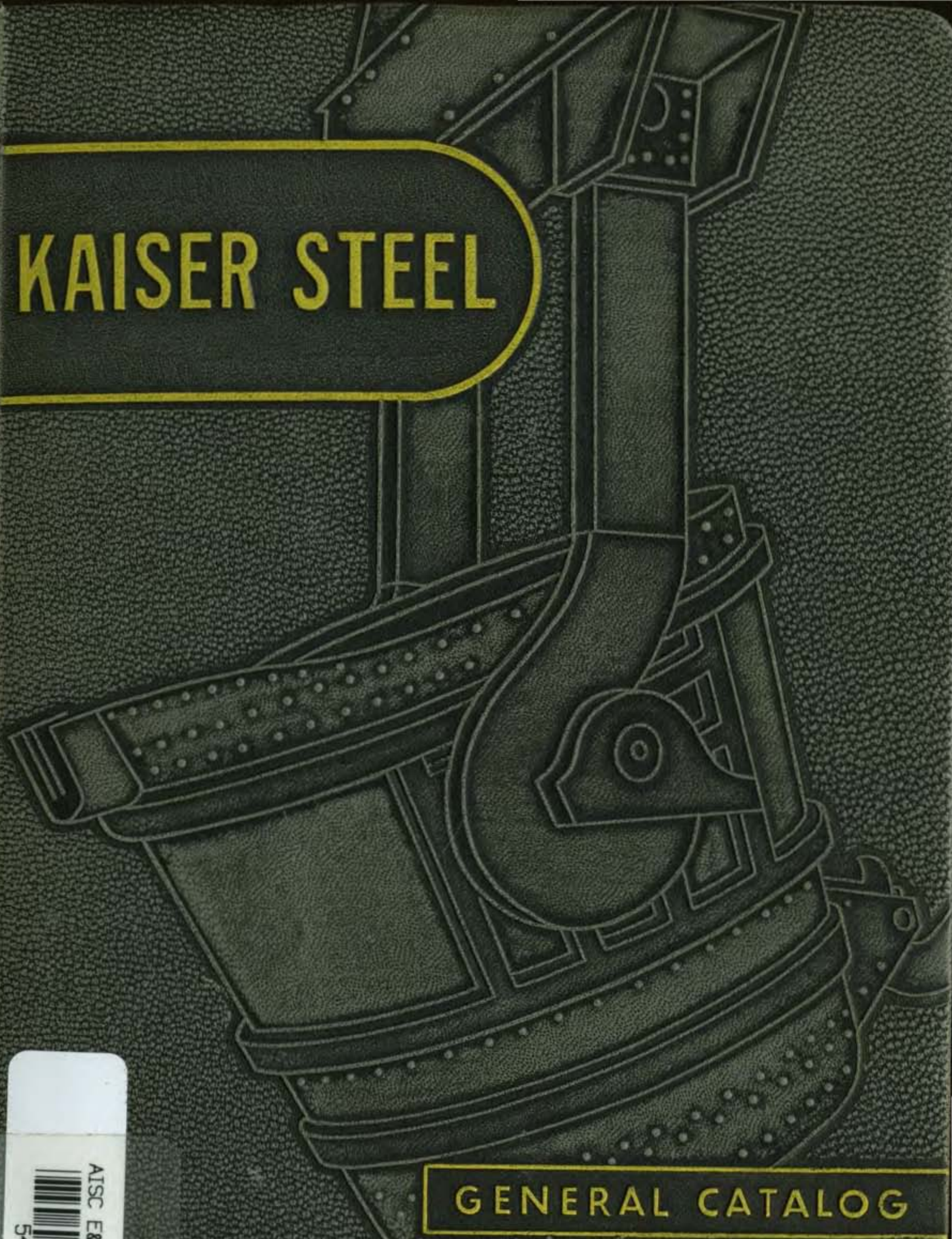
KAISER STEEL



GENERAL CATALOG

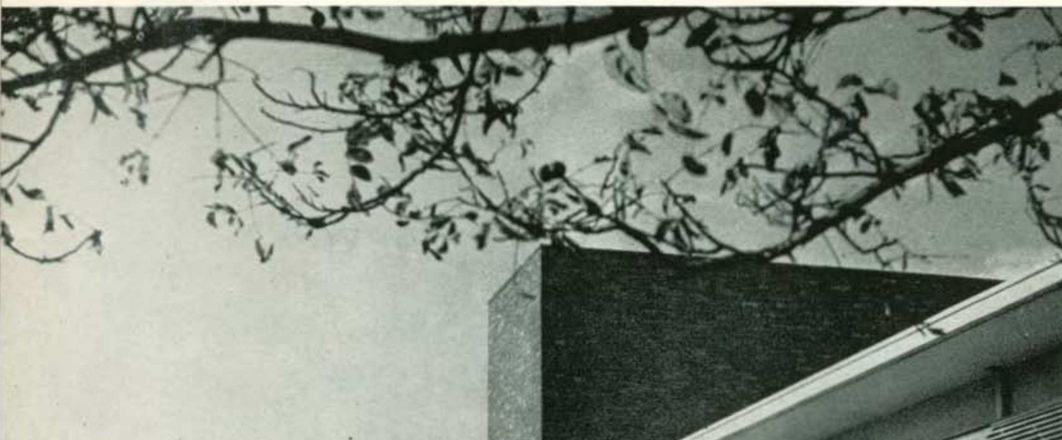
"A point which yesterday was invisible is its goal today and will be its starting post tomorrow."

—*Macaulay*

KAISER STEEL GENERAL CATALOG

Second Edition, First Printing

NOVEMBER, 1953



Administration Building at the Kaiser Steel plant

INTRODUCTION

Kaiser Steel's slogan—"Built to Serve the West"—recognizes the fact that the value of a steel mill to a region is measured by the way in which it meets the needs of its customers.

The Pacific Coast's first and only fully integrated iron and steel plant at Fontana, California, was founded to meet a great need . . . demands for steel in the West far exceeded production. A basic steel industry was essential to the industrialization of the West.

As demands for steel have continued to increase in the nation's fastest growing area, additional iron and steel-making capacity and rolling mills have been added at the steel plant in an almost uninterrupted program of expansion and diversification. We in Kaiser Steel are grateful for the support of our thousands of friends in Western industry who have helped make this history of growth and development possible.

We are pleased to present this General Catalog to give you ready, specific information on Kaiser Steel products. From it, you will observe that the wide range of finished and semi-finished products make the Fontana plant one of the most widely diversified steel operations in the country. It is a plant built upon strong economic foundations of raw materials and operating efficiency. High grade iron ore is obtained only 164 miles from Fontana at the Company-owned mine at Eagle Mountain, California, giving Kaiser Steel one of the shortest ore hauls in the nation. Coking coal comes from the Company's mines at Sunnyside, Utah, one of the most modern and low cost large coal properties in America. Using these Western raw materials, Kaiser Steel has established nationally recognized blast furnace practices and has what is believed to be the lowest coke consumption per ton of pig iron produced of any U.S. steel plant.

With its three blast furnaces, nine open hearth furnaces, 225 coke ovens and nine separate rolling mills turning out a wide variety of products tailored to the needs of the Western market, the Fontana plant is a busy place, operating in most departments on a 24-hour basis. But the operators are never too busy to show the plant to visitors. So, if you have not yet seen the magnitude and drama of steel making at Fontana, please consider this an invitation to visit the plant at your earliest opportunity. The salesman who calls on you, or anyone else in the Kaiser Steel organization, will be happy to arrange a tour for you.

Sincerely,

Henry J. Kaiser

President

KAISER STEEL CORPORATION

sales offices

LOS ANGELES 17, CALIFORNIA
612 S. Flower Street
Madison 6-8211

OAKLAND 12, CALIFORNIA
285 17th Street
Twinoaks 3-4600

SEATTLE 4, WASHINGTON
1207 Hoge Building
Seneca 4797

NEW YORK 20, N. Y.
620 Fifth Avenue
Circle 6-4725

PORTLAND 4, OREGON
703 Public Service Bldg.
Atwater 2384

HOUSTON 2, TEXAS
M & M Bldg.
Atwood 0409

TULSA, OKLAHOMA
619 S. Main Street
Tulsa 54-2871

WASHINGTON, D. C.
1625 "I" Street N.W
Sterling 3-1555

export department

OAKLAND 12, CALIFORNIA
285 17th Street
Cable Address—Kaisteel

general offices

OAKLAND 12, CALIFORNIA
Kaiser Building
Twinoaks 3-4600

ILLUSTRATIONS

The photographs throughout this catalog tell the story of steel in the West. From its iron ore mines on the California desert and its coal deposits in Utah to its blast furnaces, open hearth furnaces, blooming mills and finishing mills at Fontana, California, KAISER STEEL's story is a dramatic one—one that is ranked by the Southwestern section of the American Society of Mechanical Engineers as one of the seven engineering wonders of Southern California. But not only do the photographs show the complex operations of a great steel mill in action, they also graphically illustrate a major force behind the West Coast's declaration of industrial independence.

ACKNOWLEDGMENT

KAISER STEEL CORPORATION wishes to thank the American Iron and Steel Institute for permission to reproduce material from its Steel Products Manual in the publication of this catalog.

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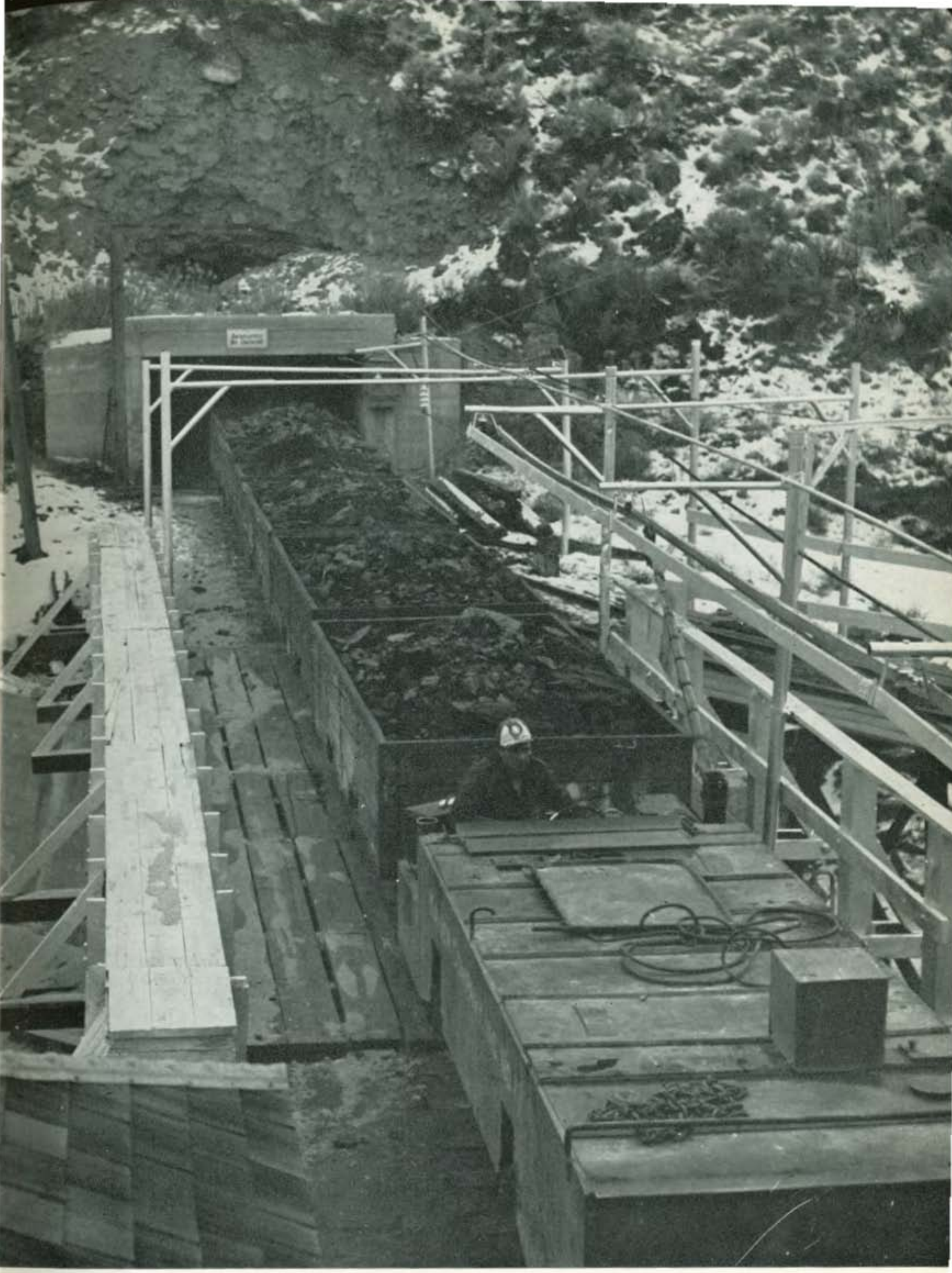
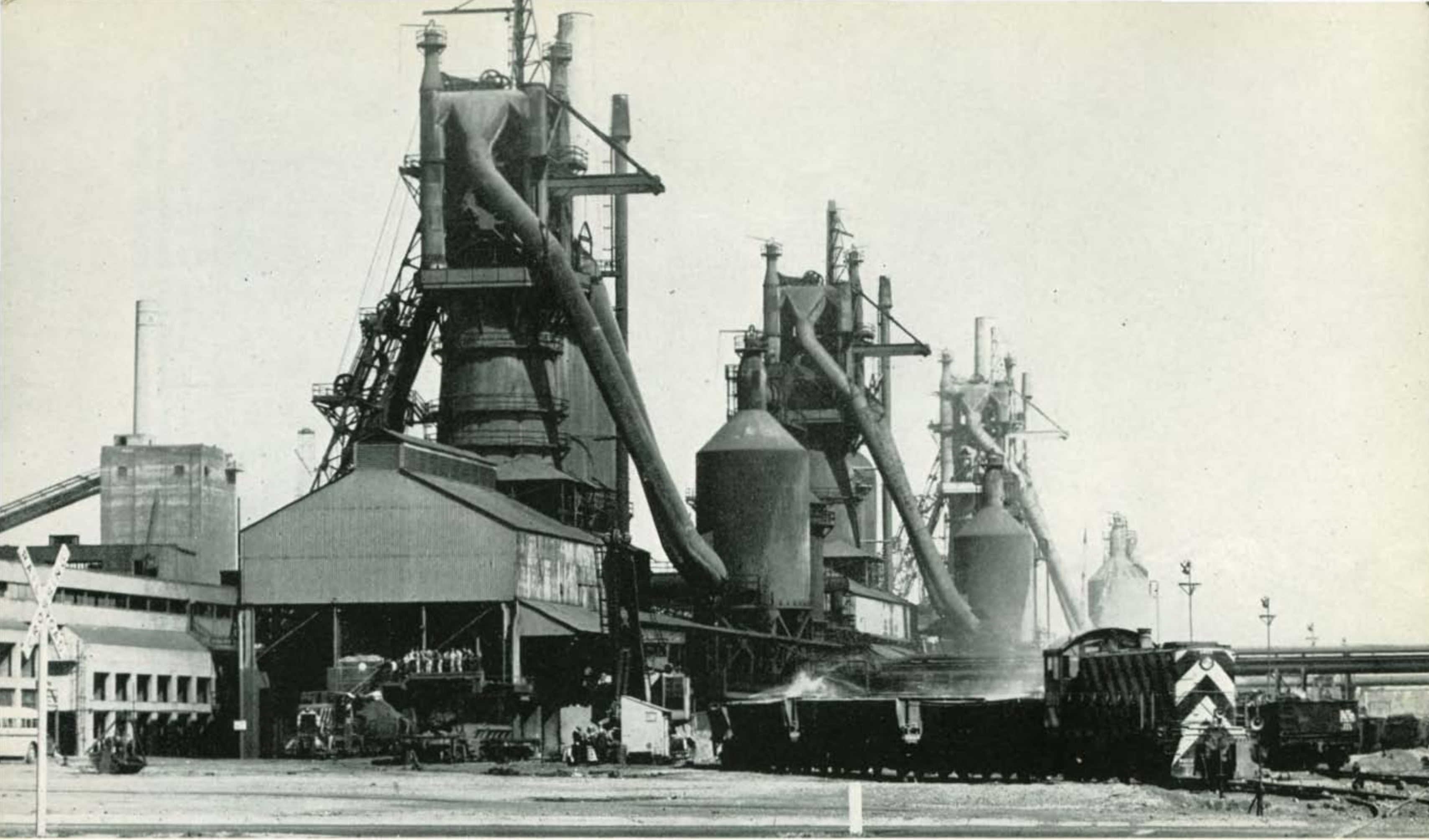
2,100,000 tons of ore, averaging 54 per cent iron content, leave Kaiser's Eagle Mountain open pit mine annually for the short 164 mile rail haul to Fontana.



1,600,000 tons of volatile-rich coal are mined annually by the Kaiser-owned mines at Sunnyside, Utah.

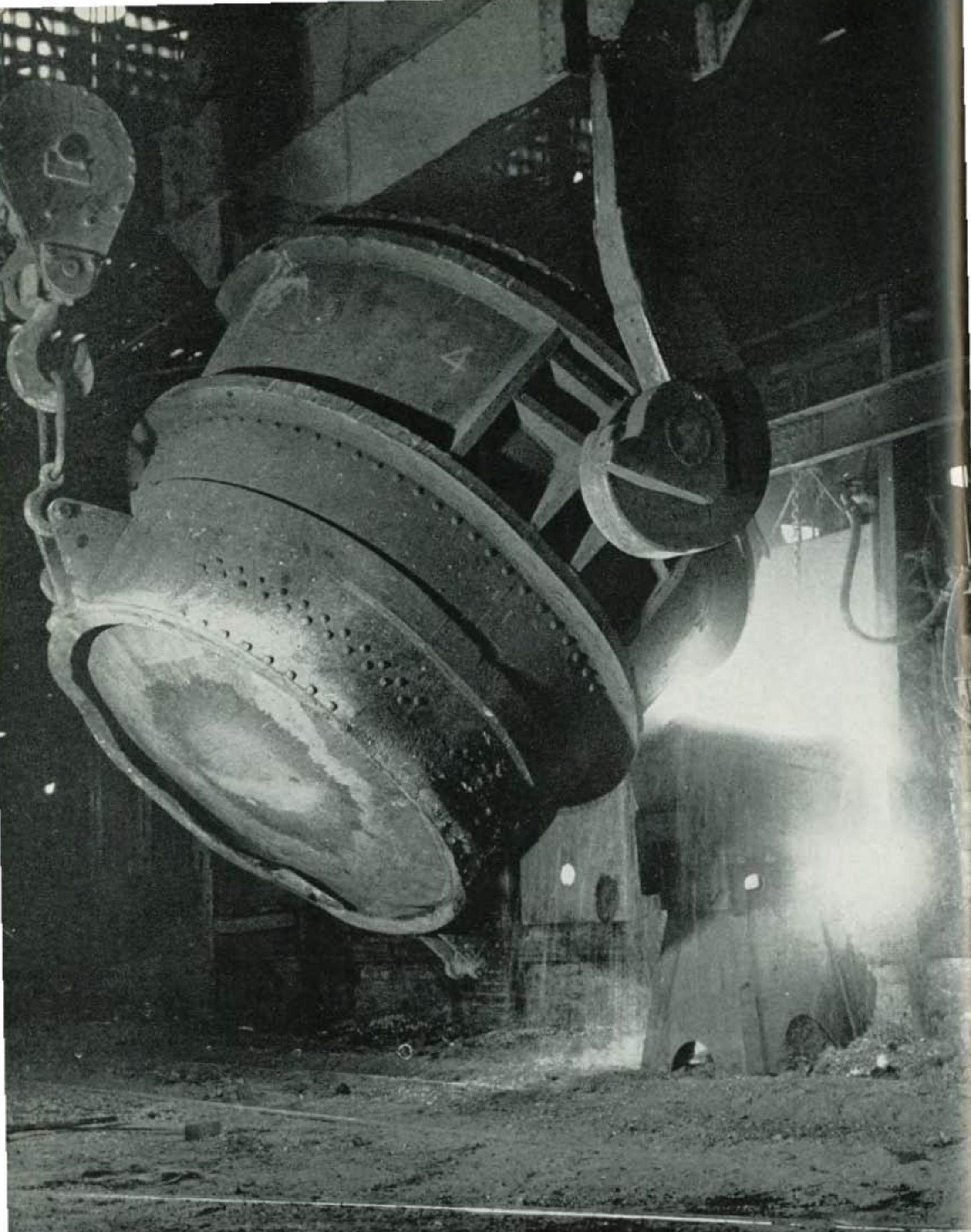
Fontana is situated in one of the largest steel scrap generating areas in the country, providing the plant with a ready supply of low cost scrap for use in the open hearths.

Besides iron ore and coal, the third raw material needed for Fontana's pig iron producing blast furnaces is limestone, which is supplied from Nevada deposits.

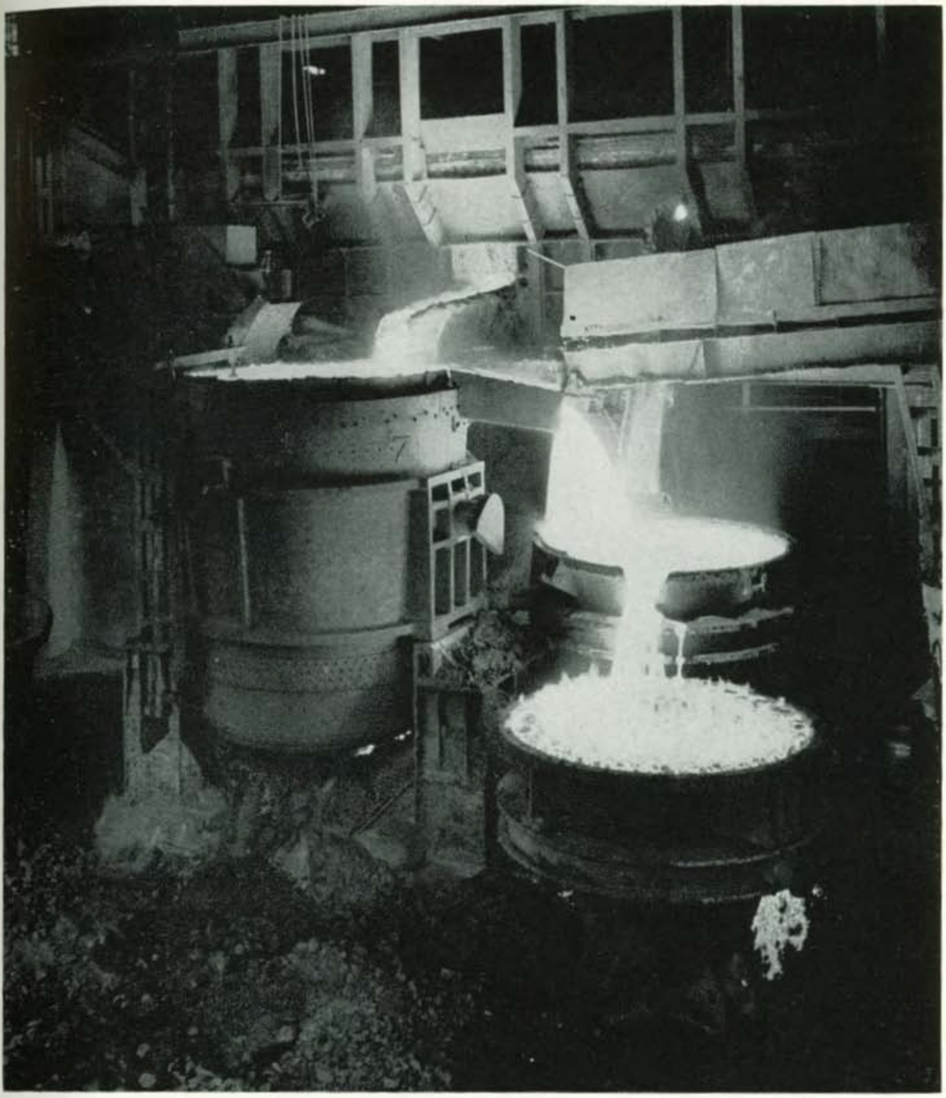


Three blast furnaces, the only ones on the Pacific Coast, give Kaiser Steel a pig iron capacity of 1,314,000 tons per year.

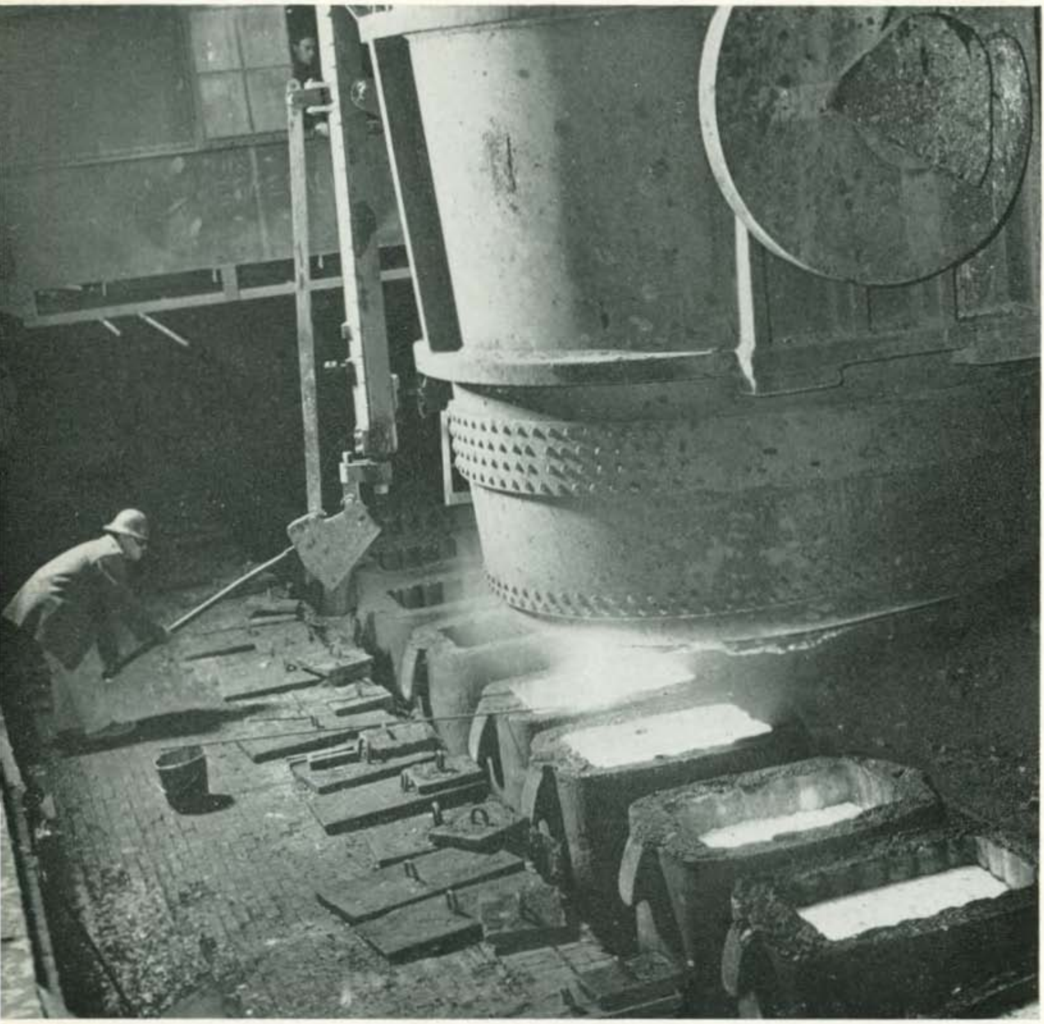
On the casting floor of a Kaiser Steel blast furnace 250 tons of pig iron are drawn off every five hours. Three furnaces are in operation.



Molten iron from the blast furnaces is poured directly into the open hearths to be refined, along with scrap and other ingredients, into high quality steel.



The nine open hearth furnaces at Fontana average 220 tons of steel at each tapping. The mill now has a capacity of 1,550,000 ingot tons per year.



