inspected, and in the case of tubing, pipe, casing, etc., every piece is tested before shipment, but it is not always possible to detect imperfections; therefore the only guarantee that is given is to replace such materials as prove defective or to allow credit for their return at Seller's option. If goods appear defective, Buyer should discontinue their use and notify Seller promptly so that Seller may investigate. Seller will not allow any claim for labor or expense occasioned by the use of defective goods, nor be responsible for damages beyond the price of the defective material.

Under no circumstances will Seller accept the return of goods for credit or replacement unless arrangements have previously been made for such return.

Special goods made to specifications, where Buyer is to inspect, must be inspected before shipment is made. After shipment of such special goods is made Seller's responsibility ceases.

Materials to be within the limits and of sizes manufactured by Seller and subject to Seller's standard manufacturing variations, classifications and extras.

All tubes sold subject to the usual variations or tolerances. Unless otherwise specified, mill lengths of 5 feet and over will be shipped. An extra charge will be made for cutting tubes to special lengths. Claims for shortage or deductions for erroneous charges must be presented promptly or will not be allowed.

All tubes 16 gage and lighter will be shipped boxed. Also all tubes in all gages in lengths two feet or shorter will be shipped boxed if, in the Seller's judgment, they should be so shipped. All other tubes will be shipped bundled unless ordered boxed by customer.

The carriers are responsible for goods lost or damaged in transit, and in case of loss or damage enroute consignee, as required by Rule No. 2, Paragraph 8 of the Uniform Bill of Lading, must immediately notify the carrier's agent at destination in writing in order to substantiate formal claim when presented.

Claims for other errors, deficiencies or imperfections will not be entertained by the Seller unless made within 15 days after receipt of material.

Except as provided above, all orders and contracts when accepted are binding both upon Buyer and Seller and not subject to cancellation. It is expressly understood and agreed that no protection against decline in the prices as shown in orders and contracts can be allowed by the Seller.

In the case of orders for tubes or other materials of special sizes, gauges and shapes the privilege is reserved of shipping ten per cent more or less than the quantity ordered. Requests for the modification of specifications calling for odd sizes, special analysis, cut lengths or formed tubes cannot be considered if the manufacture of the material has been commenced when the request reaches the mill.

Invoices payable at the General Office of Seller, Pittsburgh, Pa., to the order of the Seller, in funds current in Pittsburgh, or in New York exchange.

Any tax imposed by any present or future law, Federal, State or any other Governmental Agency, on the sale of the articles covered by any orders or contracts, shall be added to the amount to be paid thereunder.

Forbearance or failure of the Seller to enforce any of these conditions or to exercise any right accruing from any default of the Buyer shall not affect or impair the Seller's rights in case such default continue, or in case of any subsequent default of the Buyer, and such forbearance or failure will not act as a waiver in case of other or future defaults of the Buyer.

All contracts and orders are executed by the Seller in the State of Pennsylvania.

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INDEX (Concluded)

OTHER PITTSBURGH PRODUCTS

Pittsburgh Steel Company manufactures under the "Pittsburgh" family name a diversified group of products for Industry, the Trades and the Home. Some of these products are listed here:

Industrial Fences, Lawn Fences, Farm and Poultry Fences, Highway Guard, Barbed Wire, Gates, Posts, Fence Fittings, Fence Tools, Staples, Spring Wire, Bright Wire, Annealed Wire, Hot Zinc Coated (galvanized) Wire, Stainless Wire and Stainless Wire Products, Bale Ties, Nails (Bright, Blued or Hot Zinc Coated "galvanized").

Casing, Drill Pipe, Oil Well Tubing, Line Pipe, Cracking Still Tubes, Boiler Tubes, Power Piping, Refinery Piping, Refrigeration Coils, Mechanical Tubing.

Reinforcing Fabric for Roads, Streets, Sidewalks, Driveways, Runways, Buildings, Floors, Roofs, Canals, Gunite, Concrete Pipe; Steeltex (wire reinforcing mesh with integral fibrous backing) for Interior Plaster, Stucco, Brick or Stone Veneer, Partitions, Suspended Ceilings, Floors—and for Modernizing.

A request for literature and information about any of these products will put you under no obligation.

PITTSBURGH STEEL COMPANY
PITTSBURGH, PENNSYLVANIA

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