A ladleman operates a stopper rod that permits molten steel to flow through a nozzle in the bottom of the ladle into ingot molds. Ingots are poured in many shapes and sizes to meet varying rolling requirements.

Ingots lose some of their heat after they leave the open hearth building so are reheated in soaking pits to a rolling temperature of approximately 2400° F.

Trained personnel in a variety of departments at Kaiser Steel stand ready to assist customers with their steel problems.

CUSTOMER SERVICES

KAISER CUSTOMER SERVICES

The Kaiser Steel Corporation has within its operating and sales organizations several departments which actively assist customers in selecting and securing their steel requirements, encourage them in the development of markets for their products, aid in market research, freight rate studies, credit problems, advertising problems, and the like.

Metallurgical Engineers. This staff, carefully selected because of its experience and ability to work with customers, is available to provide technical service, make steel recommendations, and give helpful suggestions for the economical processing of steel products to insure that customers receive steel suited to their particular needs.

Quality Control Division. This division exercises close control of all processing operations to insure the production of highest quality steel. Metallurgical observers and mill inspectors oversee steel rolling operations, make dimensional checks, and take samples for testing during the manufacturing processes. The division has completely equipped laboratories and facilities for making chemical and metallurgical investigations, including comprehensive physical tests.

Project Engineers. Included in the sales department, this group makes the services of Kaiser Steel Corporation available to the construction industry by providing designers, fabricators, and contractors with necessary technical and product information. They generate good will for western customer fabricators, jobbers, and manufacturers in the construction industry. They are constantly working in conjunction with the American Iron and Steel Institute in the revision of building and construction codes and specifications so as to safeguard the interests of the steel industry. They are continually developing new markets for the products of customers and assist in the steel and construction industries, in the development of new specifications, uses, and markets for steel.

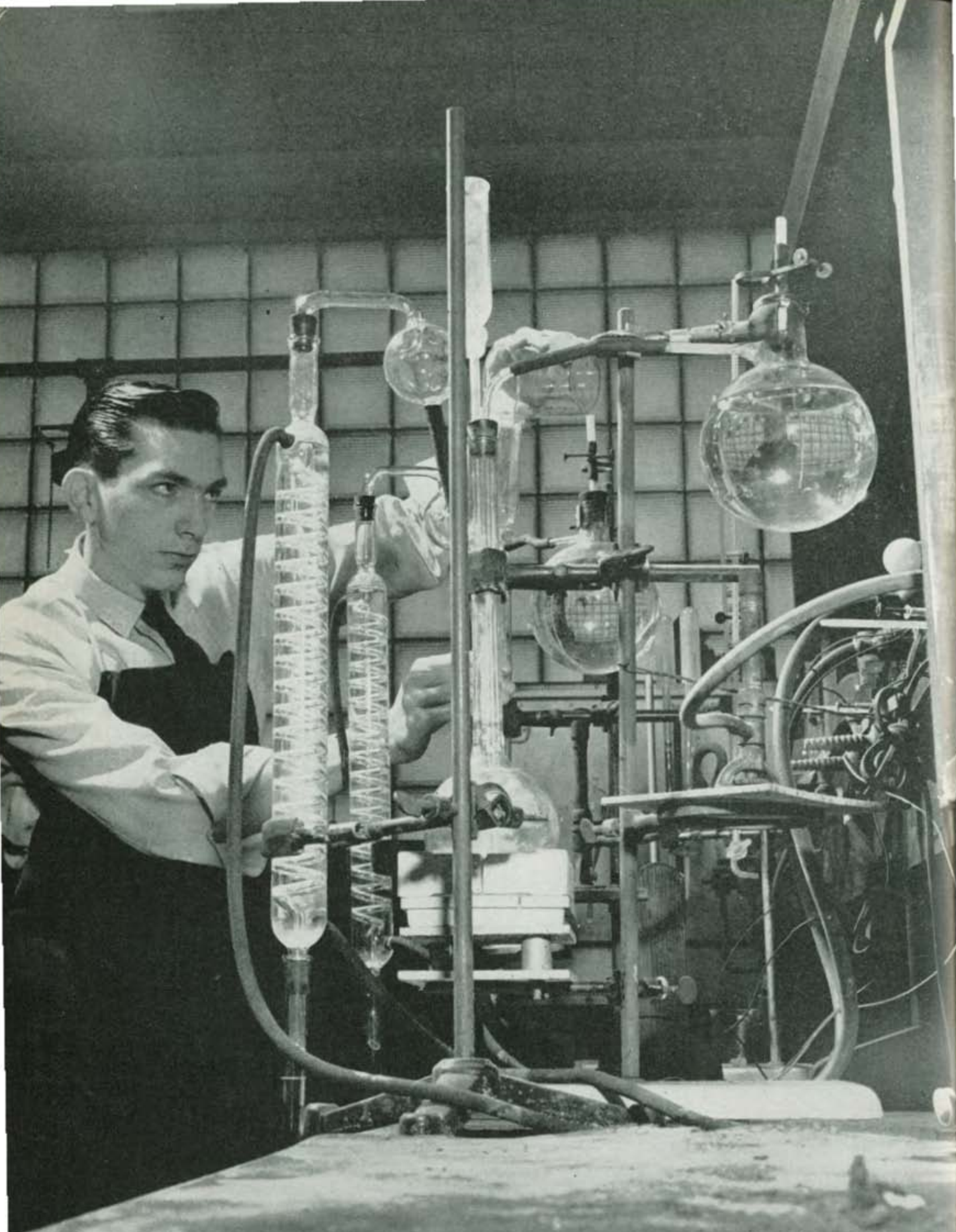
Credit Department. This department is available to assist customers in working out the financial details which arise in connection with the purchase of steel.

Traffic Department. Of valuable assistance to customers in problems incidental to the transportation of steel, this department is constantly engaged in improving transportation service which ultimately reflects economies to all western steel users.

General Planning. This department continually measures and analyzes the requirements of the western steel market. This data is coordinated with other relevant information into plans for the orderly development of facilities which will most efficiently meet the demands of western consumers. An annual summary of western steel consumption is prepared by this department for distribution to interested steel consumers.

These services have been established as an integral part of the Kaiser Steel program, providing customers with complete service facilities to augment its steel producing units. It is fully intended that these services be still further extended and improved to keep pace with the ever-expanding steel-making operations.

A trainload of Basalt-Kaiser steel line pipe heads for gas producing country where the 40-foot lengths will be welded into a continuous state-spanning pipe line. Whether shipment is by rail or truck the Kaiser Traffic Department expedites the shipment, plans the routing and checks the freight rates.



Research and development projects are continually in progress in the steel mill's laboratories, resulting in new products designed for Western needs.

CLASSIFICATION OF STEELS

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CLASSIFICATION OF STEELS

TYPES OF STEELS, CLASSIFIED BY METHOD OF MANUFACTURE

The steel industry, in keeping pace with mounting demands for steel, has demonstrated the economy of the blast furnace process for reducing iron ore to iron, and the open hearth process for making steel from iron and scrap.

The blast furnace reactions are essentially reducing while the controlling reactions of the open hearth process are oxidizing. When steel is being made in the open hearth furnace and the oxidizing reactions have reached the desired stage, the liquid metal contains oxygen. This oxygen reacts with the carbon in the steel to form gas. Unless the oxygen is eliminated or combined with a deoxidizer before the liquid steel is cast into molds, gas evolution will continue during its solidification in the mold. It is the method of deoxidizing or making use of the gases evolved during solidification that determines the type of steel which is made of the liquid metal.

The grades of steel which may be produced in the open hearth furnace can be made to vary in chemical composition from almost pure iron to a product of complex alloy. Finished steels which are produced with chemical compositions within the specified limits of a given grade, however, can have widely dissimilar chemical and physical characteristics due to pouring and rolling practices. Kaiser Steel Corporation employs every known modern practice to improve internal conditions and surface quality, such as hot topping, controlled heating and rolling practices, special discard, controlled cooling, special surface preparation, and inspection procedures.

Ingots are generally cast in molds made of cast iron. The molds are tapered and are normally larger at the bottom than at the top so that they may be readily stripped from the cast ingot. The cross section of most ingots approximates a square or rectangle with rounded corners and their height is always the greater dimension. Ingots are generally cast with the big end down. For certain purposes, however, they may be cast with the big end up and sometimes they are cast with a sink head or hot top.

The size and shape of the ingot influences the character and magnitude of the phenomena of gas evolution and the resulting chemical segregation which occurs during steel solidification. Other complicating factors which affect the amount of segregation are the casting temperature and the inherent segregating characteristics of the elements in the steel.

Kaiser Steel Corporation makes four types of steels, namely: Killed, Semi-Killed, Capped and Rimmed. Each type is made for distinct purposes and each has inherent advantages and characteristics which determine its economic use.

KILLED steels are deoxidized steels. They lie quietly in the molds with only slight gas evolution, but a shrinkage cavity, commonly termed "pipe," forms in the top of the ingots during solidification. Provision is always made to discard that part of the ingot containing pipe. Killed steels are characterized by improved internal soundness and more uniform chemical composition. Their structure and hardenability may be controlled to give a desired response to heat treatment. Most higher carbon steels and the alloy steels are produced as killed steels.

SEMI-KILLED steels are partially deoxidized. The degree of deoxidation used in making this type of steel produces ingots having less segregation than rimmed steel and less "pipe" than killed steel. Kaiser Semi-killed Rolled Steel Products have internal soundness and good surface. They are widely used for plates, structurals, bars and other applications and comprise the major portion of the tonnage produced by Kaiser Steel Corporation for structural purposes.

CAPPED steels are those in which the controlled gas evolution is stopped shortly after the ingot is cast by freezing over the top of the ingot. Gas formed after the ingot is capped remains within the ingot and counteracts shrinkage during solidification. Capped steels are somewhat similar to rimmed steels in structure. They are used interchangeably with rimmed steels or with semi-killed steels for selected applications where their characteristics and economic factors make them the logical type of steel.

RIMMED steels are not deoxidized. An evolution of gas is allowed to occur while the steel freezes inward to form a rim surrounding the ingot. As a result of the gas evolution, rimmed steel ingots have a rim of higher purity metal while the central part or core contains more carbon, phosphorus and sulphur than the average content of the ingot. Rimmed steels are generally made low in carbon. They form a large part of the nation's steel tonnage and are used for innumerable purposes because of their economy, sound surface and good drawing properties.

TYPES OF STEELS CLASSIFIED BY CHEMISTRY

CARBON STEEL is so classified when no minimum content is specified or required for Aluminum, Boron, Chromium, Cobalt, Columbium, Molybdenum, Nickel, Titanium, Tungsten, Vanadium or Zirconium, or any other element added to obtain a desired alloying effect; when the specified minimum content for Copper does not exceed 0.40 per cent; or when the maximum content specified for any of the following elements does not exceed the percentage noted: Manganese, 1.65 per cent; Silicon, 0.60 per cent; Copper, 0.60 per cent.

In all carbon steels small quantities of certain residual elements that are not specified or required are unavoidably retained from raw materials, such as Copper, Nickel, Molybdenum, Chromium, etc. These elements are considered as incidental and are not normally determined or reported.

ALLOY STEEL is so classified when the maximum of the range given for the content of alloying elements exceeds one or more of the following limits: Manganese, 1.65 per cent; Silicon, 0.60 per cent; Copper, 0.60 per cent; or in which a definite range or a definite minimum quantity of any of the following elements is specified or required within the limits of the recognized commercial field of alloy steels: Aluminum, Boron, Chromium up to 3.99 per cent, Cobalt, Columbium, Molybdenum, Nickel, Titanium, Tungsten, Vanadium, Zirconium, or any other alloying element added to obtain a desired alloying effect.

Small quantities of certain elements are present in alloy steels which are not specified or required. These elements are considered as incidental and may be present to the following maximum amounts: Copper, 0.35 per cent; Nickel, 0.25 per cent; Chromium, 0.20 per cent and Molybdenum, 0.06 per cent.

COMMONLY SPECIFIED ELEMENTS

The effects of a single element on steel-making practice or steel properties are influenced by the effects of other elements. These interrelations, frequently of a complex nature, must be considered when evaluating a change in specified composition.

The first four elements briefly discussed in the following paragraphs are those most generally specified in carbon steel.

Carbon. The surface quality becomes impaired as the carbon content increases in rimmed steels. By contrast, killed steels have poorer surface in the lower carbon grades. Carbon segregates within the ingot, and because of its major effect on properties its segregation is frequently of more significance than that of other elements.

Carbon is the principal hardening element in steel, and as carbon increases, the hardness of steel increases. Tensile strength also increases as the carbon increases up to about 0.85 per cent carbon. Ductility and weldability decrease with increasing carbon.

Manganese. This element has a lesser tendency than carbon to segregate within the ingot. Manganese is beneficial to surface quality in all carbon ranges, particularly so in high sulphur steels. The one exception is extremely low carbon rimmed steels.

Manganese contributes to strength and hardness, but to a lesser degree than carbon. The amount of increase in these properties is dependent upon the carbon content, i.e., higher carbon steels are affected more by manganese than lower carbon steels. Increasing the manganese content decreases weldability, but to a lesser extent than carbon. Manganese increases the rate of carbon penetration during carburizing.

Phosphorus has a tendency to segregate within the ingot, being exceeded in this respect usually by sulphur and carbon.

Generally, increased phosphorus results in greater strength and hardness and in less ductility and notched impact toughness. This is particularly true in higher carbon steels that are quenched and drawn. Phosphorus improves resistance to atmospheric corrosion, and in the lower carbon steels it improves machinability.

Sulphur has a greater tendency to segregate within the ingot than any of the common elements. It is detrimental to surface quality, particularly in the lower carbon and lower manganese steels.

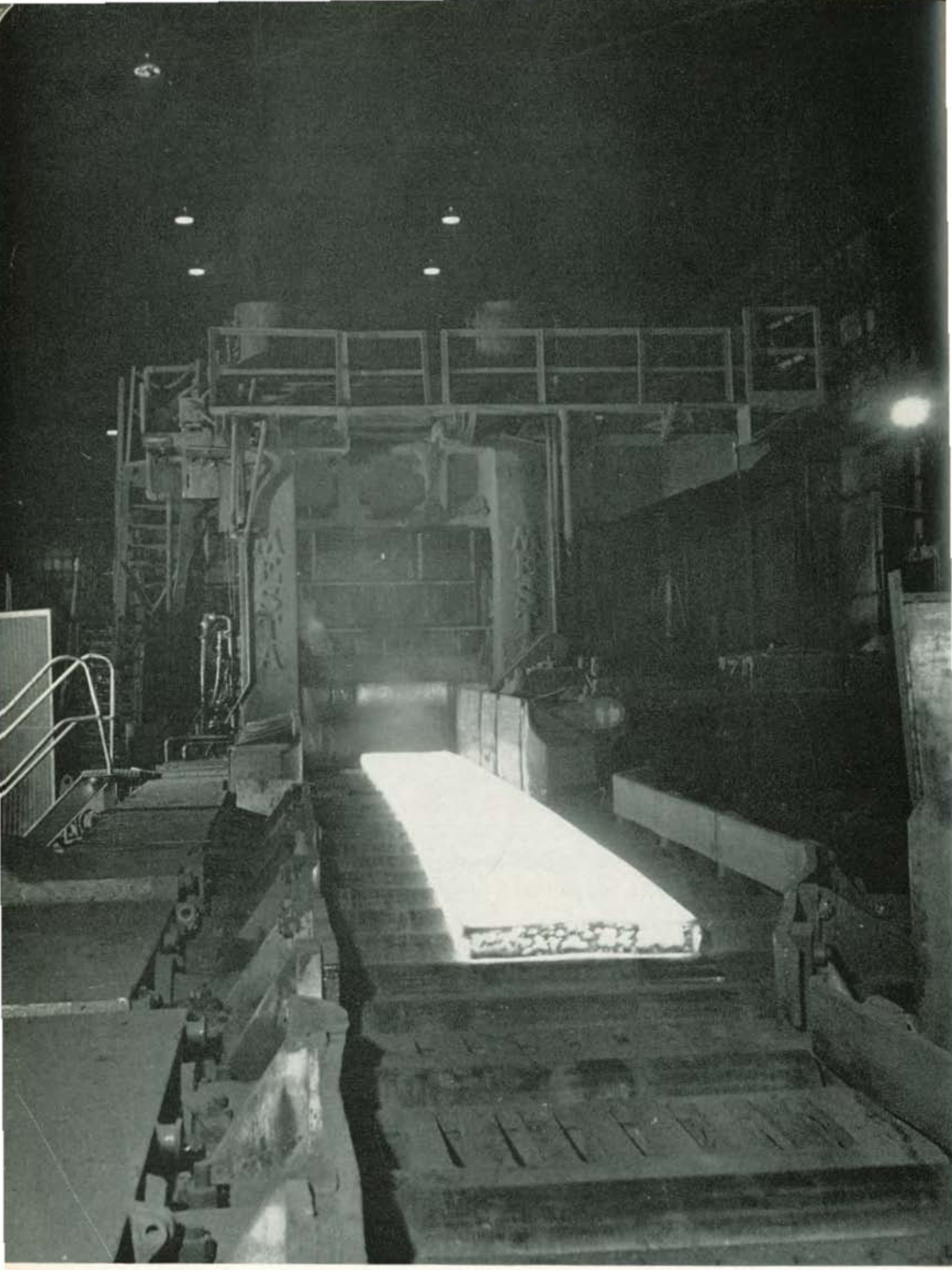
Generally, increased sulphur results in decreased transverse ductility and notched impact toughness, but has only a slight effect on longitudinal mechanical properties or hardness. Sulphur is beneficial to machinability, and the improvement in this characteristic is the only reason for adding sulphur to steel. Weldability decreases with increasing sulphur.

Silicon is one of the principal deoxidizers used in steel-making, and, therefore, the amount of silicon present is related to the type of steel. Silicon is somewhat less effective than manganese in increasing strength and hardness. It has only a slight tendency to segregate within the ingot. In the lower carbon steels, silicon is detrimental to surface quality and this condition is more pronounced in the lower carbon resulphurized grades.

COPPER has a moderate tendency to segregate within the ingot. Since copper is not removed by any of the conventional steel-making processes, it is becoming increasingly difficult to maintain low copper maxima. Copper is detrimental to surface quality and exaggerates surface defects inherent in high sulphur steels.

Copper in appreciable amounts is detrimental to hot working operations. It affects forge welding adversely, but does not seriously affect arc or acetylene welding.

In the small amounts used in carbon steels, copper has no significant effect on mechanical properties. It is, however, beneficial to atmospheric corrosion resistance when present in sufficient amounts.



In the 36-inch blooming mill ingots are reduced to slabs and blooms. Here a slab emerges from the bloomer on its way to the plate mill.

SEMI-FINISHED PRODUCTS

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KAISER SEMI-FINISHED PRODUCTS

Semi-finished products are classified as blooms, billets, slabs and sheet bars. No invariable rule prevails for distinguishing between the terms blooms and billets. The terms are used interchangeably, their chief distinction being their difference in cross-sectional area.

Semi-finished products are usually ordered for further conversion by rerolling or forging. Rerolling quality is suitable for conversion to such products as sheets, tin plate, plates, shapes, bars and rods. Forging quality is used in making all types of forgings which, after machining, must be free from injurious defects.

Two general manufacturing methods are employed in the production of Kaiser Semi-finished products, the method used being determined by the size and quality of material ordered. In one case, the product is rolled on a 36-inch blooming mill direct from the ingot. In the second case, the ingot is rolled to an intermediate size on a 36-inch blooming mill, conditioned, reheated and rerolled on a 29-inch billet or slab mill to ordered size.

On all Kaiser Semi-finished products, inquiries for sizes not listed are invited for special consideration.

BLOOMS AND BILLETS

TABLE I

SIZES OF KAISER BLOOMS AND BILLETS

Size in Inches	Ft. Wt.	Corner Radius
2½ x 2½	21.25	⅜
2¾ x 2¾	25.71	⅜
3 x 3	30.60	7/16
3½ x 3½	41.18	½
4 x 4	53.79	⅝
5 x 5	83.86	¾
6 x 6	120.76	¾

Blooms and Billets are available in lengths from 10′ to 30′.

Sizes shown are regularly produced. Larger sizes may be produced and inquiries are invited.

SLABS

Kaiser Slabs suitable for rerolling, forging and machining are produced in sizes from 2½ to 3 inches in thickness by 4 to 16½ inches in width. Larger sizes may be produced and inquiries are invited. All lengths are subject to inquiry.

SHEET BAR

TABLE 2

SIZES OF KAISER SHEET BAR

Minimum Width Inches	Thickness Range Inches	Minimum Weight Lbs. per Ft.
7	3/8 to 1 1/8	8.9
8	"	10.2
10	"	12.8
12	"	15.3
14	1/2 to 1 1/2	23.8
16	"	27.2

Sheet Bars are available in lengths from 15′ to 30′.

STANDARD PRACTICES

TOLERANCES

Semi-finished products are produced to nominal cross section within a weight tolerance of plus or minus 5 per cent for individual pieces and plus or minus 2½ per cent for carload lots. No dimensional tolerances apply.

Semi-finished products are ordered in tons of 2,000 pounds and are invoiced on mill scale weights. The theoretical weight of steel is calculated on the basis of 0.2833 lb. per cubic inch. In check weighing by the purchaser, variation from invoiced weights up to one per cent is normal expectancy due to possible scale variations. Over or under shipment of 10 per cent is considered standard within the industry.

CUTTING

In general practice, semi-finished products are cut to length by hot shearing. Other methods, such as hot sawing or flame cutting, are also used.

END PREPARATION

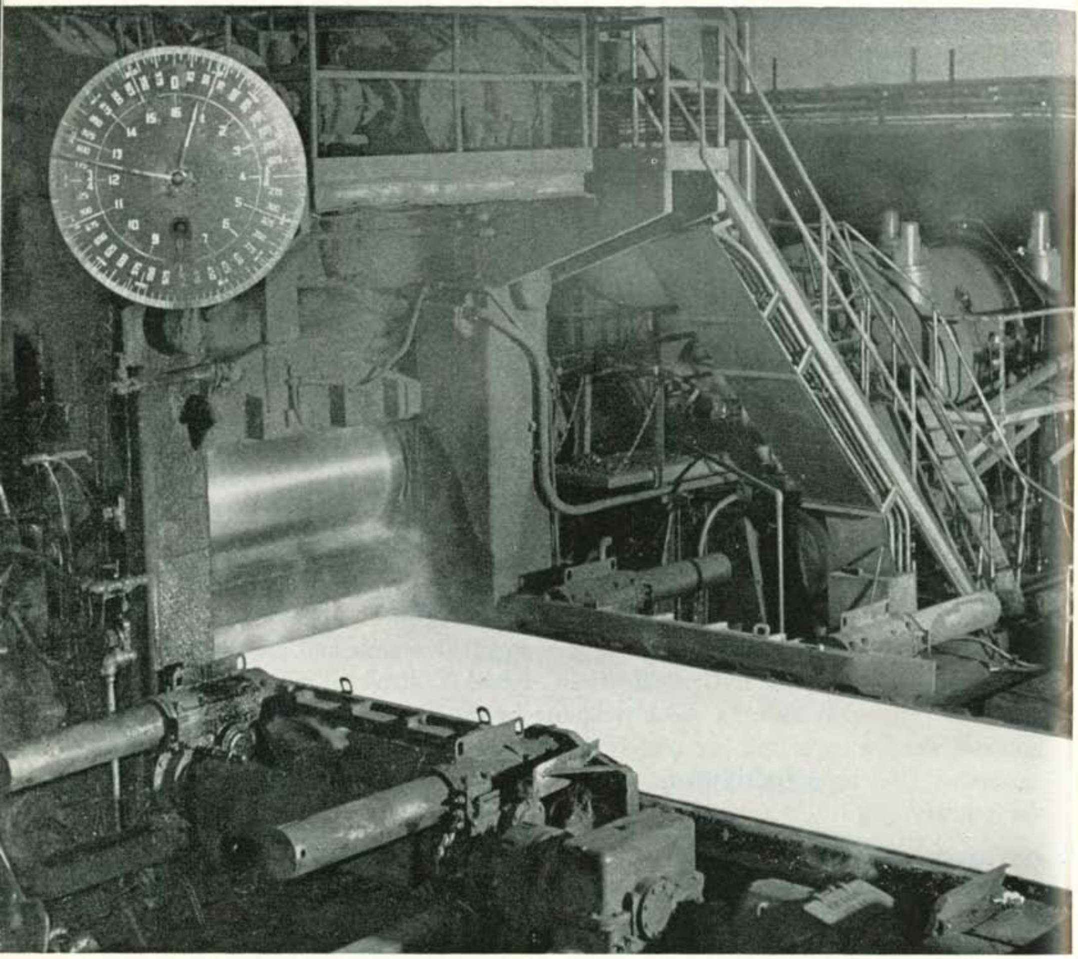
When the end distortion or burrs normally encountered in regular mill cutting methods are not satisfactory to the purchaser, end preparation can be performed by chipping, grinding, or other means, dependent upon facilities available.

SURFACE CONDITIONING

Semi-finished steel products normally contain surface imperfections in varying degrees after the final rolling operation. Depending upon the specified quality and end use of the product, semi-finished products may be conditioned by removing injurious surface imperfections by chipping, scarfing, or grinding.

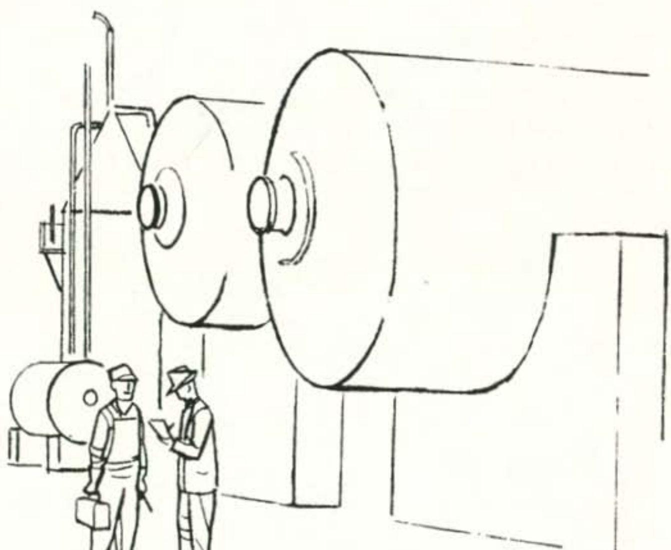
INSPECTION

When the purchaser's specifications stipulate that inspection and testing (except check analyses) for acceptance of the steel be made prior to shipment from the mill, Kaiser Steel Corporation affords the purchaser's inspector all reasonable facilities to determine that the steel is being furnished in accordance with the specification.



Kaiser Steel plate is finished on this "three-high" mill stand in widths up to 96 inches. The large dial indicates roll setting, permitting accurate control of the plate's thickness.

PLATE



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KAISER PLATE

Within the steel industry, flat rolled steel products over 6 inches wide and .2300 inch or more in thickness to over 48 inches wide and .1800 inch or more in thickness are generally classified as plate. Sheared plate has all edges trimmed. Universal Mill or U. M. plate is produced with rolled edges and is sheared to length.

Plates are used in the construction of bridges, buildings, dams, towers and other stationary structures. Large amounts of plate are used in the transportation industry for locomotives, ships, railroad cars and heavy trucks. Steel plates are used extensively in the farm and industrial machinery field, and for pressure vessels in the chemical and oil industry. Large tonnages of plates are required for tank cars, pipe lines, storage tanks and containers for transport and storage of liquids and gases.

Kaiser Sheared Plates and Universal Mill Plates are rolled to numerous industry specifications, including quality classifications. Examples of the more common of these specifications are given on pages 206-215. All plates produced by Kaiser Steel Corporation are rolled from slabs. All slabs are subject to inspection and surface conditioning before rolling.

Kaiser Steel Corporation's sheared plate mill consists of two units: a two-high reversing, roughing mill and a 110-inch three-high finishing mill. The maximum width of plates rolled on this mill is 96 inches. The rolling facilities also include an 86-inch continuous mill having six stands of four-high rolls, built in tandem with the plate mill. This mill finishes plates of lighter gages in widths up to 72 inches.

Universal Mill Plate, having edges which are formed in the rolling of the plate, is produced in the thicknesses of $\frac{1}{4}$ inch to $\frac{3}{8}$ inch inclusive, on the Company's skelp mill, and in thicknesses of $\frac{1}{2}$ inch to $1\frac{1}{2}$ inches, inclusive, on the Company's 29-inch structural mill.

TABLE 3

SIZES OF KAISER PLATE

Maximum Length (Inches)

Thickness	Wt. per Sq. Ft. in Lbs.	WIDTH OF PLATE IN INCHES										Thickness
		Over 36″ to 42″	To 48″	To 54″	To 60″	To 66″	To 72″	To 78″	To 84″	To 90″	To 96″	
3/16	7.65			480	480	480	480	480	480			3/16
1/4	10.20		480	480	480	480	480	480	480	480		1/4
5/16	12.75	480	480	480	480	480	480	480	480	480	420	5/16
3/8	15.30	480	480	480	480	480	480	480	480	480	480	3/8
7/16	17.85	480	480	480	480	480	480	480	480	480	480	7/16
1/2	20.40	480	480	480	480	480	480	480	480	480	480	1/2
9/16	22.95	480	480	480	480	480	480	480	480	480	480	9/16
5/8	25.50	480	480	480	480	480	480	480	480	480	480	5/8
11/16	28.05	480	480	480	480	480	480	480	480	480	458	11/16
3/4	30.60	480	480	480	480	480	480	480	480	480	420	3/4
7/8	35.70	480	480	480	480	480	480	443	411	384	360	7/8
1	40.80	480	480	480	480	456	420	384	360	336	315	1
1 1/8	45.90	480	480	480	451	407	373	344	320	298	273	1 1/8
1 1/4	51.00	480	480	448	402	366	366	310	288	263		1 1/4
1 3/8	56.10	480	458	407	366	333	305	282	261	244		1 3/8
1 1/2	61.20	480	420	373	336	305	280	258	240	224		1 1/2
1 3/4	71.40	411	360	320	288	261	240	221	205			1 3/4
2	81.60	360	315	280	252	229	210	192	180			2
2 1/4	91.80	320	280	248	224	203	186	172	160			2 1/4
2 1/2	102.00	288	252	224	201	183	168	155	144			2 1/2
2 3/4	112.20	262	229	203	183	166	152	141				2 3/4
3	122.40	240	210	186	168	152	140					3
3 1/4	132.60	221	193	172	155	141						3 1/4
3 1/2	142.80	205	180	160	144	130						3 1/2
3 3/4	153.00	192	168	149	134							3 3/4
4	163.20	180	157	140	126							4

Sheared or Gas cut circles in thicknesses of 3/16″ through 4″ and in diameters within the range of widths shown for the thickness are available by special arrangement.

TABLE 4

SIZES OF KAISER U. M. PLATE

Weight Per Foot in Lbs.

Thickness	¼″ (.250)	5/16″ (.312)	⅜″ (.375)	½″ (.500)	⅝″ (.625)	¾″ (.750)	⅞″ (.875)	1″ (1.00)	1¼″ (1.25)	1½″ (1.50)
Width in Inches	Max. .85 Carbon			Max. .60 Carbon						
	72″ to 126″ lengths or 168″ to 252″ lengths			120″ to 480″ lengths						
7	5.950	7.438	8.925	11.90	14.88	17.85	20.83	23.80	29.75	35.70
8	6.800	8.500	10.200	13.60	17.00	20.40	23.80	27.20	34.00	40.80
9	7.650	9.563	11.480	15.30	19.13	22.95	26.78	30.60	38.25	45.90
10	8.500	10.630	12.750	17.00	21.25	25.50	29.75	34.00	42.50	51.00
11	9.350	11.690	14.025	18.70	23.38	28.05	32.73	37.40	46.75	56.10
12	10.200	12.750	15.300	20.40	25.50	30.60	35.70	40.80	51.00	61.20
	Max. .25 Carbon									
13	11.050	13.810	16.575	22.10	27.63	33.15	38.68	44.20	55.25	66.30
14	11.900	14.880	17.850	23.80	29.75	35.70	41.65	47.60	59.50	71.40
15	12.750*	15.940*	19.125	25.50	31.88	38.25	44.63	51.00	63.75	76.50
16	13.600*	17.000*	20.400	27.20	34.00	40.80	47.60	54.40	68.00	81.60

*All ¼″, 5/16″, ⅜″ sizes can be produced in coils except those marked by an asterisk.
U. M. plate of special sizes and chemistry may be produced upon special arrangement.

DIMENSIONS OF PLATE

THICKNESS of plate may be designated either in inches or in pounds per square foot, except that thickness of plate intended for pressure vessels and plate in excess of 81.6 pounds per square foot, is customarily expressed in inches. Plate weight is calculated on a theoretical weight of 40.8 pounds per square foot per inch of thickness.

When plate thickness is specified in inches, the thickness is measured ⅜ inch in from the longitudinal edge, and will not customarily be under the standard tolerance of .010 inches. Variation in weight will generally be over the theoretical weight because: (1) the edge thickness may vary above the required minimum, (2) the plate may be slightly crowned due to rolling conditions and (3) dimensions may vary as a result of shearing. Plate may be ordered to a maximum and minimum thickness in inches, but such orders are subject to negotiation. The allowable variations in plates ordered to thickness are shown in Tables 5, 6, and 8 on pages 42 and 43.

When thickness is specified in pounds per square foot, the plate is rolled to average weight and the thickness on the longitudinal edges will be less than the equivalent for the specified weight. Due to rolling conditions, the plate increases slightly in gage toward the middle. The allowable variation in weight for plate ordered to weight per square foot is shown in Table 7 on page 43.

Width and Length of Plate are ordinarily expressed in inches. If the plates are for resquaring, suitable shearing allowances beyond normal variations should be provided. The greater of the two surface dimensions is generally considered length unless otherwise stipulated. When direction of rolling is important, the dimension required as length should be definitely indicated.

Allowed standard variations in width and length for plates, and restrictive shearing tolerances are given by the Shearing Tables on pages 44 and 45.

SPECIAL CONSIDERATIONS

The difficulty of shearing plate increases with its thickness and hardness, making it necessary for heavy plate to be gas cut. Plates are commonly conditioned for the removal of surface imperfections by grinding, or welding followed by grinding. Plates are sometimes pickled or blast cleaned prior to surface inspection. Sometimes special tests, such as macroetch, impact, segregation, and homogeneity tests and magnetic particle inspection are required before shipment. Orders for plates necessitating special surface conditioning or closer inspection than customarily employed, are subject to negotiation.

MANUFACTURE—TESTS—INSPECTION

All Kaiser Plate is subject, during manufacture, to mill inspection and tests for control of quality and workmanship. Test specimens for physical and chemical tests prescribed by the specification to which the plate is produced are taken in duplicate from the parent plates as they are laid out for shearing to ordered size. Hundreds of tests are performed each day. Metallurgical test reports are furnished to customers as stipulated by the specification or order. All tests required to assure adherence to the specification are made before the shipment is released. The purchaser's inspection representative will be afforded all reasonable facilities to inspect material during manufacture and prior to shipment.

QUALITY

Steel quality, as the term relates to plate products, is indicative of many conditions, such as degree of internal soundness, relative uniformity of mechanical property characteristics, chemical composition and relative freedom from injurious defects. Combinations of these conditions determine the quality of the plate.

The list of plate qualities shown on page 40 indicates grades of plate Kaiser

Steel Corporation is prepared to furnish. Inquiries are invited for regular and special quality plates made to meet the requirements of any accepted standard specifications. In Section 19 of this catalog are given a number of standard specifications which are commonly used in industry. Plates over .35 carbon and .60 manganese are, however, acceptable only as killed steel.

REGULAR QUALITY

Regular quality is the common designation for carbon steel plates and is usually specified to chemical composition ranges and limits. When stock steel plates are specified, or when no chemical composition limits are specified, plates having a maximum of 0.33 per cent carbon, based on ladle analysis, are commonly produced.

Plates furnished to chemistry, as stock plate, mild steel plate, or other trade designations, are not customarily produced to mechanical property requirements nor are physical test reports covering such mechanical properties furnished.

SPECIAL QUALITY

Special quality plate has been developed for many classes of service. The production of quality plate for a specific service requires special manufacturing practices, additional metallurgical control and inspection procedures.

The following list of special plate qualities and their applications is given for convenient reference.

STRUCTURAL QUALITY plates are intended for application in structures such as bridges, buildings, structural steel for locomotives, railroad cars and other mobile equipment.

HOT PRESSING QUALITY plates are intended for ordinary hot pressing, flanging or bending work. They are not intended for deep drawing, cold forming, or for pressure vessel construction.

COLD PRESSING QUALITY plates are made of soft steel, which can be bent or formed either longitudinally or transversely at ordinary temperature by good shop practice. Cold bending quality plates are of higher tensile strength and are used where greater design stresses with less severe forming are contemplated.

DRAWING QUALITY plates are produced of low carbon steel suitable for drawing into identified forms.

FORGING QUALITY plates are intended for forging, heat treating or similar purposes in which uniformity of composition and freedom from injurious defects are essential. Plates of this quality are produced by a killed steel practice to chemical ranges and limits.

FLANGE, FIREBOX, LOCOMOTIVE FLANGE, LOCOMOTIVE FIREBOX AND MARINE QUALITIES necessitate rigid controls and close supervision of mill practices, which are based on experience in producing each given grade of special quality plate, together with inspection at all stages in the process of manufacturing. The freedom and scope of application of steel for the several qualities are of necessity progressively limited as the end use becomes more severe.

Flange quality plates are intended for application in pressure vessels and for similar purposes except when exposed to fire or radiant heat.

Firebox quality plates are intended for application in pressure vessels when exposed to fire or radiant heat where they are subject to thermal and mechanical stresses. Firebox quality plates may also be used for unfired pressure vessels in lieu of flange quality and for similar purposes.

Locomotive flange quality plates are used in the construction of locomotive boilers.

Marine quality plates are intended for application in pressure vessels and combustion chambers of marine boilers and are commonly processed to meet the requirements of marine engineering inspection. This quality is made to a killed steel practice and with an additional discard.

STANDARD PRACTICE TABLES

Variations for Dimensions and Workmanship
All dimensions in inches unless otherwise shown

The accuracy of hot rolled dimensions is influenced by many factors such as heating practice, reduction between passes, roll wear, roll pressure, and composition of steel. The cumulative effect of these, as well as other factors, precludes hot rolling to exact specified size and thickness and requires that provisions be made for variations.

The accompanying tables indicate the dimensional and weight variations as may be expected in Kaiser Plates.

TABLE 5

THICKNESS

Plates Over Two Inches in Thickness

Rectangular Plates and Universal Mill Plates

Specified Thicknesses, Inches	Variations Over Specified Thickness for Widths Given, Inches			
	To 36 excl.	36 to 60 excl.	60 to 84 excl.	84 to 96 incl.
Over 2 to 3, excl.	1/16	3/32	7/64	1/8
3 to 4, excl.	5/64	3/32	7/64	1/8
4	3/32	1/8	9/64	9/64

Variation under specified thickness, 0.01 inches.

TABLE 6

THICKNESS AND WEIGHT WHEN ORDERED TO THICKNESS

Plates Two Inches and Under in Thickness

Rectangular Plates and Universal Mill Plates

Specified Thicknesses, Inches	Excess in Average Weight of Lots* for Widths Given in Inches, Expressed in Percentages of Nominal Weights				
	48 and under	48 excl. to 60 excl.	60 to 72 excl.	72 to 84 excl.	84 to 96 incl.
To 1/4 excl.	7.0	8.0	9.0	10.0	12.0
1/4 to 5/16 excl.	6.0	7.0	8.0	9.0	10.0
5/16 to 3/8 excl.	5.0	6.0	7.0	8.0	9.0
3/8 to 7/16 excl.	4.5	5.0	6.0	7.0	8.0
7/16 to 1/2 excl.	4.0	4.5	5.0	6.0	7.0
1/2 to 5/8 excl.	4.0	4.0	4.5	5.0	6.0
5/8 to 3/4 excl.	4.0	4.0	4.0	4.5	5.0
3/4 to 1 excl.	3.5	4.0	4.0	4.0	4.5
1 to 2 incl.	3.5	3.5	4.0	4.0	4.0

Variation under specified thickness, 0.01 inches.

Variations in overweight for circular and sketch plates are 25% greater than the amounts given in the above Tables.

Variations in overweight for single plates are 1⅓ times the amount indicated above.

The adopted standard density for rolled steel is 0.2833 pound per cubic inch.

*The term lot means all the plates of each tabular width and thickness group represented in each shipment.

TABLE 7
WEIGHT WHEN ORDERED TO WEIGHT
Plates 81.6 pounds per square foot and under
Rectangular Plates and Universal Mill Plates

Specified Weights, pounds per square foot	Variation in Average Weight of Lots* for Widths Given in Inches, Expressed in Percentages of the Specified Weights psf.									
	48 and under		48 excl. to 60 excl.		60 to 72 excl.		72 to 84 excl.		84 to 96 incl.	
	Over	Under	Over	Under	Over	Under	Over	Under	Over	Under
To 10 excl.	4.0	3.0	4.5	3.0	5.0	3.0	5.5	3.0	6.0	3.0
10 to 12.5 excl.	4.0	3.0	4.5	3.0	5.0	3.0	5.5	3.0	6.0	3.0
12.5 to 15 excl.	4.0	3.0	4.0	3.0	4.5	3.0	5.0	3.0	5.5	3.0
15 to 17.5 excl.	3.5	3.0	3.5	3.0	4.0	3.0	4.5	3.0	5.0	3.0
17.5 to 20 excl.	3.5	2.5	3.5	2.5	3.5	3.0	4.0	3.0	4.5	3.0
20 to 25 excl.	3.5	2.5	3.5	2.5	3.5	3.0	3.5	3.0	4.0	3.0
25 to 30 excl.	3.0	2.5	3.5	2.5	3.5	2.5	3.5	3.0	3.5	3.0
30 to 40 excl.	3.0	2.0	3.0	2.0	3.0	2.0	3.0	2.0	3.5	2.0
40 to 81.6 incl.	2.5	2.0	3.0	2.0	3.0	2.0	3.0	2.0	3.5	2.0

Variations in weight for circular and sketch plates are 25% greater than the amounts given in the above Tables.

Variations in weight for single plates are 1⅓ times the amount indicated above.

The adopted standard density for rolled steel is 0.2833 pound per cubic inch.

*The term lot means all the plates of each tabular width and thickness group represented in each shipment.

TABLE 8
RESTRICTIVE THICKNESS
Plates Two Inches and Under in Thickness
Rectangular Plates and Universal Mill Plates
Tolerances Over and Under in Decimals of an Inch

Specified Thickness, Inches	Variations* Over and Under Specified Thickness for Widths Given, in Inches			
	12 and under	Over 12 to 24 excl.	24 to 36 excl.	36 to 60 excl.
To ⅜ excl.	0.012	0.012	0.014	0.016
⅜ to ½ excl.	0.012	0.014	0.016	0.018
½ to ¾ excl.	0.014	0.016	0.018	0.020
¾ to 1 excl.	0.016	0.018	0.020	0.022
1 to 1½ excl.	0.020	0.022	0.024	0.026
1½ to 2 incl.	0.024	0.026	0.028	0.030

*Variation under of 0.01 inches is sometimes specified, in which case the variation over is equal to the sum of the over and under tolerances minus 0.01 inches.

TABLE 9

WIDTH AND LENGTH, SHEARED PLATES

One and One-Half Inches and Under in Thickness

Length of Universal Mill Plates

Two and One-Half Inches and Under in Thickness

Specified Dimensions, Inches		Variations over Specified Width and Length for Thickness, Inches, and Equivalent Weights Given							
		To 3/8 excl.		3/8 to 5/8 excl.		5/8 to 1 excl.		1 to 2 incl.*	
		To 15.3 Lb. per Sq. Ft. excl.		15.3 to 25.5 Lb. per Sq. Ft. excl.		25.5 to 40.8 Lb. per Sq. Ft. excl.		40.8 to 81.6 Lb. per Sq. Ft. incl.	
Widths	Lengths	Width	Length	Width	Length	Width	Length	Width	Length
To 60 excl.	To 120 excl.	3/8	1/2	7/16	5/8	1/2	3/4	5/8	1
60 to 84 excl.		7/16	5/8	1/2	11/16	5/8	7/8	3/4	1
84 to 96 incl.		1/2	3/4	5/8	7/8	3/4	1	1	1 1/8
To 60 excl.	120 to 240 excl.	3/8	3/4	1/2	7/8	5/8	1	3/4	1 1/8
60 to 84 excl.		1/2	3/4	5/8	7/8	3/4	1	7/8	1 1/4
84 to 96 incl.		9/16	7/8	11/16	15/16	13/16	1 1/8	1	1 3/8
To 60 excl.	240 to 360 excl.	3/8	1	1/2	1 1/8	5/8	1 1/4	3/4	1 1/2
60 to 84 excl.		1/2	1	5/8	1 1/8	3/4	1 1/4	7/8	1 1/2
84 to 96 incl.		9/16	1	11/16	1 1/8	7/8	1 3/8	1	1 1/2
To 60 excl.	360 to 480 excl.	7/16	1 1/8	1/2	1 1/4	5/8	1 3/8	3/4	1 5/8
60 to 84 excl.		1/2	1 1/4	5/8	1 3/8	3/4	1 1/2	7/8	1 5/8
84 to 96 incl.		9/16	1 1/4	3/4	1 3/8	7/8	1 1/2	1	1 7/8
To 60 excl.	480 to 600 excl.	7/16	1 1/4	1/2	1 1/2	5/8	1 5/8	3/4	1 7/8
60 to 84 excl.		1/2	1 3/8	5/8	1 1/2	3/4	1 5/8	7/8	1 7/8
84 to 96 incl.		5/8	1 3/8	3/4	1 1/2	7/8	1 5/8	1	1 7/8
To 60 excl.	600 to 720 incl.	1/2	1 3/4	5/8	1 7/8	3/4	1 7/8	7/8	2 1/4
60 to 84 excl.		5/8	1 3/4	3/4	1 7/8	7/8	1 7/8	1	2 1/4
84 to 96 incl.		5/8	1 3/4	3/4	1 7/8	7/8	1 7/8	1 1/8	2 1/4

Variation under specified width and length, 1/4 inch.

*Length tolerances apply also to U. M. plates up to 12 inches in width for thicknesses over 2 to 2 1/2 inches inclusive.

TABLE 10

CAMBER

Sheared Plates and Universal Mill Plates

Two Inches and Under in Thickness

$$\frac{1}{8}\text{ in.} \times \frac{\text{number of feet of length}}{5}$$

TABLE 11

RESTRICTIVE SHEARING

One Inch and Under in Thickness

Width and Length of Sheared Plates: Length of Universal Mill Plates

Specified Thickness, Inch	Variations Over Specified Width, In. When Width is, In. To 72, incl.	Variations Over Specified Width, In. When Width is, In. Over 72 to 96 incl.	Variations Over Specified Length, In. When Length is, In. To 120 incl.	Variations Over Specified Length, In. When Length is, In. Over 120 to 240 incl.
To 3/8, excl.	1/8	3/16	3/16	5/16
3/8 to 3/4, excl.	3/16	1/4	1/4	5/16
3/4 to 1, incl.	1/4	5/16	5/16	3/8

Variation under specified widths and lengths, 1/8 inch.

TABLE 12

ROLLED WIDTH, UNIVERSAL MILL PLATES

Two Inches and Under in Thickness

Specified Dimensions, Inches	Variations Over Specified Width for Thickness, Inches, and Equivalent Weights Given			
	To 3/8 excl.	3/8 to 5/8, excl.	5/8 to 1, excl.	1 to 2, incl.
Width	To 15.3 Lb. per Sq. Ft. excl.	15.3 to 25.5 Lb. per Sq. Ft. excl.	25.5 to 40.8 Lb. per Sq. Ft. excl.	40.8 to 81.6 Lb. per Sq. Ft. excl.
Over 6 to 20, excl.	1/8	1/8	3/16	1/4
20 to 36, excl.	3/16	1/4	5/16	3/8
36 and over	5/16	3/8	7/16	1/2

Variation under specified width, 1/8 inch.

TABLE 13

WIDTH AND LENGTH, GAS CUT RECTANGULAR PLATES

Specified Thicknesses, Inches	Variations Over for All Specified Widths, or Lengths, Inch
To 2, excl.	½
2 to 4, excl.	⅝

These variations may be taken all under or divided over and under, if so specified. Plates with universal rolled edges are cut to length only.

TABLE 14

FLATNESS

Rectangular Sheared Plates, Universal Mill Plates, Circular and Sketch Plates

Specified Thickness, Inches	Specified Weights, Lbs. per Sq. Ft.	Variations from a Flat Surface for Widths, Lengths or Diameters, Given, Inches					
		To 36 excl.	36 to 48 excl.	48 to 60 excl.	60 to 72 excl.	72 to 84 excl.	84 to 96 incl.
To ¼ excl.	To 10.2 excl.	⅝	⅞	1 1/16	1⅜	1½	1⅝
¼ to ⅜ excl.	10.2 to 15.3 excl.	9/16	¾	⅞	1 1/16	1¼	1⅜
⅜ to ½ excl.	15.3 to 20.4 excl.	½	⅝	11/16	¾	⅞	1
½ to ¾ excl.	20.4 to 30.6 excl.	7/16	9/16	⅝	11/16	¾	⅞
¾ to 1 excl.	30.6 to 40.8 excl.	7/16	9/16	⅝	11/16	11/16	¾
1 to 2 excl.	40.8 to 81.6 excl.	⅜	½	9/16	⅝	⅝	11/16
2 to 4 incl.	81.6	5/16	⅜	7/16	½	½	9/16

The longer dimension specified is considered the length and the variation in flatness along the length should not exceed the tabular amount for that dimension.

When the length exceeds 144 in. the tolerances shown for 144 in. apply for any 12 ft. 0 in. of the specified width or length.

The variations given in above table apply to plates which have a specified maximum tensile strength of not over 72,000 lbs. per sq. in. or equivalent hardness and to Flange, Firebox and Marine Quality plates up to a specified maximum tensile strength of 90,000 lbs. per sq. in. For plates specified to higher tensile strength or hardness, the figures given in the table are customarily increased by 50 per cent.

The above table and notes also cover the variations for flatness of circular and sketch plates, based on the maximum dimensions.

TABLE 15

DIAMETER, SHEARED CIRCULAR PLATES

One Inch and Under in Thickness

Specified Diameters, Inches	Variations Over Specified Diameter for Thicknesses Given, Inches		
	To 3/8, excl.	3/8 to 5/8, excl.	5/8 to 1, incl.
To 32, excl.	1/4	3/8	1/2
32 to 84, excl.	5/16	7/16	9/16
84 to 96, incl.	3/8	1/2	5/8

No variations under.

TABLE 16

DIAMETER, GAS CUT CIRCULAR PLATES

Four Inches and Under in Thickness

Specified Diameters, Inches	Variations Over Specified Diameter for Thicknesses Given, Inches		
	To 1, excl.	1 to 2, excl.	2 to 4, incl.
To 32, excl.	3/8	1/2	9/16
32 to 84, excl.	7/16	9/16	5/8
84 to 96, incl.	9/16	11/16	3/4

No variations under.

ORDERING PRACTICE FOR KAISER PLATES

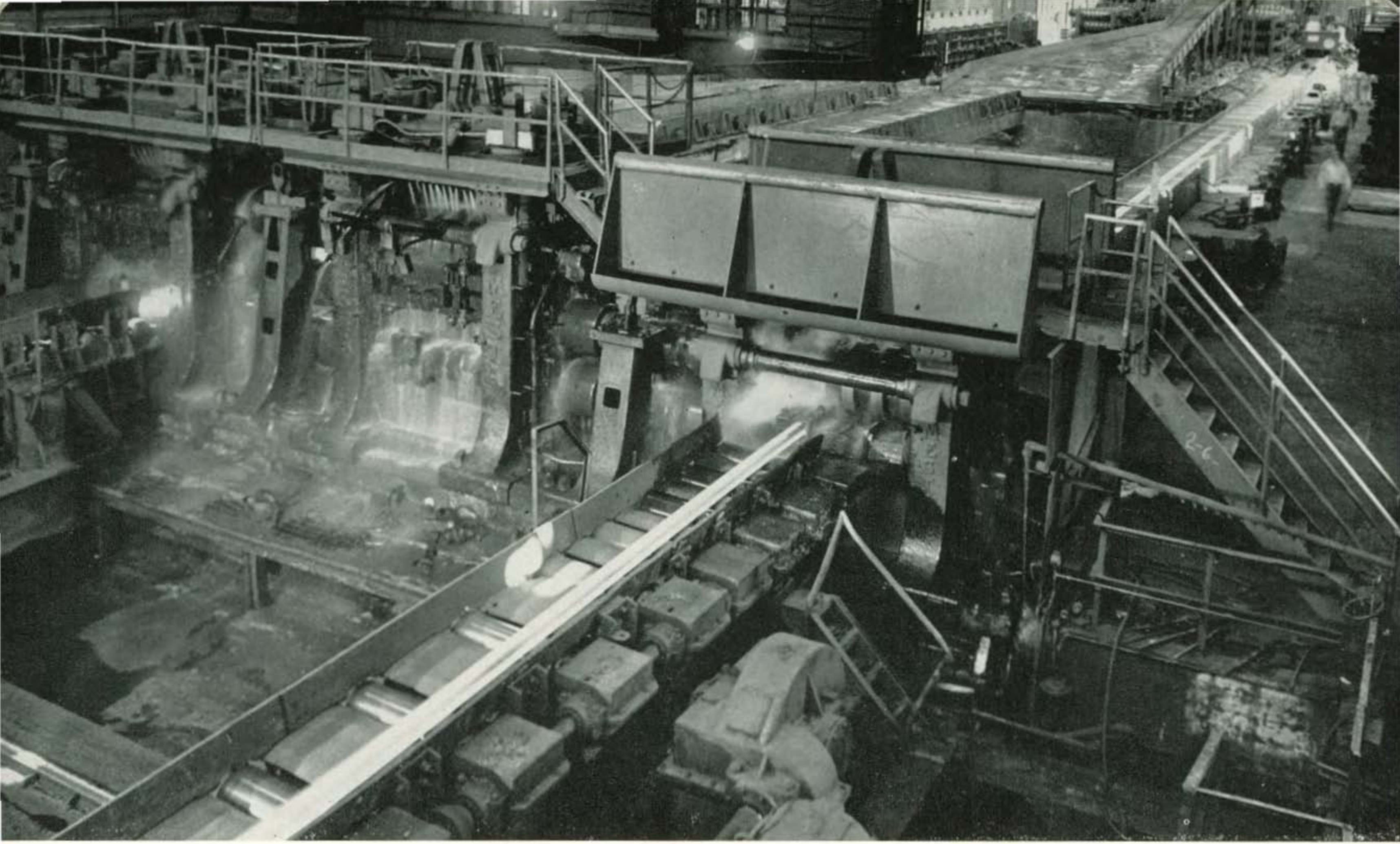
In order to more clearly describe the material desired and to avoid misunderstanding, purchasers' inquiries and orders for Plates should specify the following details:

1. Quantity.
2. Size.
3. Specification.
4. End use.
5. Required inspection, if other than mill inspection.
6. Special loading practices, if applicable.
7. Shipping destination.
8. Required routing.
9. Requested delivery.
10. Distribution of shipping notices, invoices, and bills of lading.

Plates are invoiced on mill scale weights. In checking weight by the purchaser, one per cent is considered a variation in weight to account for difference in kind, type, location and accuracy of the scales and possible errors of the weighers.

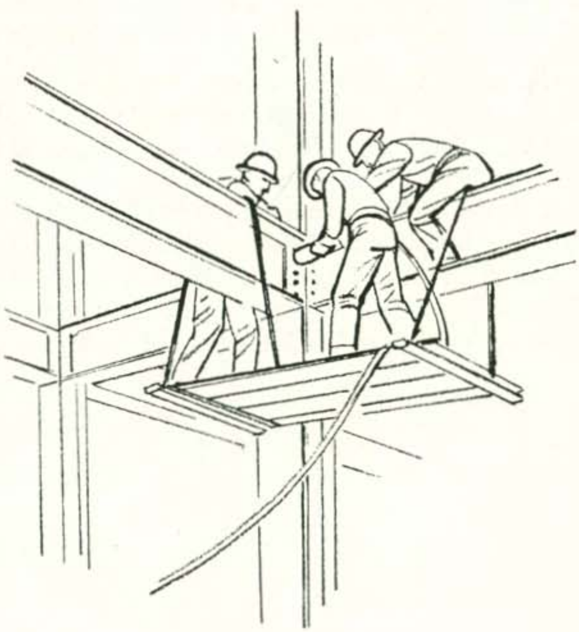
In cases of large quantities of one size and thickness there is the possibility of error in count. For such lots, the count is considered as approximate and weight the more accurate.

NOTES



The structural mill, shown above, produces a wide range of beams, angles, channels and other structural shapes.

STRUCTURAL SHAPES



5

KAISER STRUCTURAL SHAPES

Structural shapes is the general term applied to rolled flanged sections used in the construction of bridges, buildings, towers, ships, railroad rolling stock and for numerous other constructional purposes. In general they consist of equal and unequal leg angles, channels, I beams, H beams or column sections, wide flange beams, bulb angles and tee sections.

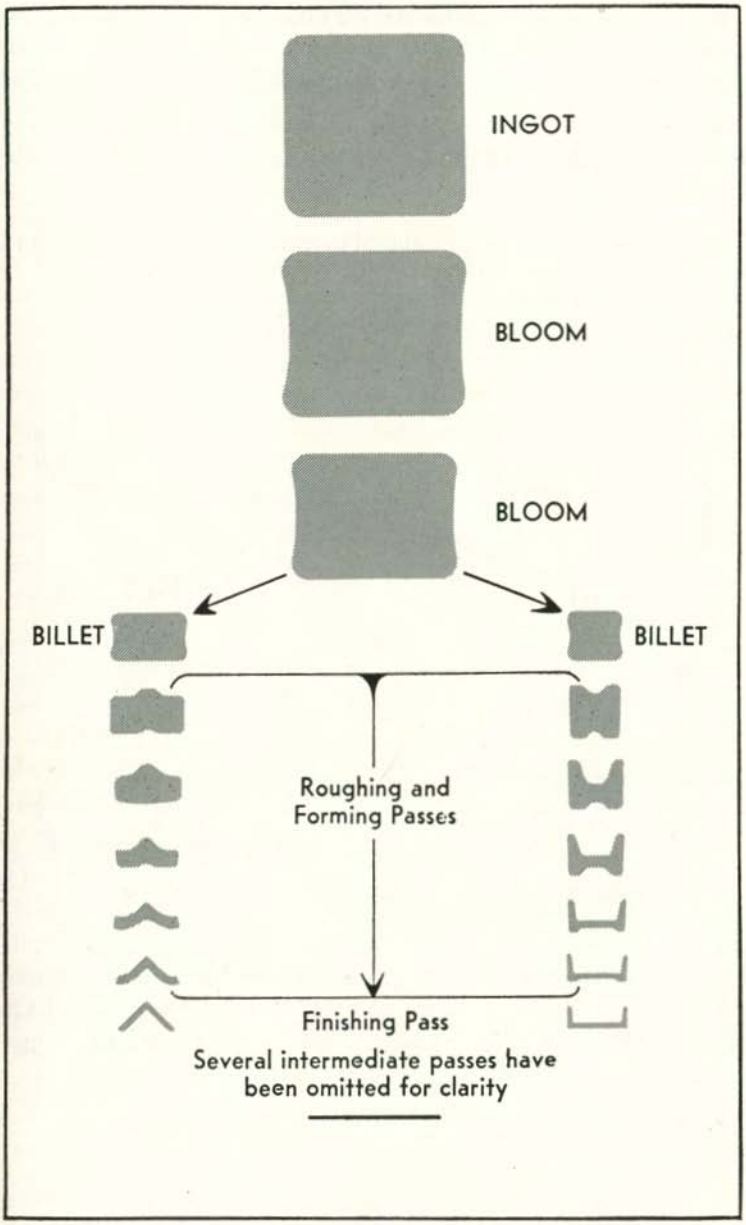
Kaiser Structural Shapes are produced in both regular and special sections. Regular sections are those for which there is a popular and constant demand, such as standard beams, channels, angles, column sections and wide flange beams. Special sections are those that, due to a fluctuating demand, are rolled at irregular intervals or require special rolls. Included in this group are the miscellaneous carbuilding and shipbuilding channels, bulb angles and tee sections.

Structural shapes are produced by passing blooms or billets through a series of grooved rolls. There are three stages in the rolling: first, the roughing, where rough-forming of the section begins; then the intermediate, in which the forming is continued; and finally the finishing passes.

Typical stages in the rolling of structural shapes are shown on page 53. The method of increasing sectional areas and weights of sections from the minimum nominal sizes by spreading the rolls is illustrated on page 54.

Kaiser Structural Shapes are rolled on a 29-inch cross-country mill, composed of a three-high rougher, a three-high intermediate stand and a two-high finishing mill. Structural shapes are rolled from heated blooms which first pass through the rougher taking the form of the pass in that set of rolls. By alternately reversing direction, the steel is progressively formed in following passes until its final shape is accomplished by the finishing rolls, after which the shape is sent to the hot saw for cutting to mill lengths. At this point, samples are taken for laboratory tests. After cooling, the shapes are straightened, inspected, sheared or cold sawed to ordered length and given final inspection before shipment.

Typical stages in the rolling of angles and channels



ROLLING PRACTICE

Kaiser Shapes are rolled to conform to the requirements of standard structural specifications for bridges and buildings, for ships, for locomotives and cars, and for structural silicon steel or high strength low alloy structural steel (Kaisaloy). Material conforming to other specifications may be furnished by special arrangement.

The dimensions and weights of shapes published in this catalog are theoretical and are subject to the usual industry variations.

All Kaiser Shapes are normally produced in lengths up to 65 feet. Longer lengths are subject to special arrangement.

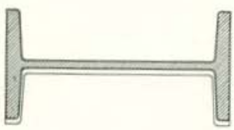


Fig. 1

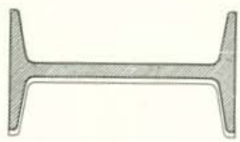


Fig. 2

Fig. 3

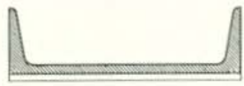


Fig. 4

Figures 1 to 4 illustrate the method of increasing the areas and weights of Kaiser Wide Flange Beams, Column Sections, Standard Beams, and Channels. The thickness of the web may be changed with a corresponding change in the flange width.

Fig. 5

In the case of angles, as shown in Figure 5, equal increments are added to the thickness of each leg, which also slightly increases the length of each leg.

KAISER WIDE FLANGE BEAMS

All segments of the West's construction industry—architects, engineers, contractors, fabricators—have enthusiastically welcomed the decision of Kaiser Steel to produce wide flange structural beams.

Kaiser Wide Flange Beams are proving in countless new structures built by principal western fabricators that they possess all the characteristics required for efficient construction. Engineers and fabricators like them because they offer a bonus in strength.

Kaiser Wide Flange Beams were designed for rolling on the Company's 29-inch structural mill, which is equipped with horizontal rolls. Wide flange beams rolled on this type of mill are slightly larger in area and stronger than other wide flange beams, and the inside faces of the flanges are given a slight taper. Two sizes of beams are offered in each group from 8 to 16 inches. They have substantially the same depth and width as wide flange beams produced on other mills and are, therefore, readily interchangeable in any normal steel structure.

This range of wide flange beams, together with the column sections and standard shapes produced by Kaiser Steel, affords a group of popular structural sections which can be efficiently employed in the design and construction of nearly all steel structures.

The section modulus of the lighter sections of Kaiser Wide Flange Beams about axis x-x and y-y will be found to be approximately 10 per cent and 3 per cent better, respectively, than other wide flange beams, due to the increased weight which is in the flanges. The section moduli of the heavier sections in each group are approximately the same as in other wide flange beams. These beams, therefore, may be used in the construction of any normal steel structure with more than equal efficiency.

The 8 by 6½ inch Kaiser Wide Flange Beams are useful as columns as well as beams. Their radii of gyration approximates those of similar sections, and their area is 10 per cent greater. Other sizes of Kaiser Wide Flange Beams are also popular as columns in many designs due to their increased sectional area.

Kaiser Wide Flange Beams may be split along the web by the fabricator to form T sections for use as truss chords and bracing, and for many other useful purposes. These T sections make excellent stiffeners for general plate work or in barge and ship construction when the web of the T is tack-welded to the plate.

ENGINEERING PROPERTIES

On the following pages are listed complete data on properties for designing and dimensions for detailing on all sizes of structural shapes produced by Kaiser Steel Corporation. Structural shapes of all sizes are sold on the basis of the theoretical weight per foot. The weights of rolled steel shapes in the following tables are computed on the basis of one cubic foot of steel weighing 489.6 lbs. The weight per linear foot of the section is 3.4 times the sectional area in square inches.

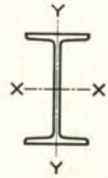


TABLE 17

KAISER WF BEAMS

Properties for Designing

Nominal Size	Wt. per Foot	Area	Depth	FLANGE		Web Thickness	AXIS X-X			AXIS Y-Y		
				Width	Thickness		I	S	r	I	S	r
Inches	Lb.	In.^{2}	In.	In.	In.	In.	In.^{4}	In.^{3}	In.	In.^{4}	In.^{3}	In.
16 x 7	45.1	13.26	15.875	7.110	.487	.417	530.1	66.8	6.32	24.2	6.8	1.35
	38.7	11.39	15.875	6.992	.487	.299	490.8	61.9	6.56	22.9	6.5	1.42
14 x 6¾	38.1	11.18	13.875	6.852	.440	.389	346.7	49.9	5.57	19.2	5.6	1.31
	32.4	9.53	13.875	6.733	.440	.270	320.2	46.1	5.79	18.1	5.4	1.38
12 x 6½	32.5	9.54	12.000	6.570	.456	.310	238.1	39.7	5.00	17.8	5.4	1.37
	29.6	8.70	12.000	6.500	.456	.240	228.0	38.0	5.12	17.1	5.3	1.40
10 x 5¾	29.1	8.55	9.875	5.935	.389	.425	131.5	26.6	3.92	11.2	3.7	1.14
	22.9	6.73	9.875	5.750	.389	.240	116.6	23.6	4.16	9.9	3.5	1.22
8 x 6½	30.8	9.06	7.875	6.675	.454	.420	95.7	24.3	3.25	18.6	5.6	1.43
	26.1	7.68	7.875	6.500	.454	.245	88.6	22.5	3.40	17.1	5.2	1.49
8 x 5¼	22.5	6.61	8.000	5.395	.352	.375	68.3	17.1	3.23	7.5	2.8	1.08
	18.5	5.44	8.000	5.250	.352	.230	62.1	15.5	3.38	6.9	2.6	1.13

All Flanges have 6° taper and flange thickness is an average thickness.

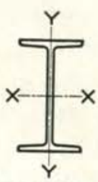


TABLE 18

LIGHT COLUMNS OR H BEAMS

Properties for Designing

Nominal Size	Wt. per Foot	Area of Sect.	Depth of Sect.	Width of Flange	Web Thickness	AXIS X-X			AXIS Y-Y		
						I	S	r	I	S	r
Inches	Lb.	In.^{2}	In.	In.	In.	In.^{4}	In.^{3}	In.	In.^{4}	In.^{3}	In.
8 x 8	34.3	10.09	8.00	8.000	.375	115.5	28.9	3.40	35.1	8.8	1.87
	32.6	9.59	8.00	7.938	.313	112.8	28.2	3.45	34.2	8.6	1.90
6 x 6	22.5	6.62	6.00	6.063	.375	41.0	13.7	2.49	12.2	4.0	1.36
	20.0	5.88	6.00	5.938	.250	38.8	12.9	2.57	11.4	3.8	1.39
5 x 5	18.9	5.56	5.00	5.000	.313	23.8	9.5	2.08	7.8	3.1	1.20
4 x 4	13.0	3.82	4.00	3.940	.253	9.9	5.0	1.64	3.3	1.7	.95

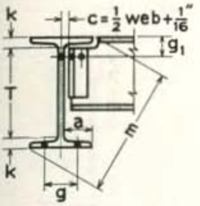


TABLE 17

KAISER WF BEAMS

Dimensions for Detailing

Nominal Size	Wt. per Foot	Depth	FLANGE		WEB		DISTANCE						Usual Gage g
			Width	Thickness	Thickness	Half Thickness	a	T	k	m	g1	c	
Inches	Lb.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
16 x 7	45.1	15 7/8	7 1/8	1/2	7/16	3/16	3 3/8	13 7/8	1	17 3/8	2 1/4	1/4	3 1/2
	38.7	15 7/8	7	1/2	5/16	1/8	3 3/8	13 7/8	1	17 3/8	2 1/4	3/16	3 1/2
14 x 6 3/4	38.1	13 7/8	6 7/8	7/16	3/8	3/16	3 1/4	12	15/16	15 1/2	2 1/4	1/4	3 1/2
	32.4	13 7/8	6 3/4	7/16	1/4	1/8	3 1/4	12	15/16	15 3/8	2 1/4	3/16	3 1/2
12 x 6 1/2	32.5	12	6 9/16	7/16	5/16	1/8	3 1/8	10 1/8	15/16	13 5/8	2 1/4	3/16	3 1/2
	29.6	12	6 1/2	7/16	1/4	1/8	3 1/8	10 1/8	15/16	13 5/8	2 1/4	3/16	3 1/2
10 x 5 3/4	29.1	9 7/8	5 15/16	3/8	7/16	3/16	2 3/4	8 1/4	13/16	11 1/2	2 1/4	1/4	2 3/4
	22.9	9 7/8	5 3/4	3/8	1/4	1/8	2 3/4	8 1/4	13/16	11 3/8	2	3/16	2 3/4
8 x 6 1/2	30.8	7 7/8	6 11/16	7/16	7/16	3/16	3 1/8	6 1/8	7/8	10 3/8	2 1/4	1/4	3 1/2
	26.1	7 7/8	6 1/2	7/16	1/4	1/8	3 1/8	6 1/8	7/8	10 1/4	2 1/4	3/16	3 1/2
8 x 5 1/4	22.5	8	5 3/8	3/8	3/8	3/16	2 1/2	6 1/2	3/4	9 5/8	2 1/4	1/4	2 3/4
	18.5	8	5 1/4	3/8	1/4	1/8	2 1/2	6 1/2	3/4	9 5/8	2 1/4	3/16	2 3/4

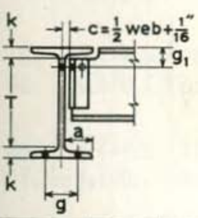


TABLE 18

LIGHT COLUMNS OR H BEAMS

Dimensions for Detailing

Nominal Size	Wt. per Foot	Depth	FLANGE		WEB		DISTANCE					Max. Flg. Rivet	Usual Gage g
			Width	Thickness	Thickness	Half Thickness	a	T	k	g1	c		
Inches	Lb.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
8 x 8	34.3	8	8	7/16	3/8	3/16	3 7/8	6 1/4	7/8	2 1/2	1/4	7/8	5 1/2
	32.6	8	8	7/16	5/16	3/16	3 7/8	6 1/4	7/8	2 1/2	1/4	7/8	5 1/2
6 x 6	22.5	6	6 1/8	3/8	3/8	3/16	2 7/8	4 3/8	13/16	2 1/4	1/4	7/8	3 1/2
	20.0	6	6	3/8	1/4	1/8	2 7/8	4 3/8	13/16	2 1/4	3/16	7/8	3 1/2
5 x 5	18.9	5	5	7/16	5/16	3/16	2 3/8	3 3/8	13/16	2 1/4	1/4	3/4	2 3/4
4 x 4	13.0	4	3 15/16	3/8	1/4	1/8	1 7/8	2 1/2	3/4	2	3/16	5/8	2 1/4

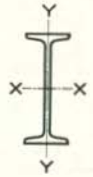


TABLE 19

KAISER BEAMS
AMERICAN STANDARD

Properties for Designing

Nominal Size	Wt. per Foot	Area	Depth	FLANGE		Web Thickness	AXIS X-X			AXIS Y-Y		
				Width	Thickness		I	S	r	I	S	r
Inches	Lb.	$In.^2$	In.	In.	In.	In.	$In.^4$	$In.^3$	In.	$In.^4$	$In.^3$	In.
20 x 6¼	75.0	21.90	20.00	6.391	.789	.641	1263.5	126.3	7.60	30.1	9.4	1.17
	65.4	19.08	20.00	6.250	.789	.500	1169.5	116.9	7.83	27.9	8.9	1.21
18 x 6	70.0	20.46	18.00	6.251	.691	.711	917.5	101.9	6.70	24.5	7.8	1.09
	54.7	15.94	18.00	6.000	.691	.460	795.5	88.4	7.07	21.2	7.1	1.15
15 x 5½	50.0	14.59	15.00	5.640	.622	.550	481.1	64.2	5.74	16.0	5.7	1.05
	42.9	12.49	15.00	5.500	.622	.410	441.8	58.9	5.95	14.6	5.3	1.08
12 x 5	35.0	10.20	12.00	5.078	.544	.428	227.0	37.8	4.72	10.0	3.9	.99
	31.8	9.26	12.00	5.000	.544	.350	215.8	36.0	4.83	9.5	3.8	1.01
10 x 4⅝	35.0	10.22	10.00	4.944	.491	.594	145.8	29.2	3.78	8.5	3.4	.91
	25.4	7.38	10.00	4.660	.491	.310	122.1	24.4	4.07	6.9	3.0	.97
8 x 4	23.0	6.71	8.00	4.171	.425	.441	64.2	16.0	3.09	4.4	2.1	.81
	18.4	5.34	8.00	4.000	.425	.270	56.9	14.2	3.26	3.8	1.9	.84
6 x 3⅜	17.25	5.02	6.00	3.565	.359	.465	26.0	8.7	2.28	2.3	1.3	.68
	12.5	3.61	6.00	3.330	.359	.230	21.8	7.3	2.46	1.8	1.1	.72
5 x 3	14.75	4.29	5.00	3.284	.326	.494	15.0	6.0	1.87	1.7	1.0	.63
	10.0	2.87	5.00	3.000	.326	.210	12.1	4.8	2.05	1.2	.82	.65
4 x 2⅝	9.5	2.76	4.00	2.796	.293	.326	6.7	3.3	1.56	.91	.65	.58
	7.7	2.21	4.00	2.660	.293	.190	6.0	3.0	1.64	.77	.58	.59

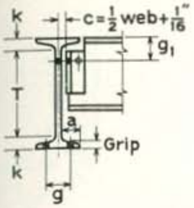


TABLE 19

KAISER BEAMS
AMERICAN STANDARD

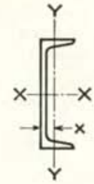
Dimensions for Detailing

Depth of Section	Wt. per Foot	FLANGE Width	FLANGE Mean Thickness	WEB Thickness	WEB Half Thickness	DISTANCE a	DISTANCE T	DISTANCE k	DISTANCE g1	DISTANCE c	Grip	Max. Fl. Rivet	Usual Gage g
Inches	Lb.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
20	75.0	6 3/8	13/16	5/8	5/16	2 7/8	16 7/8	1 9/16	3	3/8	13/16	7/8	3 1/2
	65.4	6 1/4	13/16	1/2	1/4	2 7/8	16 7/8	1 9/16	3	5/16	3/4	7/8	3 1/2
18	70.0	6 1/4	11/16	3/4	3/8	2 3/4	15 1/4	1 3/8	2 3/4	7/16	11/16	7/8	3 1/2
	54.7	6	11/16	1/2	1/4	2 3/4	15 1/4	1 3/8	2 3/4	5/16	11/16	7/8	3 1/2
15	50.0	5 5/8	5/8	9/16	5/16	2 1/2	12 1/2	1 1/4	2 3/4	3/8	9/16	3/4	3 1/2
	42.9	5 1/2	5/8	7/16	1/4	2 1/2	12 1/2	1 1/4	2 3/4	5/16	9/16	3/4	3 1/2
12	35.0	5 1/8	9/16	7/16	1/4	2 3/8	9 3/4	1 1/8	2 1/2	5/16	1/2	3/4	3
	31.8	5	9/16	3/8	3/16	2 3/8	9 3/4	1 1/8	2 1/2	1/4	1/2	3/4	3
10	35.0	5	1/2	5/8	5/16	2 1/8	8	1	2 1/2	3/8	1/2	3/4	2 3/4
	25.4	4 5/8	1/2	5/16	3/16	2 1/8	8	1	2 1/2	1/4	1/2	3/4	2 3/4
8	23.0	4 1/8	7/16	7/16	1/4	1 7/8	6 1/4	7/8	2 1/4	5/16	7/16	3/4	2 1/4
	18.4	4	7/16	5/16	1/8	1 7/8	6 1/4	7/8	2 1/4	3/16	7/16	3/4	2 1/4
6	17.25	3 5/8	3/8	1/2	1/4	1 1/2	4 1/2	3/4	2	5/16	3/8	5/8	2
	12.5	3 3/8	3/8	1/4	1/8	1 1/2	4 1/2	3/4	2	3/16	5/16		
5	14.75	3 1/4	5/16	1/2	1/4	1 3/8	3 5/8	11/16	2	5/16	5/16	1/2	1 3/4
	10.0	3	5/16	1/4	1/8	1 3/8	3 5/8	11/16	2	3/16	5/16	1/2	1 3/4
4	9.5	2 3/4	5/16	5/16	3/16	1 1/4	2 3/4	5/8	2	1/4	5/16	1/2	1 1/2
	7.7	2 5/8	5/16	3/16	1/8	1 1/4	2 3/4	5/8	2	3/16	5/16		

TABLE 20

KAISER CHANNELS
AMERICAN STANDARD

Properties for Designing



Nominal Size	Wt. per Foot	Area	Depth	FLANGE Width	FLANGE Aver. Thickness	Web Thickness	AXIS X-X I	AXIS X-X S	AXIS X-X r	AXIS Y-Y I	AXIS Y-Y S	AXIS Y-Y r	AXIS Y-Y x
Inches	Lb.	In.^{2}	In.	In.	In.	In.	In.^{4}	In.^{3}	In.	In.^{4}	In.^{3}	In.	In.
15 x 3⅜	50.0	14.64	15.00	3.716	.650	.716	401.4	53.6	5.24	11.2	3.8	.87	.80
	40.0	11.70	15.00	3.520	.650	.520	346.3	46.2	5.44	9.3	3.4	.89	.78
	33.9	9.90	15.00	3.400	.650	.400	312.6	41.7	5.62	8.2	3.2	.91	.79
12 x 3	30.0	8.79	12.00	3.170	.501	.510	161.2	26.9	4.28	5.2	2.1	.77	.68
	25.0	7.32	12.00	3.047	.501	.387	143.5	23.9	4.43	4.5	1.9	.79	.68
	20.7	6.03	12.00	2.940	.501	.280	128.1	21.4	4.61	3.9	1.7	.81	.70
10 x 2⅝	25.0	7.33	10.00	2.886	.436	.526	90.7	18.1	3.52	3.4	1.5	.68	.62
	20.0	5.86	10.00	2.739	.436	.379	78.5	15.7	3.66	2.8	1.3	.70	.61
	15.3	4.47	10.00	2.600	.436	.240	66.9	13.4	3.87	2.3	1.2	.72	.64
8 x 2¼	18.75	5.49	8.00	2.527	.390	.487	43.7	10.9	2.82	2.0	1.0	.60	.57
	13.75	4.02	8.00	2.343	.390	.303	35.8	9.0	2.99	1.5	.86	.62	.56
	11.5	3.36	8.00	2.260	.390	.220	32.3	8.1	3.10	1.3	.79	.63	.58
7 x 2⅛	14.75	4.32	7.00	2.299	.366	.419	27.1	7.7	2.51	1.4	.79	.57	.53
	12.25	3.58	7.00	2.194	.366	.314	24.1	6.9	2.59	1.2	.71	.58	.53
	9.8	2.85	7.00	2.090	.366	.210	21.1	6.0	2.72	.98	.63	.59	.55
6 x 2	13.0	3.81	6.00	2.157	.343	.437	17.3	5.8	2.13	1.1	.65	.53	.52
	10.5	3.07	6.00	2.034	.343	.314	15.1	5.0	2.22	.87	.57	.53	.50
	8.2	2.39	6.00	1.920	.343	.200	13.0	4.3	2.34	.70	.50	.54	.52
5 x 1¾	9.0	2.63	5.00	1.885	.320	.325	8.8	3.5	1.83	.64	.45	.49	.48
	6.7	1.95	5.00	1.750	.320	.190	7.4	3.0	1.95	.48	.38	.50	.49
4 x 1⅝	7.25	2.12	4.00	1.720	.296	.320	4.5	2.3	1.47	.44	.35	.46	.46
	5.4	1.56	4.00	1.580	.296	.180	3.8	1.9	1.56	.32	.29	.45	.46
3 x 1½	5.0	1.46	3.00	1.498	.273	.258	1.8	1.2	1.12	.25	.24	.41	.44
	4.1	1.19	3.00	1.410	.273	.170	1.6	1.1	1.17	.20	.21	.41	.44

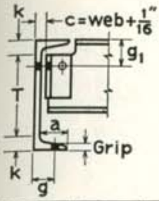


TABLE 20

KAISER CHANNELS AMERICAN STANDARD

Dimensions for Detailing

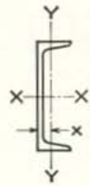
Depth of Section	Wt. per Foot	FLANGE Width	FLANGE Mean Thickness	WEB Thickness	WEB Half Thickness	DISTANCE a	DISTANCE T	DISTANCE k	DISTANCE g1	DISTANCE c	Grip	Max. Flange Rivet	Usual Gage g
Inches	Lb.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
15	50.0	3 3/4	5/8	3/4	3/8	3	12 3/8	1 5/16	2 3/4	13/16	5/8	1	2 1/4
	40.0	3 1/2	5/8	9/16	1/4	3	12 3/8	1 5/16	2 3/4	5/8	5/8	1	2
	33.9	3 3/8	5/8	7/16	3/16	3	12 3/8	1 5/16	2 3/4	1/2	5/8	1	2
12	30.0	3 1/8	1/2	1/2	1/4	2 5/8	9 7/8	1 1/16	2 1/2	9/16	1/2	7/8	1 3/4
	25.0	3	1/2	3/8	3/16	2 5/8	9 7/8	1 1/16	2 1/2	7/16	1/2	7/8	1 3/4
	20.7	3	1/2	5/16	1/8	2 5/8	9 7/8	1 1/16	2 1/2	3/8	1/2	7/8	1 3/4
10	25.0	2 7/8	7/16	9/16	1/4	2 3/8	8 1/8	15/16	2 1/2	5/8	7/16	3/4	1 3/4
	20.0	2 3/4	7/16	3/8	3/16	2 3/8	8 1/8	15/16	2 1/2	7/16	7/16	3/4	1 1/2
	15.3	2 5/8	7/16	1/4	1/8	2 3/8	8 1/8	15/16	2 1/2	5/16	7/16	3/4	1 1/2
8	18.75	2 1/2	3/8	1/2	1/4	2	6 3/8	13/16	2 1/4	9/16	3/8	3/4	1 1/2
	13.75	2 3/8	3/8	5/16	3/16	2	6 3/8	13/16	2 1/4	3/8	3/8	3/4	1 3/8
	11.5	2 1/4	3/8	1/4	1/8	2	6 3/8	13/16	2 1/4	5/16	3/8	3/4	1 3/8
7	14.75	2 1/4	3/8	7/16	1/4	1 7/8	5 3/8	13/16	2	1/2	3/8	5/8	1 1/4
	12.25	2 1/4	3/8	5/16	3/16	1 7/8	5 3/8	13/16	2	3/8	3/8	5/8	1 1/4
	9.8	2 1/8	3/8	1/4	1/8	1 7/8	5 3/8	13/16	2	5/16	3/8	5/8	1 1/4
6	13.0	2 1/8	3/8	7/16	1/4	1 3/4	4 1/2	3/4	2	1/2	5/16	5/8	1 3/8
	10.5	2	3/8	5/16	3/16	1 3/4	4 1/2	3/4	2	3/8	3/8	5/8	1 1/8
	8.2	1 7/8	3/8	3/16	1/8	1 3/4	4 1/2	3/4	2	1/4	5/16	5/8	1 1/8
5	9.0	1 7/8	5/16	5/16	3/16	1 1/2	3 5/8	11/16	2	3/8	5/16	1/2	1 1/8
	6.7	1 3/4	5/16	3/16	1/8	1 1/2	3 5/8	11/16	2	1/4	5/16	1/2	1 1/8
4	7.25	1 3/4	5/16	5/16	3/16	1 3/8	2 3/4	5/8	2	3/8	5/16	1/2	1
	5.4	1 5/8	5/16	3/16	1/8	1 3/8	2 3/4	5/8	2	1/4	1/4	1/2	1
3	5.0	1 1/2	1/4	1/4	1/8	1 1/4	1 3/4	5/8		5/16	1/4	1/2	7/8
	4.1	1 3/8	1/4	3/16	1/8	1 1/4	1 3/4	5/8		1/4	1/4		

TABLE 21

KAISER CHANNELS

CARBUILDING AND SHIPBUILDING

Properties for Designing



Nominal Size	Wt. per Foot	Area	Depth	FLANGE		Web Thickness	AXIS X-X			AXIS Y-Y			
				Width	Aver. Thickness		I	S	r	I	S	r	x
Inches	Lb.	In.²	In.	In.	In.	In.	In.⁴	In.³	In.	In.⁴	In.³	In.	In.
*18 x 4	58.0	16.98	18.00	4.200	.625	.700	670.7	74.5	6.29	18.5	5.6	1.04	.88
	51.9	15.18	18.00	4.100	.625	.600	622.1	69.1	6.40	17.1	5.3	1.06	.87
	45.8	13.38	18.00	4.000	.625	.500	573.5	63.7	6.55	15.8	5.1	1.09	.89
	42.7	12.48	18.00	3.950	.625	.450	549.2	61.0	6.64	15.0	4.9	1.10	.90
13 x 4	50.0	14.66	13.00	4.412	.610	.787	312.9	48.1	4.62	16.7	4.9	1.07	.98
	40.0	11.71	13.00	4.185	.610	.560	271.4	41.7	4.82	13.9	4.3	1.09	.97
	35.0	10.24	13.00	4.072	.610	.447	250.7	38.6	4.95	12.5	4.0	1.10	.99
	31.8	9.30	13.00	4.000	.610	.375	237.5	36.5	5.05	11.6	3.9	1.11	1.01
12 x 4	45.0	13.24	12.00	4.000	.700	.700	248.4	41.4	4.37	16.0	5.4	1.11	1.05
	40.0	11.70	12.00	3.890	.700	.590	232.6	38.8	4.46	14.5	5.1	1.11	1.05
	35.0	10.22	12.00	3.767	.700	.467	214.9	35.8	4.58	12.9	4.8	1.12	1.07
12 x 3½	37.0	10.80	12.00	3.600	.600	.600	203.4	33.9	4.34	10.3	3.8	.98	.89
	32.9	9.60	12.00	3.500	.600	.500	189.0	31.5	4.44	9.4	3.6	.99	.89
	30.9	9.00	12.00	3.450	.600	.450	181.8	30.3	4.50	8.9	3.5	.99	.90
10 x 4	33.6	9.80	10.00	4.100	.575	.575	138.0	27.6	3.75	13.7	4.6	1.18	1.11
	28.5	8.30	10.00	3.950	.575	.425	125.5	25.1	3.89	11.8	4.2	1.19	1.15

*This channel is sometimes classed as American Standard.

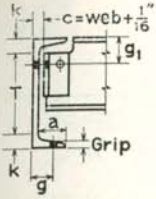


TABLE 21

KAISER CHANNELS

CARBUILDING AND SHIPBUILDING

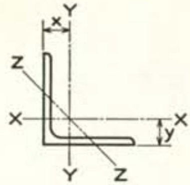
Dimensions for Detailing

Depth of Section	Wt. per Foot	FLANGE		WEB		DISTANCE					Grip	Max. Flange Rivet	Usual Gage g
		Width	Mean Thickness	Thickness	Half Thickness	a	T	k	g_1	c			
Inches	Lb.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
*18	58.0	4¼	⅝	11/16	⅜	3½	15⅜	1 5/16	2¾	¾	⅝	1	2½
	51.9	4⅛	⅝	⅝	5/16	3½	15⅜	1 5/16	2¾	11/16	⅝	1	2½
	45.8	4	⅝	½	¼	3½	15⅜	1 5/16	2¾	9/16	⅝	1	2½
	42.7	4	⅝	7/16	¼	3½	15⅜	1 5/16	2¾	½	⅝	1	2½
13	50.0	4⅜	⅝	13/16	7/16	3⅝	10⅜	1 5/16	2¾	⅞	⅝	1	2½
	40.0	4⅛	⅝	9/16	5/16	3⅝	10⅜	1 5/16	2¾	⅝	⅝	1	2½
	35.0	4⅛	⅝	7/16	¼	3⅝	10⅜	1 5/16	2¾	½	9/16	1	2½
	31.8	4	⅝	⅜	3/16	3⅝	10⅜	1 5/16	2¾	7/16	9/16	1	2½
12	45.0	4	11/16	11/16	⅜	3⅜	9½	1¼	2½	¾	11/16	1	2½
	40.0	3⅞	11/16	⅝	5/16	3⅜	9½	1¼	2½	11/16	11/16	1	2½
	35.0	3¾	11/16	½	¼	3⅜	9½	1¼	2½	9/16	11/16	1	2½
12	37.0	3⅝	⅝	⅝	5/16	3	9½	1¼	2½	11/16	⅝	⅞	2¼
	32.9	3½	⅝	½	¼	3	9½	1¼	2½	9/16	9/16	⅞	2¼
	30.9	3½	⅝	7/16	¼	3	9½	1¼	2½	½	9/16	⅞	2¼
10	33.6	4⅛	9/16	9/16	5/16	3½	7⅝	1 3/16	2½	⅝	9/16	⅞	2
	28.5	4	9/16	7/16	¼	3½	7⅝	1 3/16	2½	½	9/16	⅞	2

*This channel is sometimes classed as American Standard.

TABLE 22

KAISER ANGLES
EQUAL LEGS
Properties for Designing



Size	Thick-ness	Weight per Ft.	Area	AXIS X-X AND AXIS Y-Y				AXIS Z-Z
				I	S	r	x or y	r
In.	In.	Lb.	In.^{2}	In.^{4}	In.^{3}	In.	In.	In.
8 x 8	1⅛	56.9	16.73	98.0	17.5	2.42	2.41	1.56
	1	51.0	15.00	89.0	15.8	2.44	2.37	1.56
	⅞	45.0	13.23	79.6	14.0	2.45	2.32	1.57
	¾	38.9	11.44	69.7	12.2	2.47	2.28	1.57
	⅝	32.7	9.61	59.4	10.3	2.49	2.23	1.58
	½	26.4	7.75	48.6	8.4	2.50	2.19	1.59
6 x 6	1	37.4	11.00	35.5	8.6	1.80	1.86	1.17
	⅞	33.1	9.73	31.9	7.6	1.81	1.82	1.17
	¾	28.7	8.44	28.2	6.7	1.83	1.78	1.17
	⅝	24.2	7.11	24.2	5.7	1.84	1.73	1.18
	½	19.6	5.75	19.9	4.6	1.86	1.68	1.18
	⅜	14.9	4.36	15.4	3.5	1.88	1.64	1.19
5 x 5	¾	23.6	6.94	15.7	4.5	1.51	1.52	.97
	⅝	20.0	5.86	13.6	3.9	1.52	1.48	.98
	½	16.2	4.75	11.3	3.2	1.54	1.43	.98
	⅜	12.3	3.61	8.7	2.4	1.56	1.39	.99
4 x 4	¾	18.5	5.44	7.7	2.8	1.19	1.27	.78
	⅝	15.7	4.61	6.7	2.4	1.20	1.23	.78
	½	12.8	3.75	5.6	2.0	1.22	1.18	.78
	⅜	9.8	2.86	4.4	1.5	1.23	1.14	.79
	5/16	8.2	2.40	3.7	1.3	1.24	1.12	.79
	¼	6.6	1.94	3.0	1.1	1.25	1.09	.80
3½ x 3½	½	11.1	3.25	3.6	1.5	1.06	1.06	.68
	⅜	8.5	2.48	2.9	1.2	1.07	1.01	.69
	15/16	7.2	2.09	2.5	.98	1.08	.99	.69
	¼	5.8	1.69	2.0	.79	1.09	.97	.69
3 x 3	½	9.4	2.75	2.2	1.1	.90	.93	.58
	⅜	7.2	2.11	1.8	.83	.91	.89	.58
	5/16	6.1	1.78	1.5	.71	.92	.87	.59
	¼	4.9	1.44	1.2	.58	.93	.84	.59
	3/16	3.71	1.09	.96	.44	.94	.82	.59
2½ x 2½	½	7.7	2.25	1.2	.72	.74	.81	.49
	⅜	5.9	1.73	.98	.57	.75	.76	.49
	5/16	5.0	1.47	.85	.48	.76	.74	.49
	¼	4.1	1.19	.70	.39	.77	.72	.49
	3/16	3.07	.90	.55	.30	.78	.69	.49
2 x 2	⅜	4.7	1.36	.48	.35	.59	.64	.39
	5/16	3.92	1.15	.42	.30	.60	.61	.39
	¼	3.19	.94	.35	.25	.61	.59	.39
	3/16	2.44	.71	.27	.19	.62	.57	.39

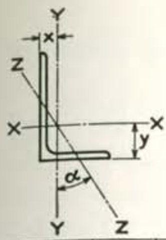


TABLE 23

KAISER ANGLES

UNEQUAL LEGS

Properties for Designing

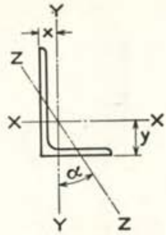
Size	Thickness	Wt. per Foot	Area	AXIS X-X				AXIS Y-Y				AXIS Z-Z	
				I	S	r	y	I	S	r	x	r	Tan α
Inches	In.	Lb.	In.^{2}	In.^{4}	In.^{3}	In.	In.	In.^{4}	In.^{3}	In.	In.	In.	
9 x 4	5/8	26.3	7.73	64.9	11.5	2.90	3.36	8.3	2.6	1.04	.86	.85	.216
	9/16	23.8	7.00	59.1	10.4	2.91	3.33	7.6	2.4	1.04	.83	.85	.218
	1/2	21.3	6.25	53.2	9.3	2.92	3.31	6.9	2.2	1.05	.81	.85	.220
8 x 6	1	44.2	13.00	80.8	15.1	2.49	2.65	38.8	8.9	1.73	1.65	1.28	.543
	7/8	39.1	11.48	72.3	13.4	2.51	2.61	34.9	7.9	1.74	1.61	1.28	.547
	3/4	33.8	9.94	63.4	11.7	2.53	2.56	30.7	6.9	1.76	1.56	1.29	.551
	5/8	28.5	8.36	54.1	9.9	2.54	2.52	26.3	5.9	1.77	1.52	1.29	.554
	1/2	23.0	6.75	44.3	8.0	2.56	2.47	21.7	4.8	1.79	1.47	1.30	.558
	7/16	20.2	5.93	39.2	7.1	2.57	2.45	19.3	4.2	1.80	1.45	1.31	.560
8 x 4	1	37.4	11.00	69.6	14.1	2.52	3.05	11.6	3.9	1.03	1.05	.85	.247
	7/8	33.1	9.73	62.5	12.5	2.53	3.00	10.5	3.5	1.04	1.00	.85	.253
	3/4	28.7	8.44	54.9	10.9	2.55	2.95	9.4	3.1	1.05	.95	.85	.258
	5/8	24.2	7.11	46.9	9.2	2.57	2.91	8.1	2.6	1.07	.91	.86	.262
	1/2	19.6	5.75	38.5	7.5	2.59	2.86	6.7	2.2	1.08	.86	.86	.267
	7/16	17.2	5.06	34.1	6.6	2.60	2.83	6.0	1.9	1.09	.83	.87	.269
7 x 4	3/4	26.2	7.69	37.8	8.4	2.22	2.51	9.1	3.0	1.09	1.01	.86	.324
	5/8	22.1	6.48	32.4	7.1	2.24	2.46	7.8	2.6	1.10	.96	.86	.329
	1/2	17.9	5.25	26.7	5.8	2.25	2.42	6.5	2.1	1.11	.92	.87	.335
	3/8	13.6	3.98	20.6	4.4	2.27	2.37	5.1	1.6	1.13	.87	.88	.339
6 x 4	7/8	27.2	7.98	27.7	7.2	1.86	2.12	9.8	3.4	1.11	1.12	.86	.421
	3/4	23.6	6.94	24.5	6.3	1.88	2.08	8.7	3.0	1.12	1.08	.86	.428
	5/8	20.0	5.86	21.1	5.3	1.90	2.03	7.5	2.5	1.13	1.03	.86	.435
	1/2	16.2	4.75	17.4	4.3	1.91	1.99	6.3	2.1	1.15	.99	.87	.440
	3/8	12.3	3.61	13.5	3.3	1.93	1.94	4.9	1.6	1.17	.94	.88	.446
5 x 3½	3/4	19.8	5.81	13.9	4.3	1.55	1.75	5.6	2.2	.98	1.00	.75	.464
	5/8	16.8	4.92	12.0	3.7	1.56	1.70	4.8	1.9	.99	.95	.75	.472
	1/2	13.6	4.00	10.0	3.0	1.58	1.66	4.1	1.6	1.01	.91	.75	.479
	3/8	10.4	3.05	7.8	2.3	1.60	1.61	3.2	1.2	1.02	.86	.76	.486
	5/16	8.7	2.56	6.6	1.9	1.61	1.59	2.7	1.0	1.03	.84	.76	.489
5 x 3	5/8	15.7	4.61	11.4	3.5	1.57	1.80	3.1	1.4	.81	.80	.64	.350
	1/2	12.8	3.75	9.5	2.9	1.59	1.75	2.6	1.1	.83	.75	.65	.357
	3/8	9.8	2.86	7.4	2.2	1.61	1.70	2.0	.89	.84	.70	.65	.364
	5/16	8.2	2.40	6.3	1.9	1.61	1.68	1.8	.75	.85	.68	.66	.368

TABLE 23—(Continued)

KAISER ANGLES

UNEQUAL LEGS

Properties for Designing



Size	Thickness	Wt. per Foot	Area	AXIS X-X				AXIS Y-Y				AXIS Z-Z	
				I	S	r	y	I	S	r	x	r	Tan α
Inches	In.	Lb.	$In.^2$	$In.^4$	$In.^3$	In.	In.	$In.^4$	$In.^3$	In.	In.	In.	
4x3	½	11.1	3.25	5.1	1.9	1.25	1.33	2.4	1.1	.86	.83	.64	.543
	⅜	8.5	2.48	4.0	1.5	1.26	1.28	1.9	.87	.88	.78	.64	.551
	5/16	7.2	2.09	3.4	1.2	1.27	1.26	1.7	.73	.89	.76	.65	.554
	¼	5.8	1.69	2.8	1.0	1.28	1.24	1.4	.60	.90	.74	.65	.558
3½x3	½	10.2	3.00	3.5	1.5	1.07	1.13	2.3	1.1	.88	.88	.62	.714
	⅜	7.9	2.30	2.7	1.1	1.09	1.08	1.9	.85	.90	.83	.62	.721
	5/16	6.6	1.93	2.3	.95	1.10	1.06	1.6	.72	.90	.81	.63	.724
	¼	5.4	1.56	1.9	.78	1.11	1.04	1.3	.59	.91	.79	.63	.727
3½x2½	½	9.4	2.75	3.2	1.4	1.09	1.20	1.4	.76	.70	.70	.53	.486
	⅜	7.2	2.11	2.6	1.1	1.10	1.16	1.1	.59	.72	.66	.54	.496
	5/16	6.1	1.78	2.2	.93	1.11	1.14	.94	.50	.73	.64	.54	.501
	¼	4.9	1.44	1.8	.75	1.12	1.11	.78	.41	.74	.61	.54	.506
3x2½	½	8.5	2.50	2.1	1.0	.91	1.00	1.3	.74	.72	.75	.52	.667
	⅜	6.6	1.92	1.7	.81	.93	.96	1.0	.58	.74	.71	.52	.676
	5/16	5.6	1.62	1.4	.69	.94	.93	.90	.49	.74	.68	.53	.680
	¼	4.5	1.31	1.2	.56	.95	.91	.74	.40	.75	.66	.53	.684
3x2	½	7.7	2.25	1.9	1.0	.92	1.08	.67	.47	.55	.58	.43	.414
	⅜	5.9	1.73	1.5	.78	.94	1.04	.54	.37	.56	.54	.43	.428
	5/16	5.0	1.47	1.3	.66	.95	1.02	.47	.32	.57	.52	.43	.435
	¼	4.1	1.19	1.1	.54	.95	.99	.39	.26	.57	.49	.43	.440
	3/16	3.07	.90	.84	.41	.97	.97	.31	.20	.58	.47	.44	.446
2½x2	⅜	5.3	1.55	.91	.55	.77	.83	.51	.36	.58	.58	.42	.614
	5/16	4.5	1.31	.79	.47	.78	.81	.45	.31	.58	.56	.42	.620
	¼	3.62	1.06	.65	.38	.78	.79	.37	.25	.59	.54	.42	.626
	3/16	2.75	.81	.51	.29	.79	.76	.29	.20	.60	.51	.43	.631
2½x1½	5/16	3.92	1.15	.71	.44	.79	.90	.19	.17	.41	.40	.32	.349
	¼	3.19	.94	.59	.36	.79	.88	.16	.14	.41	.38	.32	.357
	3/16	2.44	.72	.46	.28	.80	.85	.13	.11	.42	.35	.33	.364
2x1½	⅜	3.99	1.17	.43	.34	.61	.71	.21	.20	.42	.46	.32	.527
	5/16	3.39	1.00	.38	.29	.62	.69	.18	.17	.42	.44	.32	.535
	¼	2.77	.81	.32	.24	.62	.66	.15	.14	.43	.41	.32	.543
	3/16	2.12	.62	.25	.18	.63	.64	.12	.11	.44	.39	.32	.551

MANUFACTURING PRACTICES

Mechanical Test Requirements—Mechanical testing of carbon steel structural sections usually consists of tension and bend tests, when specified. Requirements for elongation, bend tests and the ratio of minimum yield point to minimum tensile strength are not customarily greater than those required by American Society for Testing Materials specifications for similar grades of steel. More restrictive mechanical test requirements necessitate selection of heats and other special practices, and are undertaken only upon special arrangement.

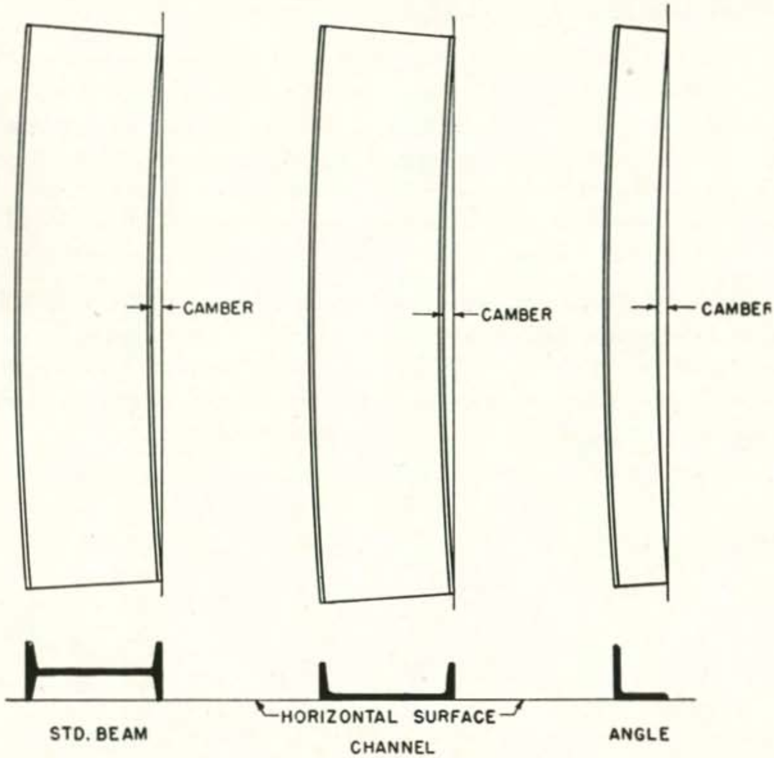
Chemical Requirements—Structural sections are customarily specified to mechanical test requirements rather than to chemical limits, except so far as standard specifications call for maximum limits for phosphorous and sulphur or for a minimum copper content, when specified. Special chemical composition for structural shapes is produced only upon special arrangement.

STANDARD PRACTICE TABLES

Variations for Dimensions and Workmanship
All dimensions in inches unless otherwise shown

Accuracy of hot rolled dimensions is influenced by many factors, such as mill design, heating practice, reduction between passes, roll wear, roll pressure, and composition of steel. The cumulative effect of these as well as other factors, precludes hot rolling to exact specified size and requires that provisions be made for variations.

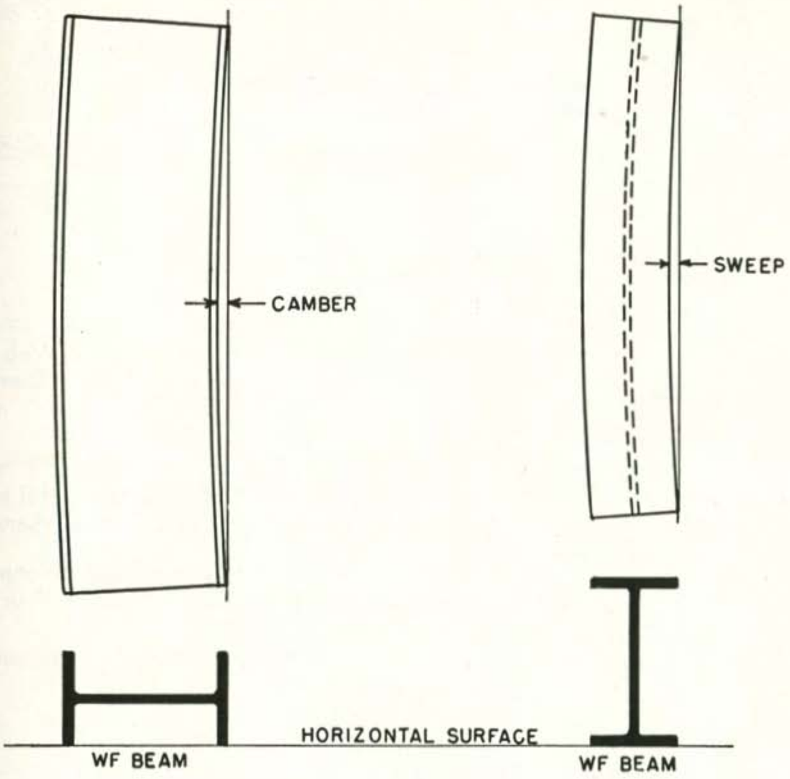
The variation from the calculated or specified weight is customarily plus or minus 2.5 per cent. Other tolerances may be agreed upon by special negotiation. The accompanying tables indicate the expectancy of dimensional variations.



POSITION FOR MEASURING CAMBER

STANDARD BEAMS
STD. MILL H-BEAMS
CHANNELS
ANGLES
BULB ANGLES

Camber denotes the curvature from the plane of a flange in the length of the section, either leg of an angle being taken as the flange.



POSITIONS FOR MEASURING CAMBER AND SWEEP

Sweep denotes the curvature from the plane of the web in the length of the beam.

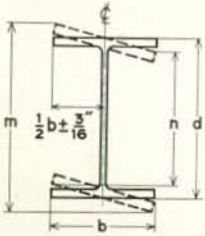
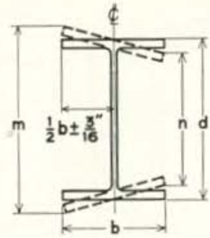


TABLE 24

KAISER WIDE FLANGE BEAMS

Rolling Tolerances



Size—Depth	d Depth		b Width of Fl.		m minus n	m	
	Over	Under	Over	Under	Out of Square or Parallel	Maximum Depth at any point	Web Off Center
Up to and including 12"	1/8"	1/8"	1/4"	3/16"	Not more than 3/16"	Not more than 1/4" over theo.	Not more than 3/16"
Over 12"	1/8"	1/8"	1/4"	3/16"	Not more than 1/4"	Not more than 1/4" over theo.	Not more than 3/16"

Shapes may have an allowable variation in weight of 2½% either way from the nominal weight. Beam depth (d) is measured at center line of web.

Cutting Tolerances

Size—Depth	Up to 30′ incl.		Over 30′	
	Over	Under	Over	Under
Beams to 24" incl.	3/8"	3/8"	3/8" plus 1/16" for each 5′ or fraction thereof above 30′	3/8"
Columns—all Sizes	1/2"	1/2"	1/2" plus 1/16" for each 5′ or fraction thereof above 30′	1/2"

Ends Out of Square:

1/64" per inch of depth or flange width if greater than depth.

Allowance for Milling:

For material which is to be milled customer should state on orders whether one or both ends are to be milled, what allowance has been made and whether we are to cut to standard or special tolerances as given above.

We recommend for material to be milled that ordered lengths be made as follows:

For milling one end only: Finished length plus 5/8".

For milling both ends: Finished length plus 7/8".

Straightness:

Tolerances for beams: $\frac{1}{8}'' \times \dfrac{\text{total length in feet}}{10'}$

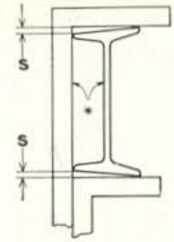
Where sections are specified on orders as columns, the following tolerances will apply:

Lengths up to 45′0": $\frac{1}{8}'' \times \dfrac{\text{total length in feet}}{10'}$ but not over 3/8" maximum.

Lengths over 45′0": $\frac{3}{8}'' + \frac{1}{8}'' \times \dfrac{\text{total length—45}'}{10'}$

TABLE 25

STANDARD BEAMS



Rolling Tolerances

Size—Depth	d Depth		b Width of Flanges		s + s Out of Square or Parallel	Weight	
	Over	Under	Over	Under		Over	Under
3″ to 7″ incl.	3/32″	1/16″	1/8″	1/8″	1/32″ per inch of flange	2½%	2½%
Over 7″ to 14″ incl.	1/8″	3/32″	5/32″	5/32″		2½%	2½%
Over 14″ to 24″ incl.	3/16″	1/8″	3/16″	3/16″		2½%	2½%

Beam depth d is measured at center line of web.

Cutting Tolerances

Size—Depth	Up to 30′ incl.		Over 30′ to 40′ incl.		Over 40′ to 50′ incl.		Over 50′	
	Over	Under	Over	Under	Over	Under	Over	Under
Structural Beams	3/8″	3/8″	5/8″	3/8″	7/8″	3/8″	1″	3/8″

Ends out of square—1/64″ per inch of depth.

$$\text{Camber tolerance} = \tfrac{1}{8}'' \times \frac{\text{total length in feet}}{5'}$$

Weight tolerances are based on each shipment consisting of carload lots or fraction thereof of the same figured or ordered weight per linear foot.

*Back of square and web to be parallel when measuring for "out of square."

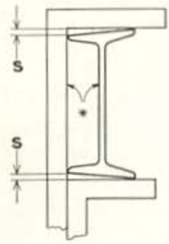
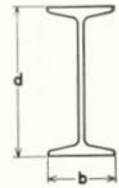


TABLE 26

COLUMN SECTIONS

Rolling Tolerances



Size—Depth	d Depth		b Width of Flanges		s + s Out of Square or Parallel	Weight	
	Over	Under	Over	Under		Over	Under
4″	3/32″	1/16″	1/8″	1/8″	1/32″ per Inch of flange	2½%	2½%
5″	3/32″	1/16″	5/32″	5/32″		2½%	2½%
6″	1/8″	3/32″	3/16″	3/16″		2½%	2½%
8″	1/8″	3/32″	3/16″	3/16″		2½%	2½%

Beam depth d is measured at center line of web.

Cutting Tolerances

Size—Depth	Up to 30′ incl.		Over 30′ to 40′ incl.		Over 40′ to 50′ incl.		Over 50′	
	Over	Under	Over	Under	Over	Under	Over	Under
All H Beams	3/8″	3/8″	5/8″	3/8″	7/8″	3/8″	1″	3/8″

Ends out of square—1/64″ per inch of depth or flange width.

$$\text{Camber tolerance} = \tfrac{1}{8}'' \times \frac{\text{total length in feet}}{5'}$$

Weight tolerances are based on each shipment consisting of carload lots or fraction thereof of the same figured or ordered weight per linear foot.

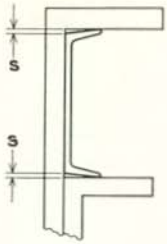
*Back of square and web to be parallel when measuring for "out of square."

TABLE 27

CHANNELS

STANDARD, CAR AND SHIP

Rolling Tolerances



Size—Depth	d Depth		b Width of Flanges		s + s Out of Square or Parallel	Weight	
	Over	Under	Over	Under		Over	Under
3″ to 7″ incl.	3/32″	1/16″	1/8″	1/8″	1/32″ per inch of flange	2½%	2½%
Over 7″ to 14″ incl.	1/8″	3/32″	1/8″	5/32″		2½%	2½%
Over 14″ to 18″ incl.	3/16″	1/8″	1/8″	3/16″		2½%	2½%

Channel depth d is measured at back of web.

Cutting Tolerances

Size—Depth	Up to 30′ incl.		Over 30′ to 40′ incl.		Over 40′ to 50′ incl.		Over 50′	
	Over	Under	Over	Under	Over	Under	Over	Under
Structural	3/8″	3/8″	5/8″	3/8″	7/8″	3/8″	1″	3/8″

Ends out of square—1/64″ per inch of depth.

$$\text{Camber tolerance} = \tfrac{1}{8}'' \times \frac{\text{total length in feet}}{5'}$$

Weight tolerances are based on each shipment consisting of carload lots or fraction thereof of the same figured or ordered weight per linear foot.

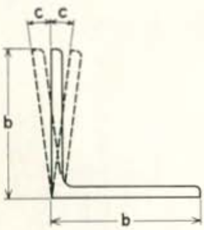


TABLE 28

ANGLES

Rolling Tolerances

Size—Length of Leg	Gages	b Length of Leg		c Out of Square	Weight	
		Over	Under		Over	Under
3″ to 4″ incl.	All	⅛″	3/32″	1½° or	2½%	2½%
Over 4″ to 6″ incl.	All	⅛″	⅛″	3/128″ per inch of	2½%	2½%
Over 6″	All	3/16″	⅛″	leg length	2½%	2½%

Cutting Tolerances

Size—Length of Leg	Gages	Up to 30′ incl.		Over 30′ to 40′ incl.		Over 40′	
		Over	Under	Over	Under	Over	Under
Structural	All	¾″	0″	1″	0″	1¼″	0″

Ends out of square—For Angles, 1½ degrees or 3/128″ per inch of leg length.

$$\text{Camber tolerance} = \tfrac{1}{8}'' \times \frac{\text{total length in feet}}{5'}$$

Weight tolerances are based on each shipment consisting of carload lots or fraction thereof of the same figured or ordered weight per linear foot.

Longer leg of unequal leg angle determines size for tolerance.

ORDERING PRACTICE FOR KAISER STRUCTURAL SHAPES

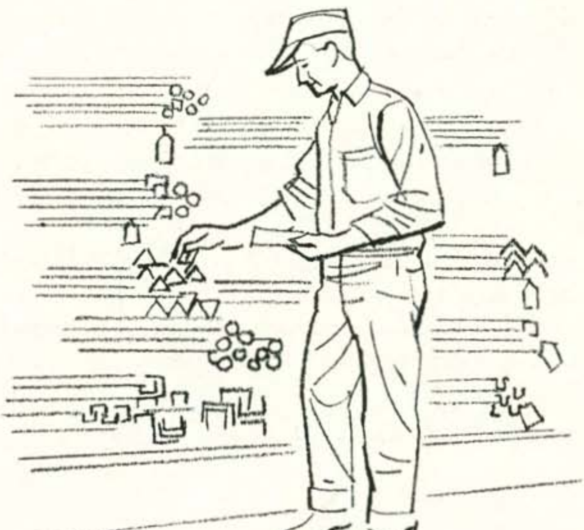
In order to more clearly describe the material desired and to avoid misunderstanding, purchasers' inquiries and orders for Structural Shapes should specify the following details:

1. Quantity.
2. Size, including foot weight and length.
3. Specification.
4. End use.
5. Required inspection, if other than mill inspection.
6. Special loading practices if applicable.
7. Shipping destination.
8. Required routing.
9. Requested delivery.
10. Distribution of shipping notices, invoices, and bills of lading.

Structural sections of all types are estimated and invoiced on the basis of calculated weights per lineal foot as shown in the preceding tables.

Bar sections are rolled in the Merchant Mill.

BARS AND BAR SIZE SHAPES



6

KAISER BARS AND BAR SIZE SHAPES

Hot rolled products commonly classified as bars include the following:

Rounds	$\frac{1}{4}''$ to $8\frac{1}{4}''$ inclusive.
Squares	$\frac{1}{4}''$ to $5\frac{1}{2}''$ inclusive.
Round Cornered Squares	$\frac{3}{8}''$ to $8''$ inclusive.
Hexagons	$\frac{1}{4}''$ to $4\frac{1}{16}''$ inclusive.
Flats	$\frac{13}{64}''$ and over in thickness and up to $6''$ in width.
Special Bar Sections	

Bar Size Shapes: Angles, channels, tees and zees when their greatest sectional dimension is less than 3 inches.

All sections and all sizes, however, are not rolled by all producers. Bars and bar size shapes rolled by Kaiser Steel Corporation are shown on pages 79 to 83.

Bars are the raw material for many forgings and are the product from which most cold drawn steel bar products are made. They are used for numerous applications in machinery, structures, transportation equipment and in general construction.

Kaiser Bars are produced from double converted and conditioned billets in rounds, squares, square edge flats, round edge flats and bar size equal and unequal angles. They are rolled on a 21-18-14-inch merchant mill consisting of an 8-stand continuous roughing mill and four 2-high finishing stands. Production may be to specified chemical limits or in accordance with the physical properties and chemical limits of standard specifications, as required by the customer. Merchant Bar Quality and Special Bar Quality are rolled in all steel grades and in the range of sizes and shapes shown on the following pages.

Kaiser Steel Corporation produces many special sections required for industrial applications. Inquiries for the production of special sections are solicited.

TABLE 29

KAISER STANDARD ROUNDS

Size in Inches	Wt. Per Ft., Lbs.	Area Sq. In.	Size in Inches	Wt. Per Ft., Lbs.	Area Sq. In.
1/2	.67	.20	1 15/16	10.02	2.95
5/8	1.04	.31	2	10.68	3.14
11/16	1.26	.37	2 1/16	11.36	3.34
3/4	1.50	.44	2 1/8	12.06	3.55
13/16	1.76	.52	2 3/16	12.78	3.76
7/8	2.04	.60	2 1/4	13.52	3.98
15/16	2.35	.69	2 5/16	14.28	4.20
1	2.67	.79	2 3/8	15.06	4.43
1 1/16	3.02	.89	2 7/16	15.87	4.67
1 1/8	3.38	.99	2 1/2	16.69	4.91
1 3/16	3.77	1.11	2 9/16	17.53	5.16
1 1/4	4.17	1.23	2 5/8	18.40	5.41
1 5/16	4.60	1.35	2 11/16	19.29	5.67
1 3/8	5.05	1.48	2 3/4	20.20	5.94
1 7/16	5.52	1.62	2 13/16	21.12	6.21
1 1/2	6.01	1.77	2 7/8	22.07	6.49
1 9/16	6.52	1.92	2 15/16	23.04	6.78
1 5/8	7.05	2.07	3	24.03	7.07
1 11/16	7.60	2.24	3 1/16	25.05	7.37
1 3/4	8.18	2.41	3 1/8	26.08	7.67
1 13/16	8.77	2.58	3 3/16	27.13	7.98
1 7/8	9.39	2.76	3 1/4	28.21	8.30

Kaiser standard rounds from 1/2″ to 1″ inclusive may be supplied either in cut lengths up to 65 feet or in coils weighing an average of 1,000 lbs. each.

Two coil dimensions may be furnished: 56″ O.D. × 39″ I.D. or 46″ O.D. × 34″ I.D.

Machine straightened rounds are available in all sizes.

TABLE 30

KAISER STANDARD SQUARES

Size in Inches	Wt. Per Ft., Lbs.	Area Sq. In.	Size in Inches	Wt. Per Ft., Lbs.	Area Sq. In.
½	.85	.25	1½	7.65	2.25
⅝	1.33	.39	1⅝	8.98	2.64
¾	1.91	.56	1¾	10.41	3.06
⅞	2.60	.77	1⅞	11.95	3.52
1	3.40	1.00	2	13.60	4.00
1⅛	4.30	1.27	2¼	17.21	5.06
1¼	5.31	1.56	2½	21.25	6.25
1⅜	6.43	1.89	2¾	25.71	7.56

Squares are produced in maximum lengths of 65 feet.

TABLE 31

KAISER ROUND CORNERED SQUARES

Size in Inches	Wt. Per Ft., Lbs.	Area Sq. In.	Size in Inches	Wt. Per Ft., Lbs.	Area Sq. In.
1½	7.55	2.22	2¼	16.98	4.99
1⅝	8.86	2.61	2½	20.97	6.17
1¾	10.27	3.02	2¾	25.37	7.46
1⅞	11.79	3.46	3	30.60	9.00
2	13.42	3.95			

The above sizes are produced in maximum lengths of 65 feet.

TABLE 32

KAISER BAR SIZE SHAPES

ANGLES (Equal)			ANGLES (Unequal)		
Size in Inches	Wt. Per Ft., Lbs.	Area Sq. In.	Size in Inches	Wt. Per Ft., Lbs.	Area Sq. In.
2 x 2 x 3/16	2.44	.71	2 x 1½ x 3/16	2.12	.62
¼	3.19	.94	¼	2.77	.81
5/16	3.92	1.15	5/16	3.39	1.00
⅜	4.70	1.36	⅜	3.99	1.17
2½ x 2½ x 3/16	3.07	.90	2½ x 1½ x 3/16	2.44	.72
¼	4.10	1.19	¼	3.19	.94
5/16	5.00	1.47	5/16	3.92	1.15
⅜	5.90	1.73			
½	7.70	2.25	2½ x 2 x 3/16	2.75	.81
			¼	3.62	1.06
			5/16	4.50	1.31
			⅜	5.30	1.55

Bar size shapes are produced in maximum lengths of 65 feet.

TABLE 33

KAISER SQUARE EDGE FLATS

(Weight per foot in lbs.)

Thick-ness	¼"	5/16"	⅜"	½"	⅝"	¾"	⅞"	1"	1¼"	1½"
Width	.250	.3125	.375	.500	.625	.750	.875	1.00	1.25	1.50
1½"	....	....	1.913	2.550	3.188	3.825	....	....	....	....
1¾"	....	....	2.231	2.975	3.719	4.463	....	....	....	....
2"	1.700	2.125	2.550	3.400	4.250	5.100	5.950	6.800	....	....
2½"	2.125	2.656	3.188	4.250	5.313	6.375	7.438	8.500	....	....
3"	2.550	3.188	3.825	5.100	6.375	7.650	8.925	10.200	12.750	15.30
3½"	2.975	3.719	4.463	5.950	7.438	8.925	10.41	11.900	14.875	17.85
4"	3.400	4.250	5.100	6.800	8.500	10.200	11.90	13.600	17.000	20.40
5"	4.250	5.313	6.375	8.500	10.625	12.750	14.88	17.000	21.250	25.50
6"	5.100	6.375	7.650	10.200	12.750	15.300	17.85	20.400	25.500	30.60

All widths are produced to 780 inches maximum length.

Between 2" and 6" in width, intermediate widths not listed are available on a special inquiry basis.

TABLE 34

KAISER SPRING FLATS

(Round Edge)

(Weight per foot in lbs.)

Thickness		15/64"	1/4"	9/32"	5/16"	3/8"	1/2"	5/8"	3/4"	7/8"	1"
Width	.214	.234	.250	.28125	.3125	.375	.500	.625	.750	.875	1.00
1¾"	1.248	1.395	1.488	1.673	1.859	2.231	2.975	3.719	....	....	....
2"	1.430	1.594	1.700	1.913	2.125	2.550	3.400	4.250	....	....	....
2¼"	1.613	1.793	1.913	2.152	2.391	2.869	3.825	4.781	....	....	....
2½"	1.793	1.992	2.125	2.391	2.656	3.188	4.250	5.313	....	....	....
2¾"	1.972	2.192	2.338	2.630	2.922	3.506	4.675	5.844	....	....	....
3"	....	2.391	2.550	2.869	3.188	3.825	5.100	6.375	....	....	....
3½"	....	2.789	2.975	3.348	3.719	4.463	5.950	7.438	8.925	....	....
4"	....	3.188	3.400	3.815	4.250	5.100	6.800	8.500	10.200	11.900	13.600
4½"	....	....	....	4.303	4.781	5.738	7.650	9.554	11.475	13.388	15.300
5"	....	....	....	4.781	5.313	6.375	8.500	10.625	12.750	14.875	17.000
6"	....	....	....	5.737	6.375	7.650	10.200	12,750	15.300	17.850	20.400

All sizes produced in maximum lengths of 780 inches.

Spring flats are available in flat or double concave shape.

MERCHANT BAR QUALITY

Merchant quality and special quality are the two fundamental qualities of carbon steel bars. Merchant quality bars are specified for a wide range of structural uses involving mild cold bending, mild hot forming, punching, and welding as used in the production of non-critical parts of bridges, buildings, ships, agricultural implements, road building and railway equipment, machinery and other uses. The type of steel in which merchant quality is produced is customarily left to the producer's discretion. Bars of merchant quality should be free of visible pipe. They may, however, contain pronounced segregation. Seams or other surface irregularities may be expected.

SPECIAL BAR QUALITY

Special quality bars are produced for applications involving forging, heat treating, cold drawing, machining, and the like. These bars are furnished in standard or restricted chemical grades or to mechanical property specifications. Special quality bars are produced in the type of steel determined by producer's facilities and the end use requirements.

Visible pipe is eliminated and bars are subject to standard variations in check analysis. Blooms and billets for special quality bars are conditioned before rolling to eliminate surface imperfections, but surface defects may be present to some degree after final rolling. If defects in special quality bars are removed by chipping or grinding, the extent of the conditioning must be consistent with the end use of the bars.

Special quality bars are sometimes specified with requirements for chemical composition, workmanship or finish more restrictive than special quality as previously described and additional handling, processing, testing or inspection procedures are required. Bars for forging and/or heat treating should be ordered as killed steel.

SPECIAL BAR QUALITY INVOLVING OTHER RESTRICTIVE REQUIREMENTS

Special quality bars involving other restrictive requirements are cold heading quality, special surface quality, or those in which special heat treating requirements must be met. They also include those bars requiring restricted ladle or check analysis, restricted decarburization or specified maximum incidental elements.

STANDARD PRACTICE TABLES

Variations for Dimensions and Workmanship

The accuracy of dimensions of rolled steel products is influenced by many factors such as mill design, heating practices, roll pass design, reduction between passes, roll wear and grade of steel. The cumulative effect of these, as well as other factors, precludes hot rolling to exact ordered size and requires that provisions be made for variations.

The accompanying tables indicate the expectancy of dimensional variations.

TABLE 35

ROUNDS AND SQUARES AND ROUND CORNERED SQUARES

Sizes in Inches

Specified Sizes	Variations from Size		Out of Round or Out of Square Section
	Over	Under	
To 5/16 incl.	0.005	0.005	0.008
Over 5/16 to 7/16 incl.	0.006	0.006	0.009
Over 7/16 to 5/8 incl.	0.007	0.007	0.010
Over 5/8 to 7/8 incl.	0.008	0.008	0.012
Over 7/8 to 1 incl.	0.009	0.009	0.013
Over 1 to 1 1/8 incl.	0.010	0.010	0.015
Over 1 1/8 to 1 1/4 incl.	0.011	0.011	0.016
Over 1 1/4 to 1 3/8 incl.	0.012	0.012	0.018
Over 1 3/8 to 1 1/2 incl.	0.014	0.014	0.021
Over 1 1/2 to 2 incl.	1/64	1/64	0.023
Over 2 to 2 1/2 incl.	1/32	0	0.023
Over 2 1/2 to 3 1/2 incl.	3/64	0	0.035

NOTE: Out-of-round is the difference between the maximum and minimum diameters of the bar, measured at the same cross section. Out-of-square section is the difference in the two dimensions at the same cross section of a square bar between opposite faces.

TABLE 36

SQUARE-EDGE AND ROUND-EDGE FLATS

Thickness and Width in Inches

Specified Widths	Variations from Thickness, for Thicknesses Given, Over & Under					Variations from Width	
	Under 1/4	1/4 to 1/2 incl.	Over 1/2 to 1 incl.	Over 1 to 2 incl.	Over 2	Over	Under
To 1 incl.	0.007	0.008	0.010	....	....	1/64	1/64
Over 1 to 2 incl.	0.007	0.012	0.015	1/32	....	1/32	1/32
Over 2 to 4 incl.	0.008	0.015	0.020	1/32	3/64	1/16	1/32
Over 4 to 6 incl.	0.009	0.015	0.020	1/32	1/16	3/32	1/16

TABLE 37

STRAIGHTNESS

All Bars and Bar Size Shapes

1/4 inch in any 5 ft. or 1/4 inch × number of ft. of length divided by 5.

Because of warpage, straightness tolerances do not apply to bars if any subsequent heating operation has been performed.

TABLE 38

AUTOMOTIVE LEAF SPRING FLATS

Thickness, Width and Concavity in Inches

Variations in Width		Variations in Thickness,[1] Over & Under			Variations towards Concavity[2]			Maximum Difference in Thickness[3]		
		For Thickness			For Thickness			For Thickness		
Specified Widths	Variation Over No Var. Under	0.375 and Under	Over 0.375 to 0.875 incl.	Over 0.875 to 1.500 incl.	0.375 and Under	Over 0.375 to 0.875 incl.	Over 0.875 to 1.500 incl.	0.375 and Under	Over 0.375 to 0.875 incl.	Over 0.875 to 1.500 incl.
To 2½ incl.	1/32	0.005	0.006	....	0.005	0.006	....	0.002	0.002	....
Over 2½ to 4 incl.	3/64	0.006	0.008	0.012	0.006	0.008	0.012	0.003	0.004	0.006
Over 4 to 5 incl.	1/16	0.007	0.010	0.016	0.007	0.010	0.016	0.004	0.005	0.008
Over 5 to 6 incl.	3/32	....	0.012	0.020	....	0.012	0.020	....	0.006	0.010

[1]Thickness measurements are taken at the edges of the bar where the flat surfaces intersect the rounded edges.

[2]Concavity is the difference between the thickness at the center of the bar and the thickness at the edges.

[3]Maximum difference in thickness between the two edges of each bar.

TABLE 39

RANDOM LENGTHS — CUTTING RANGES

All Bars and Bar Size Shapes

For sizes to and including 3 in. round or equivalent cross-sectional area:
- 2 ft. range when minimum of length range specified is 5 ft to 20 ft. inclusive.
- 3 ft. range when minimum of length range specified is over 20 ft. to 30 ft. inclusive.

For sizes over 3 in. round or equivalent cross-sectional area:
- 3 ft. range when minimum of length range specified is 5 ft. to 20 ft. inclusive.
- 4 ft. range when minimum of length range specified is over 20 ft. to 30 ft. inclusive.

For all sizes and cross-sectional areas:
- 4 ft. range when minimum of length range specified is over 30 ft. to 40 ft. inclusive.
- 5 ft. range when minimum of length range specified is over 40 ft.

TABLE 40

BAR SIZE ANGLES

Dimensions in Inches

	Variations from Thickness for Thicknesses Given, Over and Under			
Specified Length of Leg	To 3/16 Incl.	Over 3/16 to 3/8, Incl.	Over 3/8	Variations From Length of Leg, Over and Under
To 1, incl.	0.008	0.010	....	1/32
Over 1 to 2, incl.	0.010	0.010	0.012	3/64
Over 2 to 3, excl.	0.012	0.015	0.015	1/16

The longer leg of an unequal angle determines the size for variations.
The out-of-square tolerance in either direction is 1½ degrees.

TABLE 41

ROUNDS, SQUARES, FLATS AND BAR SIZE SHAPES

Length

Mill Shearing

Specified Size of Rounds, Squares Inches	Specified Size of Flats, Inches		Variations Over Specified Length, Inches, No Variation Under				
	Thickness	Width	5-10 Ft. Excl.	10-20 Ft. Excl.	20-30 Ft. Excl.	30-40 Ft. Excl.	40-60 Ft. Incl.
To 1, incl.	To 1, incl.	To 3, incl.	½	¾	1¼	1¾	2¼
Over 1 to 2, incl.	Over 1	To 3, incl.	⅝	1	1½	2	2½
Over 1 to 2, incl.	To 1, incl.	Over 3 to 6, incl.	⅝	1	1½	2	2½
Over 2, incl.	Over 1	Over 3 to 6, incl.	1	1½	1¾	2¼	2¾
Bar Size Sections			⅝	1	1½	2	2½

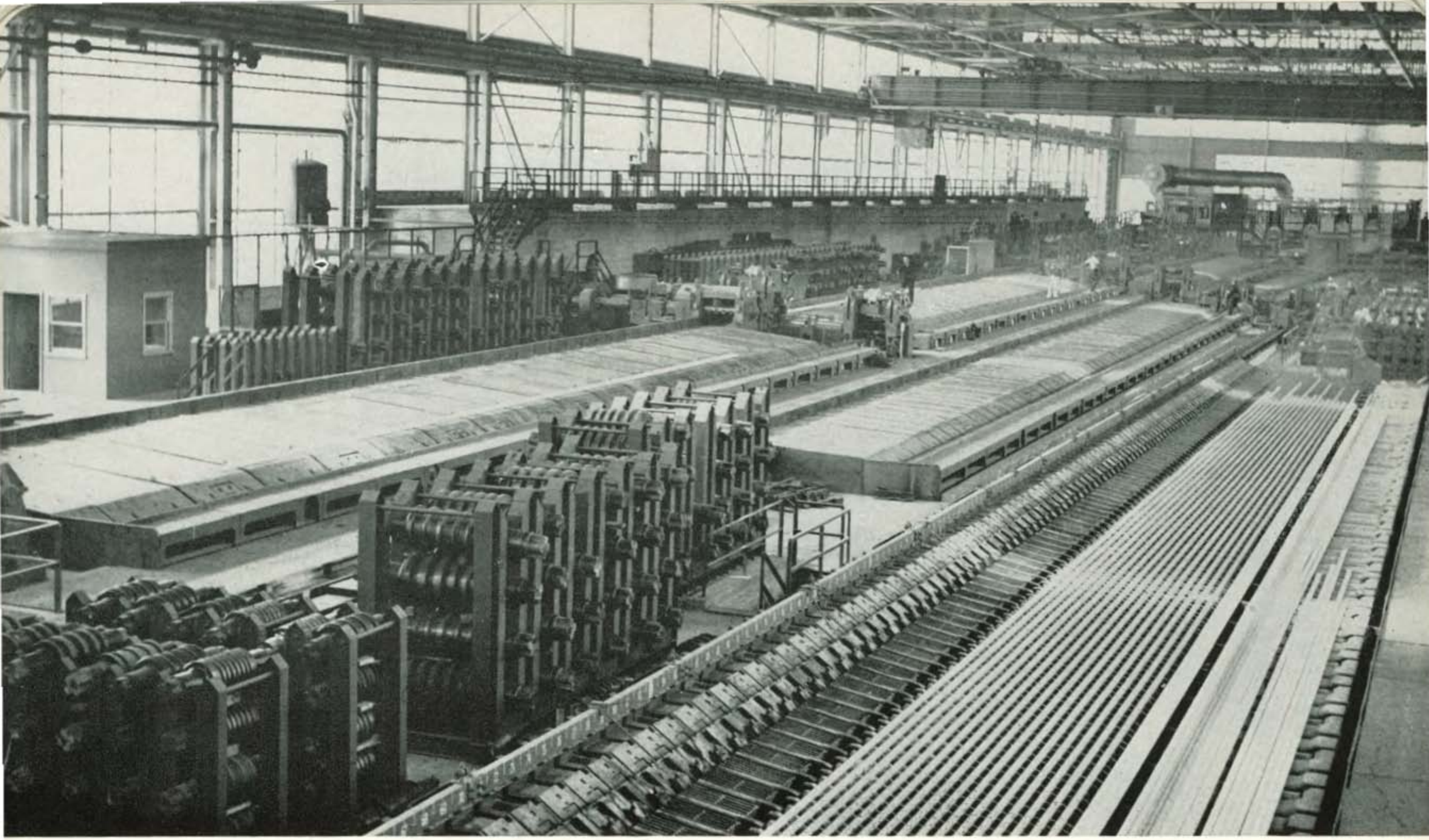
ORDERING PRACTICE FOR KAISER BARS AND BAR SIZE SHAPES

In order to more clearly describe the material desired and to avoid misunderstanding, purchasers' inquiries and orders for Bars and Bar Sized Shapes, should specify the following details:

1. Quantity.
2. Size.
3. Specification.
4. Quality (either merchant bar quality or special bar quality).
5. End use.
6. Required inspection, if other than mill inspection.
7. Special loading practices if applicable.
8. Shipping destination.
9. Required routing.
10. Requested delivery.
11. Distribution of shipping notices, invoices, and bills of lading.

When ordering round bars that are to be machined, experience has shown that it is advisable for the purchaser to make adequate allowances for finishing. These allowances should not be less than 1/8 inch from the surface for rounds 1 1/2 to 3 inches in diameter and 1/4 inch for rounds over 3 inches in diameter. All sections of cut bars may be ordered to specific or random lengths. The maximum length is 65 feet.

Bars are invoiced on mill scale weights. In check-weighing by the purchaser, variation from invoiced weights up to one per cent may be expected due to differences in kind, type, location and accuracy of the scales. When the number of pieces in a lift is required to be shown on the shipping papers, the count is considered as approximate and weight the more accurate.



Portion of the rod and bar section of the Merchant Mill where Kaiser Hi-Bond reinforcing bar is produced.

CONCRETE REINFORCING BARS

KAISER CONCRETE REINFORCING BARS

Concrete reinforcing bars are steel bars used to resist tension, compression or shear stresses in concrete. Deformed bars with surface patterns meeting certain minimum industry standards for deformation are most generally used. Plain bars, however, are used in many special cases. It has become a practice in the trade to use the word "nominal" in referring to the size of deformed bars and to designate them by number. The nominal size of a deformed bar is equivalent to the diameter of a plain round bar or the side of a square bar having the same weight per foot as the deformed bar. The number of the bar indicates its nominal size in ⅛ inches.

Kaiser Concrete Reinforcing Bars are extensively used in the construction of concrete dams, bridges, buildings, pipe lines, aqueducts, foundations and the like.

Kaiser Concrete Reinforcing Steel Bars are produced from new open hearth steel billets in grades to conform to latest industry specifications in either deformed bars (Kaiser Hi-Bond Bars) in sizes from ½ to 1¼ inches inclusive, or in plain round bars, in sizes from ½ to 1 inch inclusive.

TABLE 42

KAISER CONCRETE REINFORCING BARS

Bar No.	4	5	6	7	8	9	10	11
Size inches (rounds)	½	⅝	¾	⅞	1	1.128 (1 sq.)	1.270 (1⅛ sq.)	1.410 (1¼ sq.)
Area (sq. in.)	0.20	0.31	0.44	0.60	0.79	1.00	1.27	1.56
Weight (lbs. per lin. ft.)	0.668	1.043	1.502	2.044	2.670	3.400	4.303	5.313

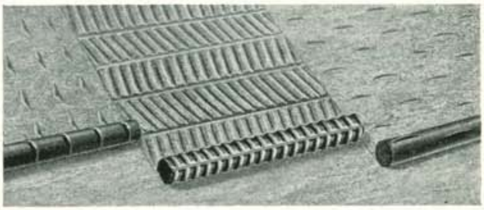
Orders for ½" bars are accepted only by special arrangement. For those sizes designated as numbers 9, 10 and 11, Kaiser Hi-Bond Bars of round section are furnished to the equivalent sectional area of square bars. For those sizes designated as numbers 4, 5, 6, 7 and 8, both plain round bars and Kaiser Hi-Bond bars are furnished. Plain round bars in cut lengths only, also may be furnished in sizes 1⅛", 1¼" and 1½" in diameter in lengths not exceeding 60 feet.

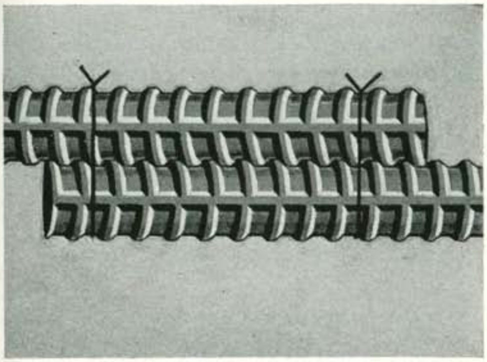
KAISER HI-BOND CONCRETE REINFORCING BARS

Kaiser Hi-Bond Reinforcing Bar increases the effectiveness of reinforcing steel in concrete through greatly improved load transfer between the two materials. This is accomplished by means of reversed double helical ribs of proper height which extend between diametrically opposed longitudinal ribs. The helical ribs are spaced at close intervals and so dimensioned as to provide potential bearing and shearing areas which in addition to having the proper relationship to each other, are properly proportioned to the effective strength of the bars. The bearing area is more than double that of most types of reinforcing bars.

These reversed double-helical ribs in Kaiser Hi-Bond reinforcing bars provide the most effective mechanical grip with concrete ever developed—regardless of the position in which the bars are cast or the direction in which they are pulled.

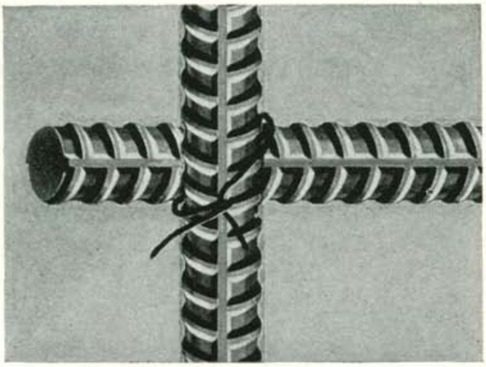
Patterns in wet concrete prove no ordinary bar can anchor itself as firmly as a Kaiser Hi-Bond bar.





High tensile strength at splices—with shorter overlap—comes from dovetailed helical ribs.

Kaiser Hi-Bond bars have gear-like contact when crossed and wired. The result is that they hold firmly with a simple tie.



The angle at which the ribs are inclined is so fixed that the area for any section normal to the longitudinal axis of the bar is a constant. The large fillets where the helical ribs join the body of the bar induce better contact between the concrete and the steel.

This design results in a bar which bends exceptionally well and is easy to handle and fabricate due to the close and even rib arrangement.

All engineering tests which have been conducted support the following conclusions:

Kaiser Hi-Bond Bars have the highest possible bond value as compared with other reinforcing bars.

Kaiser Hi-Bond Bars provide a more effective mechanical grip with the concrete regardless of the position in which they are cast, or the direction in which they are pulled.

Kaiser Hi-Bond Bars provide a more efficient transfer of stress at splices and reduce the need for hook anchorage.

Kaiser Hi-Bond Bars reduce the width of cracks, thereby reducing the possibility of corrosion of the steel at the cracks.

Kaiser Hi-Bond Bars, through superior resistance to slip, reduce deflections of beams and deformations of columns.

Kaiser Hi-Bond Bars contribute to the effective use of high yield strength reinforcing steel and the development of pre-stressed construction.

Kaiser Hi-Bond Bars in reinforced concrete result in more efficient structures and lower construction costs through the conservation of materials and labor.

Kaiser Hi-Bond Bars are rolled in sizes from ½ to 1¼ inches, inclusive, and are furnished in cut lengths from 20 to 60 feet, inclusive. Shorter or longer lengths may be furnished by special arrangement. In sizes from ½ to 1 inch, inclusive, these bars may be furnished in coils averaging in weight 1,000 pounds per coil, to standard industry specifications.

Two sizes of coils are supplied:

56″ O.D. x 39″ I.D.

46″ O.D. x 34″ I.D.

KAISER PLAIN ROUND CONCRETE REINFORCING BARS

Kaiser Plain Round Concrete Reinforcing Bars are rolled in sizes from ½ to 1 inch inclusive and may be furnished in cut lengths from 20 to 60 feet inclusive. Shorter or longer lengths may be supplied by special arrangement. Plain round bars may also be furnished in coils averaging 1,000 pounds per coil.

STANDARD PRACTICE TABLES

TOLERANCES

The length of concrete reinforcing bars is customarily specified in feet and inches and all lengths are commonly subject to variations from ordered lengths as follows:

Up to 40′, inclusive.................2″ over and 1″ under

Over 40′...................................3″ over and 1″ under

Concrete reinforcing bars, by industry practice, are furnished to weight tolerances and are not customarily furnished to dimensional tolerances other than for length. The theoretical weights of Kaiser Plain and Deformed Reinforcing Bars of the same nominal size are considered to be the same, i.e., the metal in the deformation is included in the theoretical weight and is not additional to it. Actual weights should not differ from theoretical weights more than the variations shown below.

TABLE 43

WEIGHT

Size in Inches	Variation, Per Cent	
	Over	Under
½″ to 1¼″ inclusive in any lot	3½	3½
½″ to 1¼″ inclusive individual bars	—	6

NOTE: The term "lot" means all the bars of the same nominal size in a carload.

ORDERING PRACTICE FOR KAISER CONCRETE REINFORCING BARS

In order to more clearly describe the material desired and to avoid misunderstanding, purchasers' inquiries and orders for concrete reinforcing bars, should specify the following details:

1. Quantity.
2. Size (on sizes 1″, 1⅛″ and 1¼″ clarify as to whether rounds or square equivalents are required).
3. Specification.
4. Grade (intermediate grade or structural grade).
5. Required inspection, if other than mill inspection.
6. Special loading practices, if applicable.
7. Shipping destination.
8. Required routing.
9. Requested delivery.
10. Distribution of shipping notices, invoices and bills of lading.

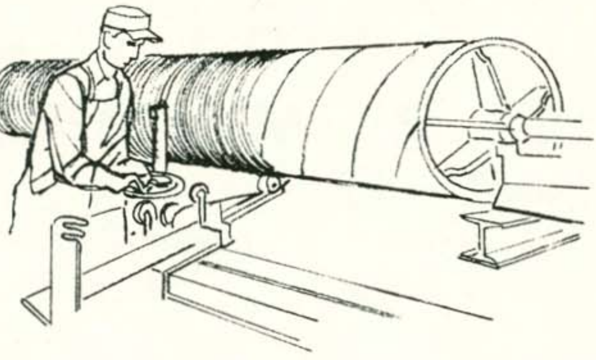
Concrete reinforcing bars are invoiced on the basis of the theoretical weight per foot of the bar.

NOTES

Coiled rods are rolled in continuous lengths from double converted billets on a combination mill.

COILED RODS

8



KAISER COILED RODS

Kaiser Coiled Rods are rolled from billets to an approximate round cross section. They are produced in coils of one continuous length. Rods are not comparable to hot rolled bars in accuracy of cross section nor surface finish. Rods are considered a semi-finished product.

Kaised Coiled Rods are rolled for use where continuous length material is essential or where economies may be effected by the use of coiled rods. Their predominant use is for reinforcing concrete pipe, and in reinforcing massive concrete structures. They are produced from double converted billets on a combination mill. The manufacture of the larger sizes of rods involves additional precautions in steel making and in the preparation of billets to assure a quality more readily obtainable in the smaller size of rods.

RANGE OF SIZES

$\frac{1}{2}$″ to $\frac{47}{64}$″ in $\frac{1}{16}$″ increments

Coil Diameters—56″ O.D. x 39″ I.D. or 46″ O.D. x 34″ I.D.

Coil Weights—1000 lbs. average.

Kaiser Coiled Rods are available in standard grades and conform to the specified quality requirements of the end use or commodity designated. They are rolled to conform to standard size tolerances.

STANDARD PRACTICES

TOLERANCES

Variation from specified diameter: Plus or Minus $\frac{1}{64}$″ (0.0156″)

Out of round variation: 0.025″ maximum

Out of round means the difference btween the maximum and minimum diameters measured at the same cross section.

Tolerances closer than the above standards necessitate a manufacturing procedure such as is used to produce bars.

ORDERING PRACTICE FOR KAISER COILED RODS

In order to more clearly describe the material desired and to avoid misunderstanding, purchasers' inquiries and orders for Coiled Rods should specify the following details:

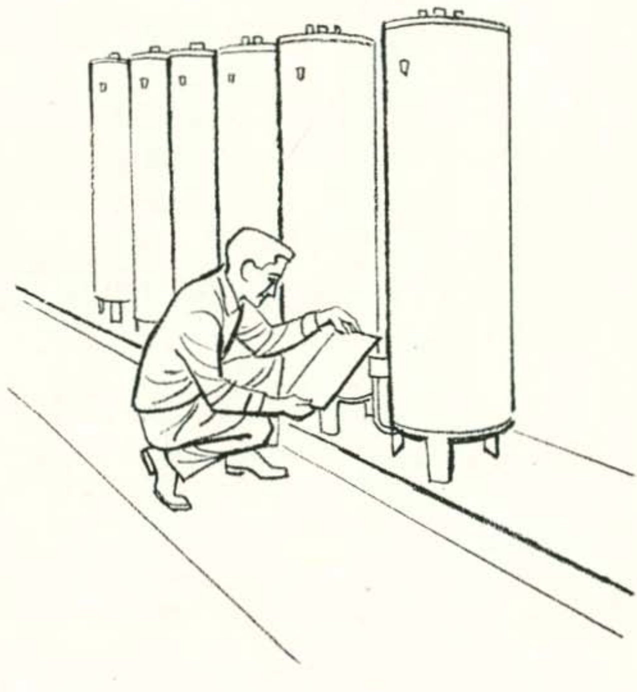
1. Quantity.
2. Size.
3. Specification.
4. Quality (that is, merchant quality, cold rolling quality, cold forging quality, etc.)
5. End use.
6. Required inspection, if other than mill inspection.
7. Special loading practices if applicable.
8. Shipping destination.
9. Required routing.
10. Requested delivery.
11. Distribution of shipping notices, invoices and bills of lading.

Coiled rods are invoiced on the basis of mill scale weights.

In check weighing by the purchaser, variation from invoiced weights up to one per cent may be expected due to differences in kind, type, location and accuracy of the scales.

Kaiser Steel's hot strip mill produces hot rolled sheets in coils or cut lengths, in widths from 24 to 72 inches.

HOT ROLLED SHEETS



KAISER HOT ROLLED SHEETS

Flat rolled steel products are classified as bar, plate, strip and sheet in accordance with thickness and width. On page 233 of this catalog is a table giving the usual industry accepted classification of flat rolled products.

Hot rolled sheets are used in large tonnages for drawn, cold formed and structural parts in the manufacturing and fabricating industries. They are used in automobile parts, machinery, furniture, pipe, general appliances and many other fields of manufacture.

Kaiser Hot Rolled Sheets are made in the full range of steel grades used in industry. Sheets to 72 inches in width are rolled on a combination mill consisting of a 110-inch reversing roughing mill and a 110-inch three-high semi-finishing mill, and are finished on six stands of 86-inch four-high continuous finishing rolls. Sheets over 12 to 16½ inches, inclusive, in width are rolled on a ten-stand, tandem continuous mill. Sheets from 12 to 72 inches in width may be cut to length or coiled after rolling.

TABLE 44
KAISER HOT ROLLED SHEETS

Width (Inches)	Minimum Thickness	Manufacturers Std. Gage No.
Over 12″ to 16½″, incl.	.1046	12 Ga.
Over 24″ to 43″, incl.	.0478	18 Ga.
Over 43″ to 50″, incl.	.0598	16 Ga.
Over 50″ to 60″, incl.	.0747	14 Ga.
Over 60″ to 65″, incl.	.0897	13 Ga.
Over 65″ to 72″, incl.	.1046	12 Ga.

Sheets over 12″ to 16½″, incl., wide are available in lengths from 72″ to 126″ and from 168″ to 252″. Coils in this width range will average 250 pounds per inch of width and are furnished with mill edge only.

Sheets 24″ to 72″ wide are produced in coils or cut lengths from 84″ to 240″.

TABLE 45
HOT ROLLED PICKLED AND OILED SHEETS

Width (Inches)	Min. Thickness
Over 12″ - 16½″, incl.	.1046
Over 24″ - 43″, incl.	.0478
Over 43″ - 49″, incl.	.0598

QUALITIES

COMMERCIAL QUALITY hot rolled sheets are suitable for many purposes where the presence of oxide is not objectionable and surface is of secondary importance. They are not commonly used for exposed parts where finish is the prime requirement. When a carbon content is not specified, it is assumed that commercial quality sheets, not exceeding 0.15 per cent carbon on ladle analysis, are desired. When required, commercial quality sheets may be specified to standard chemical ranges and limits.

For any carbon range specified or required, the maximum of which does not exceed 0.15 per cent, a test specimen should withstand being bent flat on itself in any direction at room temperature.

For any carbon range specified or required, the maximum of which is over 0.15 per cent and not over 0.25 per cent, a test specimen should withstand being bent, at room temperature, through 180 degrees in any direction around a thickness equal to that of the specimen.

Bend tests are not customarily required for commercial quality sheets with carbon over 0.25 per cent maximum.

If mechanical properties or uniformity of temper are required, physical quality should be specified.

If greater ductility than that indicated by the foregoing bend test is required, drawing quality should be specified.

DRAWING QUALITY sheets are customarily produced for use in fabricating identified parts where the surface before and after drawing is of secondary importance. Proper identification of parts may include visual examination, prints or description, or combination of these. These sheets are not recommended for exposed parts. They should produce parts too difficult for the fabricating properties of commercial quality sheets, within the breakage allowance as commonly negotiated between purchaser and producer. This quality of sheets is not commonly specified to chemical composition.

PHYSICAL QUALITY sheets are produced when mechanical properties are specified or required other than the bend tests of commercial quality or when uniformity of temper is required. Such properties or values include those determined by tensile tests, hardness tests, or other commonly accepted mechanical tests. It is customary to specify only one kind of a test requirement on any one item.

Requirements of sheets to meet both mechanical tests and drawing qualities are commonly negotiated between purchaser and producer.

Physical quality sheets are sometimes specified to structural specifications or to standard tensile ranges. The composition of steel is related to the required tensile properties; hence, a range for carbon is not commonly specified.

When surface finish is of prime importance, special surface should be specified.

STANDARD PRACTICE TABLES

Variations for Dimensions and Workmanship
(For Carbon Steel Sheets of 0.25% Max. Carbon Content)

Accuracy of hot rolled dimensions is influenced by many factors such as mill design, heating practice, reduction between passes, roll wear, roll pressure, and composition of steel. The cumulative effect of these, as well as other factors, precludes hot rolling to exact specified size and requires that provisions be made for variations.

The accompanying tables indicate the expectancy of dimensional variations.

TABLE 46

WEIGHT

(All of one gage and size)

Specified Weights, Lbs. per Sq. Ft.	Variation from Specified Weight, Per Cent Over or Under			
	20 Tons and Over	Under 20 Tons to 3 Tons, incl.	Under 3 Tons to 1 Ton, incl.	Under 1 Ton
1.875 (18 gage) and Heavier	3.5	5	7.5	10
1.874 (19 gage) and Lighter	2.5	3	5	10

For sheets 72" and over in width, add 2 to percentage shown in the table.

TABLE 47

THICKNESS

(Coils and Cut Lengths)

Specified Widths, Inches	Variations from Specified Thickness for Widths and Thicknesses Given—Over or Under, Inches						
	.2299 .1875	.1874 .1800	.1799 .1420	.1419 .0972	.0971 .0822	.0821 .0710	.0709 .0568
Over 12 to 15 incl.	.008	.007	.007	.007	.006	.006	.006
Over 15 to 20 incl.	.008	.008	.008	.008	.007	.007	.006
Over 20 to 32 incl.	.009	.009	.009	.008	.007	.007	.006
Over 32 to 40 incl.	.009	.009	.009	.009	.008	.007	.006
Over 40 to 48 incl.	.010	.010	.010	.010	.008	.007	.006
Over 48 to 60 incl.	......	......	.010	.010	.008	.007	.007
Over 60 to 70 incl.	......	......	.011	.011	.009	.008	.007
Over 70 to 80 incl.	......	......	.012	.012	.009	.008	......

Thickness is measured at any point on the sheet not less than ⅜" in from an edge.

TABLE 48

WIDTH

(Sheets Not Resquared)

(Coils and Cut Lengths)

Specified Widths, Inches	Variation Over Specified Widths, Inches No Variation Under
	Sheared or Slit Edge
To 15 incl.	1/8
Over 15 to 20 incl.	1/8
Over 20 to 30 incl.	3/16
Over 30 to 50 incl.	1/4
Over 50 to 80 incl.	5/16

TABLE 49

LENGTH

(Sheets Not Resquared, including Pickled Sheets)

Specified Lengths, Inches	Variation Over Specified Length, Inches No Variation Under
To 15 incl.	1/8
Over 15 to 30 incl.	1/4
Over 30 to 60 incl.	1/2
Over 60 to 96 incl.	3/4
Over 96 to 120 incl.	1
Over 120 to 156 incl.	1 1/4
Over 156 to 192 incl.	1 1/2
Over 192 to 240 incl.	1 3/4
Over 240	2

CAMBER

Camber is the greatest deviation of a side edge from a straight line; and measurement is taken on the concave side with a straight edge. The camber for sheets in cut lengths, not resquared, is shown below:

TABLE 50

CAMBER

(Includes Pickled Sheets)

Sheet Length, Feet	Camber, Inches
To 4 incl.	1/8
Over 4 to 6 incl.	3/16
Over 6 to 8 incl.	1/4
Over 8 to 10 incl.	5/16
Over 10 to 12 incl.	3/8
Over 12 to 14 incl.	1/2
Over 14 to 16 incl.	5/8
Over 16 to 18 incl.	3/4
Over 18 to 20 incl.	7/8
Over 20 to 30 incl.	1 1/4
Over 30 to 40 incl.	1 1/2

For sheets in coils, camber does not commonly exceed one inch in any 20′ of length.

OUT-OF-SQUARE

(Not Resquared, including Pickled and Oiled Sheets)

Out-of-square is the greatest deviation of an end edge from a straight line at right-angles to a side and touching one corner. The variation for sheets of all gages and all sizes is $\frac{1}{16}$ inch per 6 inches, or fraction thereof, of width.

RESQUARED SHEETS — VARIATIONS

(Includes Pickled and Oiled Sheets)

When sheets are specified resquared, the width and length are customarily not less than the dimensions specified. The variation for over-width, over-length, camber and out-of-square customarily does not exceed $\frac{1}{16}$ inch for sheets up to and including 48 inches in width and up to and including 120 inches in length; nor 1/8 inch for wider or longer sheets.

TABLE 51

FLATNESS

(Sheets Not Specified to Stretcher Leveled Standard of Flatness, including Pickled and Oiled Sheets)

Specified Weight, Lb. per Sq. Ft.	Specified Thickness, Inch	Specified Width, Inches	Variation from Flat, Inch
2.375 (16 Ga.) and heavier	0.0568 and thicker	To 60 incl. Over 60 to 72 incl. Over 72	½ ¾ 1

The flatness standards in Table 51 above are not applicable to coils.

ORDERING PRACTICE FOR KAISER HOT ROLLED SHEETS

In order to more clearly describe the material desired and to avoid misunderstanding, purchasers' inquiries and orders for Hot Rolled Sheets, should specify the following details:

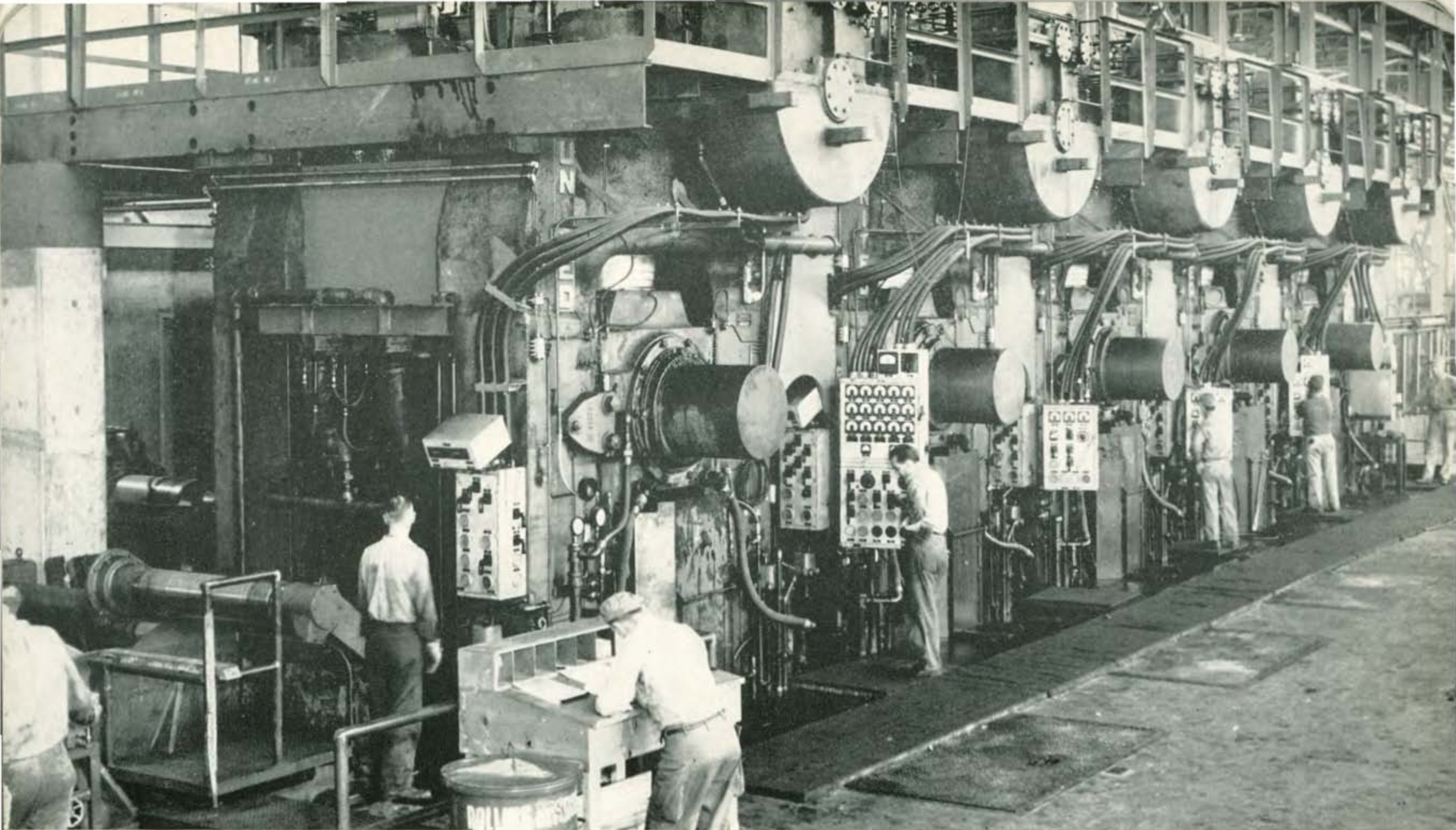
1. Quantity.
2. Size.
3. Specification.
4. Quality (that is, commercial quality, drawing quality, special killed steel, or physical quality, etc.)
5. End use.
6. Required inspection, if other than mill inspection.
7. Special loading practices if applicable.
8. Shipping destination.
9. Required routing.
10. Requested delivery.
11. Distribution of shipping notices, invoices, and bills of lading.

Sheets are invoiced on mill scale weights.

In check-weighing by the purchaser a variation from invoiced weights up to one per cent may be expected due to differences in kind, type, location and accuracy of the scales.

In cases of large quantities of one size and thickness, there is the possibility of error in count. For such lots, the weight is considered more accurate than the count as the basis for settlement of the invoices.

NOTES



Superior surface finish and forming qualities are inherent in Kaiser Steel's cold rolled sheets due to equipment of the latest design.

COLD ROLLED SHEETS

KAISER COLD ROLLED SHEETS

Cold rolled sheets are defined as steel sheets cold rolled to gage from hot rolled, coiled, pickled sheets in order to produce a surface superior to that of a hot rolled product.

Kaiser Cold Rolled Steel Sheets are produced to the highest standards of quality and are extensively used for articles requiring a superior surface and excellent forming qualities. Cold rolled sheets are used for automotive parts, conduit, electrical fixtures, household appliances, machine parts, hardware and for many other miscellaneous applications. It is important that Kaiser metallurgists be given complete information on the manufacturing process and the end product so that the producing mill can be set up to produce sheets with properties suitable for the ordered use.

Kaiser Cold Rolled Sheets are rolled to gage from hot rolled, coiled, pickled sheets on the most modern cold reduction units and are annealed in controlled atmosphere furnaces. The Company employs two cold reduction mills, one a five stand continuous mill and the other a two-high reversing mill.

Kaiser Cold Rolled Sheets are produced from 14 gage to 28 gage and from 12⅛ inches to 35 inches in width.

Sheets may be shipped in coils or cut lengths, as ordered, and will be finished with sheared edges unless mill edge is specified in widths from 12⅛ inches to 16 inches. The inside coil diameter is 16 inches and the maximum coil weight is approximately 220 pounds per inch of width. In widths from 24 inches to 35 inches, the inside coil diameter is 16 inches and the coils weigh approximately 825 pounds per inch of width.

GRADES

Cold rolled sheets are graded according to surface conditions as cold rolled primes or cold rolled sheets, and can be so specified.

COLD ROLLED SHEETS may contain surface inperfections of such a character that the sheets can be used for identified parts with a reasonable amount of metal finishing by the purchaser. They are supplied in coils or cut lengths.

COLD ROLLED PRIMES are sheets inspected to meet specific surface requirements without metal finishing by the purchaser to remove surface imperfections other than those caused by the purchaser's handling and fabrication. They are supplied in cut lengths only. Inquiries for this grade are subject to negotiation.

QUALITIES

Cold rolled sheets are commonly produced in three principal qualities: commercial quality, drawing quality and physical quality.

COMMERCIAL QUALITY sheets are ordinarily produced in a low carbon grade of steel, and are suitable for exposed parts requiring a good surface. Commercial quality sheets are not guaranteed to be suitable for electroplating where surface uniformity in the finished product is essential. Commercial quality can be specified to standard chemical ranges. Where no chemical composition is specified, commercial quality sheets should ordinarily not exceed a hardness equivalent of Rockwell B60. Hardness values, however, are not reported. Commercial quality sheets are processed so as to be free from surface disturbances known as stretcher straining during fabrication, provided the sheets are properly roller leveled immediately before using.

Drawing Quality sheets are customarily produced for fabricating identified parts where the surface before and after drawing is of prime importance. Proper identification of parts may include visual examination, prints or description, or combination of these. Drawing quality sheets are not suitable for electroplating where surface uniformity in the finished product is essential. Drawing quality sheets should produce identified parts too difficult for the drawing properties of sheets of any other quality, within the breakage allowances as commonly negotiated between purchaser and producer. When sheets of this quality are required to be essentially free from surface disturbances such as stretcher strains without roller leveling immediately prior to use, or when the sheets are to be essentially free from significant changes in mechanical properties over a period of time, Special Killed Steel should be specified.

Physical Quality sheets are produced when mechanical properties are specified or required, other than those described under other qualities of cold rolled sheets. Such properties or values include those determined by tension tests, hardness tests, or other commonly accepted mechanical tests. It is customary to specify only one kind of a test requirement. Cold rolled sheets of this quality are subject to negotiation.

Bright Finish sheets may be supplied in any quality. Inquiries for bright finish are subject to negotiation. Such sheets are produced on specially prepared rolls.

Tables covering the dimensional tolerances allowed in the production of Kaiser Cold Rolled Sheets are given on the following pages. These tolerance are recognized as standard by the steel industry.

STANDARD PRACTICE TABLES

TABLE 52

WEIGHT

(All of One Gage and Size)

Specified Weights, Lbs. per Sq. Ft.	Variation from Specified Weight, Per Cent Over or Under			
	20 Tons and Over	Under 20 Tons to 3 Tons, incl.	Under 3 Tons to 1 Ton, incl.	Under 1 Ton
1.875 (18 gage) and Heavier	3.5	5	7.5	10
1.874 (19 gage) and Lighter	2.5	3	5	10

TABLE 53

THICKNESS

(Coils and Cut Lengths)

Specified Widths, Inches	For Widths and Thicknesses Given—Over or Under, In.						
	.1875 and Thicker	.1874 .1420	.1419 .0972	.0971 .0822	.0821 .0710	.0709 .0568	.0567 .0509
Up to 15 incl.	.007	.006	.006	.006	.005	.005	.005
Over 15 to 20 incl.	.007	.007	.007	.006	.005	.005	.005
Over 20 to 24 incl.	.007	.007	.007	.006	.005	.005	.005

Specified Widths, Inches	For Widths and Thicknesses Given—Over or Under, In.						
	.0508 .0389	.0388 .0314	.0313 .0255	.0254 .0195	.0194 .0142	.0141 .0113	.0112 and Thinner
Up to 15 incl.	.004	.003	.003	.003	.002	......	......
Over 15 to 20 incl.	.004	.003	.003	.003	.002	......	......
Over 20 to 24 incl.	.004	.003	.003	.003	.002	......	......

The thickness is measured at any point on the sheet not less than ⅜″ in from an edge.

TABLE 54

WIDTH

(Sheets Not Resquared)

(Coils and Cut Lengths)

Specified Widths, Inches	Variation Over Specified Width, Inches No Variation Under
Up to 20 incl.	1/8
Over 20 to 32 incl.	3/16

TABLE 55

LENGTH

(Sheets Not Resquared)

Specified Lengths, Inches	Variation Over Specified Length, Inches No Variation Under
To 15 incl.	1/8
Over 15 to 30 incl.	1/4
Over 30 to 60 incl.	1/2
Over 60 to 96 incl.	3/4
Over 96 to 120 incl.	1
Over 120 to 156 incl.	1 1/4
Over 156 to 192 incl.	1 1/2
Over 192 to 240 incl.	1 3/4
Over 240	2

CAMBER

Camber is the greatest deviation of a side edge from a straight line; and measurement is taken on the concave side with a straight edge.

The camber for sheets in cut lengths, not resquared, is as follows.

TABLE 56

CAMBER

Sheet Length, Feet	Camber, Inches
To 4 incl.	1/8
Over 4 to 6 incl.	3/16
Over 6 to 8 incl.	1/4
Over 8 to 10 incl.	5/16
Over 10 to 12 incl.	3/8
Over 12 to 14 incl.	1/2
Over 14 to 16 incl.	5/8
Over 16 to 18 incl.	3/4
Over 18 to 20 incl.	7/8
Over 20 to 30 incl.	1 1/4
Over 30 to 40 incl.	1 1/2

For sheets in coils, camber does not commonly exceed 1 inch in any 20 feet of length.

TABLE 57

FLATNESS

(Sheets Not Specified to Stretcher Leveled Standard of Flatness)

Specified Weight, Lbs. per Sq. Ft.	Specified Thickness, Inch	Specified Width, Inches	Variation from Flat, Inch
2.375 (16 Ga.) and Heavier	0.0568 and Thicker	To 60 incl.	1/2
2.374 (17 Ga.) and Lighter	0.0567 and Thinner	To 36 incl.	1/2

The flatness standards in Table 57 are not applicable to coils.

OUT-OF-SQUARE

(Not Resquared)

Out-of-square is the greatest deviation of an end edge from a straight line at right angle to a side and touching one corner. The variation for sheets of all gages and all sizes is $\frac{1}{16}$ inch per 6 inches, or fraction thereof, of width.

RESQUARED SHEETS

When sheets are specified resquared, the width and length are customarily not less than the dimensions specified. The variations for over-width, over-length, camber and out-of-square customarily does not exceed $\frac{1}{16}$ inch for sheets up to and including 48 inches in width and up to and including 120 inches in length; nor $\frac{1}{8}$ inch for wider or longer sheets.

HARDNESS

Cold rolled sheets may be specified to chemical composition, may be produced to mechanical requirement specifications or may be ordered to hardness ranges. Hardness of Rockwell B-60 maximum is commonly recognized as a standard for commercial quality sheets. When cold rolled sheets are specified to a hardness range, no special finish beyond recognized sheet standards should be designated nor should the sheet be required to meet definite forming requirements. Standard variations from a horizontal flat surface do not commonly apply when sheets are produced to hardness ranges.

ORDERING PRACTICE FOR KAISER COLD ROLLED SHEETS

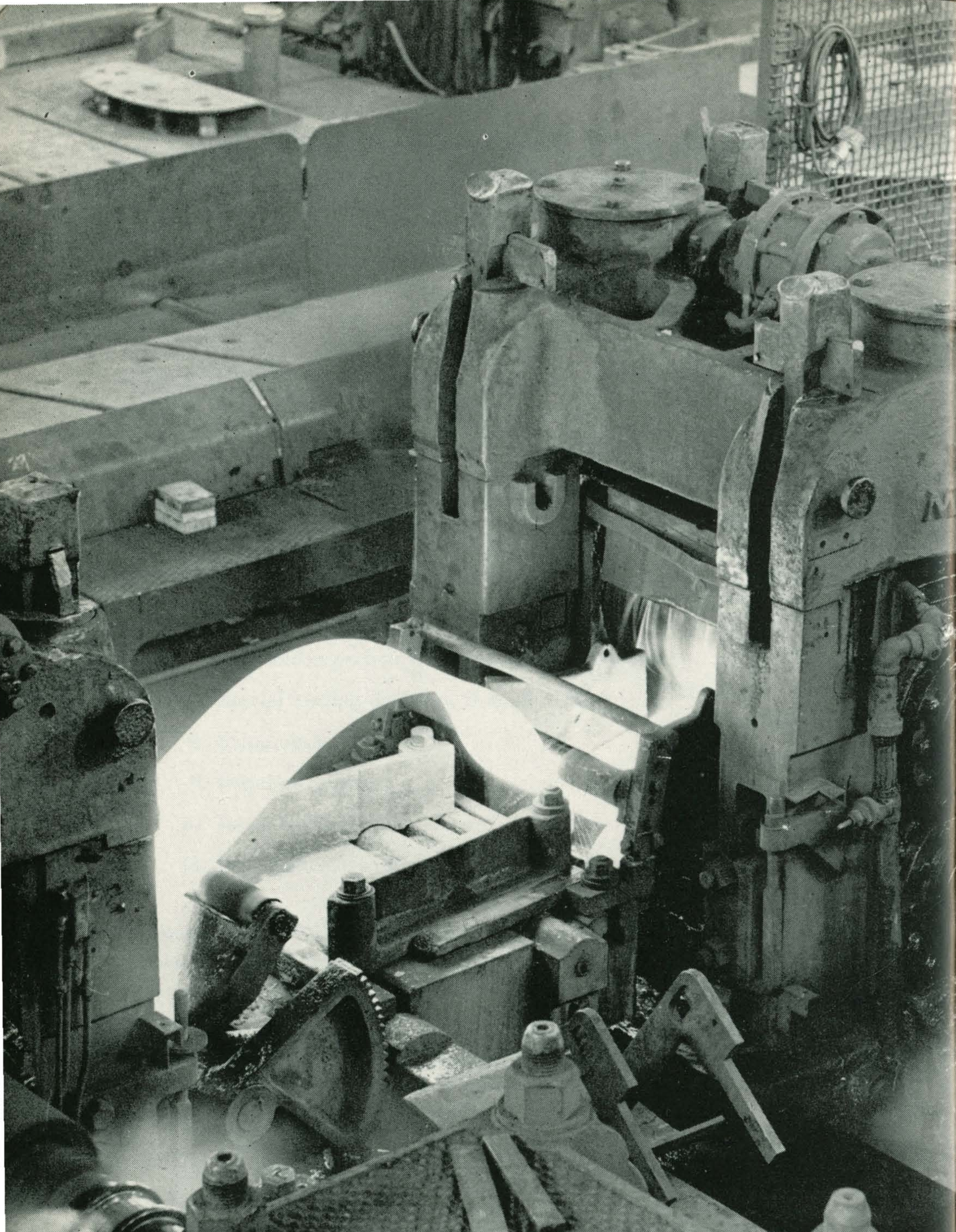
In order to more clearly describe the material desired and to avoid misunderstanding, purchasers' inquiries and orders for Cold Rolled Sheets should specify the following details:

1. Quantity.
2. Size.
3. Quality (that is, commercial quality, drawing quality or physical quality).
4. Special and restrictive requirements (include in specification where applicable, special killed steel, special finish quality, primes only, and any specification restrictions closer than standard tolerances).
5. End use.
6. Required inspection, if other than mill inspection.
7. Special loading practices, if applicable.
8. Shipping destination.
9. Required routing.
10. Requested delivery.
11. Distribution of shipping notices, invoices, and bills of lading.

Sheets are invoiced on mill scale weights. In check-weighing by the purchaser a variation from invoiced weights up to one per cent may be expected due to differences in kind, type, location and accuracy of the scales.

In cases of large quantities of one size and thickness, there is the possibility of error in count. For such lots, the weight is considered more accurate than the count as the basis for settlement of the invoices.

NOTES



Kaiser Hot Rolled Strip is rolled on a continuous mill consisting of a series of vertical and horizontal rolls.

HOT ROLLED STRIP

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KAISER HOT ROLLED STRIP

Hot rolled strip is 12 inches or less in width and under .2300 inches in thickness. It is produced to qualities and dimensional limits as described later in this section. In industry, hot rolled strip is used when a specific width within the strip range is needed or a mill edge is required. It is used in the automotive, building, industrial and mechanical fields.

Kaiser Hot Rolled Strip is rolled on a continuous mill consisting of a series of vertical and horizontal rolls arranged in tandem so that strip rolled on the mill passes continuously through successive stands until it is reduced to the desired thickness. The vertical rolls control the width of the strip and loosen the oxide scale which is then removed by suitable hydraulic sprays. The strip may be coiled or cut in lengths as it leaves the mill. All cut length strip is accurately sheared and leveled before shipment.

The high standard of workmanship and quality maintained in Kaiser Hot Rolled Strip is a principal reason for its increasing use in western industry.

The table below shows the chemical ranges and rolling limits of Kaiser Hot Rolled Strip.

TABLE 58

KAISER HOT ROLLED STRIP

MAXIMUM .25 CARBON		MAXIMUM C-1085	
Width	Gage	Width	Gage
2″ to 4½″ incl. 5⅛″ to 6″ incl. 6⅛″ to 12″ incl.	.125 to .203 .104 to .203 .104 to .2299	6″ 6⅛″ to 12″ incl.	.1875 to .203 .1875 to .2299

All sizes 5⅛″ and wider are available in coils or cut lengths.

QUALITIES

Kaiser Hot Rolled Strip is furnished in commercial quality, drawing quality and physical quality.

COMMERCIAL QUALITY strip is ordinarily produced in a low carbon grade of steel, and is suitable for many purposes where the presence of oxide and normal surface defects are not objectionable. Commercial quality is commonly specified to chemical ranges and limits. When a carbon content is not specified, it is assumed that hot rolled commercial quality strip, not exceeding 0.15 per cent carbon by ladle analysis, is desired. For any carbon range specified or required, the maximum of which does not exceed 0.15 per cent, a test specimen should withstand being bent flat on itself in any direction at room temperature. If mechanical properties or uniformity of temper are required, physical quality should be specified. If greater ductility than that indicated by the foregoing bend test is required drawing quality should be specified.

DRAWING QUALITY strip is customarily produced for use in fabricating identified parts where the surface before and after drawing is of secondary importance. This quality should produce parts too difficult for the fabricating properties of commercial quality strip, within the breakage allowance as usually negotiated between purchaser and producer. Because of excessive die scoring, the oxide on hot rolled strip should be removed by pickling prior to drawing.

PHYSICAL QUALITY strip is produced when mechanical properties are specified or required other than the bend tests of commercial quality or when uniformity of temper is required. Such properties or values include those determined by tensile tests, hardness tests, or other commonly accepted mechanical tests. It is customary to specify only one kind of a test requirement on any one item.

The tensile characteristics of hot rolled strip are influenced chiefly by chemical composition and thickness of section. The carbon content is the dominant factor in meeting required tensile properties. Consequently, if the ultimate use or method of fabrication should require either a maximum or a minimum carbon limit along with tensile limits, the specified carbon should not have the effect of restricting the normal application for the given thickness and tensile requirements.

SPECIAL SURFACE strip is produced for applications requiring a better surface than is obtained in the previously described types of hot rolled strip. This surface is specified when strip having one smooth, clean surface and adherent oxide is required.

Hot rolled special surface, together with the proper strip quality, is usually specified when the strip after pickling or blast cleaning by the purchaser is required to have a surface equivalent to that of the pickled commercial quality.

All Kaiser Hot Rolled Strip is furnished with a natural mill edge.

STANDARD PRACTICE TABLES

CAMBER

Camber is the greatest deviation of a side edge from a straight line; and measurement is taken by placing an eight-foot straight edge on the concave side and measuring the distance between the strip edge and the straight edge in the center of the arc.

The camber for hot rolled strip is shown in the table below.

TABLE 59

CAMBER

For strip wider than 1½ inches	¼ inch in any 8 feet
For strip 1½ inches and narrower	½ inch in any 8 feet

TABLE 60

THICKNESS

Coils and Cut Lengths

Specified Widths, Inches	Variations from Specified Thickness for Widths Given—Over or Under, Inches					
	0.2299 to 0.2031 incl.	0.2030 to 0.1875 incl.	0.1874 to 0.1180 incl.	0.1179 to 0.0568 incl.	0.0567 to 0.0344 incl.	0.0343 to 0.0255 incl.
Up to 3½ incl.	....	0.006	0.005	0.004	0.003	0.003
Over 3½ to 6 incl.	....	0.006	0.005	0.005	0.003	....
Over 6 to 12 incl.	0.006	0.006	0.005	0.005	....	....

Thickness measurements are taken ⅜" in from edge of strip on 1 inch or wider; and at any place on the strip when narrower than 1 inch.

The given variations do not include crown.

TABLE 61
CROWN

Tolerance for Thickness at Center of Strip is that of the Edge Measurement Plus the Following:

Specified Widths, Inches	Variations from Specified Width for Thicknesses Given, Inches					
	0.2299 to 0.2031 incl.	0.2030 to 0.1875 incl.	0.1874 to 0.1180 incl.	0.1179 to 0.0568 incl.	0.0567 to 0.0344 incl.	0.0343 to 0.0255 incl.
Over 1 to 3½, incl.	....	0.001	0.002	0.002	0.002	0.002
Over 3½ to 6, incl.	....	0.002	0.002	0.003	0.003	....
Over 6 to 12, incl.	0.002	0.003	0.003	0.004	....	....

TABLE 62
WIDTH

Specified Widths, Inches	Variations from Specified Width for Thicknesses Given, Over or Under, Inches		
	Mill Edge and Square Edge All Thicknesses	Slit Edge	
		To 0.109 incl.	Over 0.109
To 2, incl.	1/32	0.008	0.016
Over 2 to 5, incl.	3/64	0.008	0.016
Over 5 to 10, incl.	1/16	0.010	0.016
Over 10 to 12, incl.	3/32	0.016	0.016

TABLE 63
LENGTH

Specified Widths, Inches	Variation over Specified Length in Feet for Widths Given, Inches					
	To 5′ incl.	Over 5′ to 10′ incl.	Over 10′ to 20′ incl.	Over 20′ to 30′ incl.	Over 30′ to 40′ incl.	Over 40′
To 3, incl.	¼	⅜	½	¾	1	1½
Over 3 to 6, incl.	⅜	½	⅝	¾	1	1½
Over 6 to 12, incl.	½	¾	1	1¼	1½	1¾

No variation under.

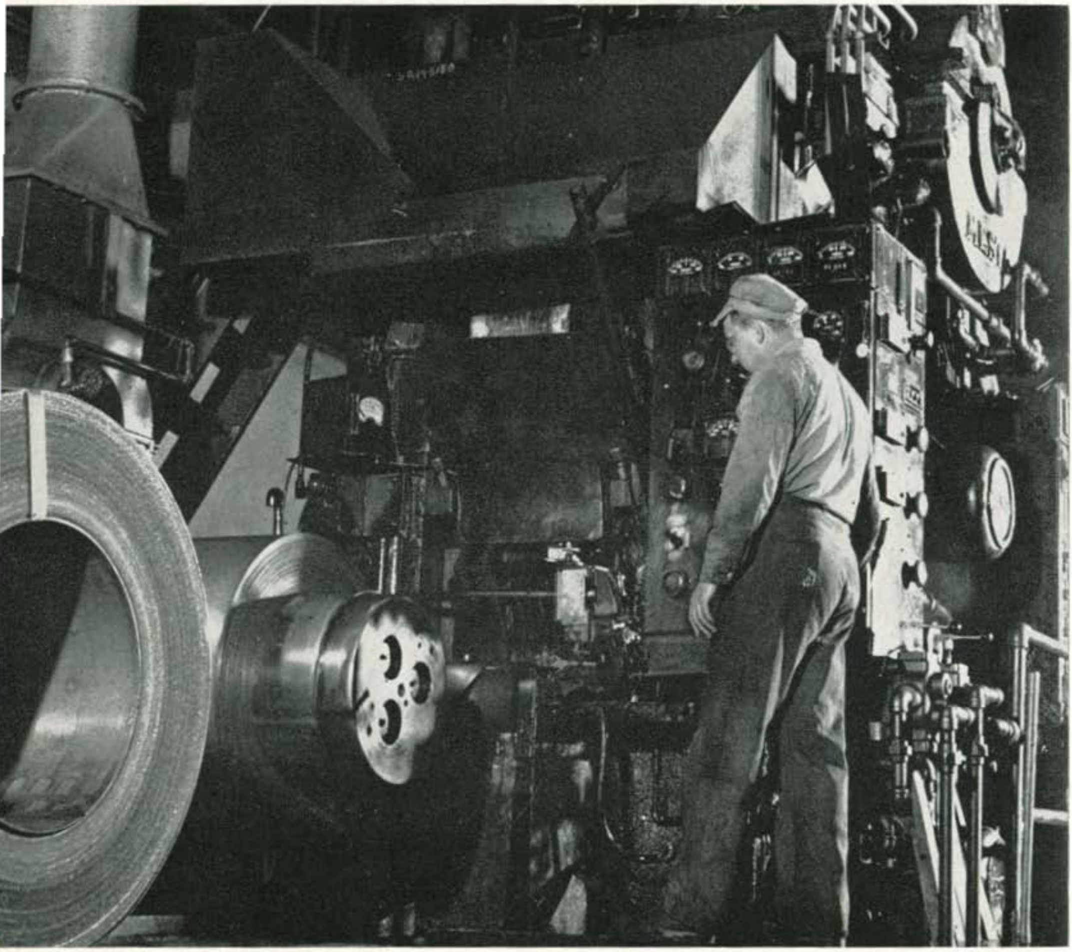
ORDERING PRACTICE FOR KAISER HOT ROLLED STRIP

In order to more clearly describe the material desired and to avoid misunderstanding, purchasers' inquiries and orders for Hot Rolled Strip should specify the following details:

1. Quantity.
2. Size.
3. Specification.
4. Quality (that is, commercial quality, drawing quality, special killed steel or physical quality, etc.).
5. End use.
6. Required inspection, if other than mill inspection.
7. Special loading practices, if applicable.
8. Shipping destination.
9. Required routing.
10. Requested delivery.
11. Distribution of shipping notices, invoices, and bills of lading.

Hot rolled strip is invoiced on mill scale weights. In check-weighing by the purchaser, a variation in invoiced weights up to one per cent may be expected due to differences in kind, type, location, and accuracy of the scales.

NOTES



Kaiser cold rolled strip steel is produced in many widths, gages and tempers.

COLD ROLLED STRIP

12

KAISER COLD ROLLED STRIP

Cold rolled strip by industry definition is steel strip less than 24 inches wide rolled to gage from hot rolled, coiled, pickled strip to produce a product with specified temper, edge, and finish. The processing of steel in pickling, rolling, annealing, temper rolling and slitting to meet the requirements for temper, edge and finish that are demanded by cold rolled strip necessitates such close control of all operations that cold rolled strip is literally a tailor-made product.

Among its many applications, Kaiser Cold Rolled Strip is used in the manufacture of moldings, furniture tubing, household and general hardware, tools and instruments, calculators, automobile and aircraft parts and plumbing and heating equipment.

In the Kaiser practice, mill scale is removed from the coils of hot rolled steel in modern, continuous pickling equipment to prepare it for cold rolling. The action of a combination of mechanical and chemical processes, which takes place as the steel moves through the pickling unit, produces a remarkably clean and stain free surface. Continuous inspection of the pickled surface insures the selection of hot rolled strip with sound surface for cold rolling.

The pickled strip is cold rolled to the desired thickness by successive passes in alternate directions through a four-high reversing mill. The Kaiser practice of large percentage reduction from the hot roll to the cold roll thickness insures excellent recrystallization in the cold rolled strip and superior drawing properties in the final product. An electric gage, mounted on the rolling mill, continuously measures the thickness of the strip during rolling, enabling the operator to maintain uniformly accurate thickness throughout the coil.

After cold rolling to thickness the steel is hard, stiff and has very little ductility. Annealing in modern, bell type, zone controlled furnaces softens the strip. The original brightness of the strip is retained during annealing by a protective atmosphere. The annealed strip is dead soft but it is characteristic of annealed steel that when it is stressed beyond its elastic limit, initial elongation does not occur uniformly but commences in isolated areas which become visible as objectionable depressions in the surface. These depressions are commonly termed "stretcher strains." Stretcher strains can be prevented by lightly rolling annealed strip. To eliminate stretcher straining and develop desired physical characteristics, annealed strip is skin rolled to the degree of ductility or stiffness needed for the end product. The effect of skin rolling, however, is not permanent, and stretcher strains may reappear in the softer temper strip unless it is used shortly after temper rolling. If freedom from stretcher strains is imperative, special aluminum killed steel should be specified.

The following data shows the width and thickness ranges and the tempers and edges of Kaiser Cold Rolled Strip.

KAISER COLD ROLLED STRIP

Widths:	Over $\frac{1}{2}''$ to 12″ inclusive	
	Over 12″ to 16″ inclusive	(When a particular temper or a special edge, or special finish is specified).
Thickness:	.0150 to .0900 inches	

Lengths: This material is available in coils or cut lengths 48″ to 120″.
Standard weight per inch of coil width is approximately 225 pounds.
Standard coil dimensions: I.D. 16″ O.D. 42″

TEMPERS

Kaiser Cold Rolled Strip is temper rolled to degrees of ductility commonly designated by temper numbers. Temper numbers indicate ranges of hardness associated with the ability of the steel to withstand deformation. The close control given the temper rolling of Kaiser strip largely contributes to its successful performance.

The following is a full description of cold rolled strip tempers, currently accepted as standard practice.

No. 1 (Hard Temper) is a very stiff, springy, cold rolled strip intended for flat work not requiring ability to withstand cold forming. This temper is commonly produced in chemical compositions of less than 0.25 per cent carbon (ladle analysis) and Rockwell B-84 minimum for thicknesses 0.070 inches and greater, or Rockwell B-90 minimum for thicknesses less than 0.070 inches.

No. 2 (Half Hard Temper) is a moderately stiff cold rolled strip suitable for limited bending. Strip of this temper can be bent 90 degrees across the direction of rolling around a radius equal to the thickness. This temper is commonly produced in chemical compositions of less than 0.25 per cent carbon (ladle analysis) Rockwell B-70 minimum and approximately Rockwell B-85 maximum.

No. 3 (Quarter Hard Temper) is a medium soft cold rolled strip suitable for limited bending and forming and drawing. Strip of this temper can be bent 180 degrees across the direction of rolling and 90 degrees in the direction of rolling around a radius equal to the thickness. This temper is commonly produced in chemical compositions of less than 0.25 per cent carbon (ladle analysis) Rockwell B-60 minimum and approximately Rockwell B-75 maximum.

No. 4 (Skin Rolled Temper) is a soft, ductile, cold rolled strip, suitable for fairly deep drawing where surface disturbances such as stretcher strains are objectionable. It is capable of being bent flat upon itself in any direction. Skin-rolled, planish rolled, and pinch passed are equivalent terms with respect to temper. This temper is commonly produced in chemical compositions of less than 0.15 per cent carbon (ladle analysis) and approximately Rockwell B-65 maximum.

No. 5 (Dead Soft Temper) is a soft, ductile, cold rolled strip produced without definite control of stretcher straining and fluting. It is suitable for difficult drawing applications where such surface disturbances are not objectionable. It is suitable for bending flat upon itself in any direction. This temper is commonly produced in chemical compositions of less than 0.15 per cent carbon (ladle analysis) and approximately Rockwell B-55 maximum.

Although the maximum ductility is obtained in strip steel in its dead soft or annealed condition, it is unsuited to many forming operations due to its tendency to stretcher strain. A small amount of cold rolling will prevent this, but the effect is only temporary due to the phenomenon called aging. Usually the higher the storage temperature, and the less the amount of skin rolling after final annealing, the shorter the elapsed time necessary for stretcher strain to recur. The phenomenon of aging is accompanied by a loss of ductility with an increase in hardness, yield point, and tensile strength. For those uses in which stretcher straining or breakage due to aging of the steel are likely to occur, the material should be fabricated as promptly as possible after temper rolling.

No. 1 temper strip is rolled direct to gage on the four-high reversing mill and is not annealed. Strip of Nos. 2, 3 and 4 tempers are rolled slightly heavier than the final thickness on the four-high reversing mill and after annealing are temper rolled on the two-high mill to the final thickness and desired temper. No. 5 temper strip is rolled to gage on the four-high reversing mill and no further rolling is done after annealing; the strip is shipped in the dead soft annealed condition. After slitting to width and final inspection and testing, coils are bundled or cut into specified lengths for shipment.

FINISHES

No. 2 (Regular bright finish). This luster surface is produced by finishing on bright rolls and is the finish regularly supplied.

No. 3 (Best bright finish). This high luster surface is produced by special practice and by finishing on especially bright rolls. It is guaranteed for electroplating. A limited amount of No. 3 finish is accepted for processing, and inquiries for this finish are subject to negotiation.

EDGES

Kaiser Cold Rolled Strip may be furnished with mill or slit edges.

The edge desired should be specified on the order.

No. 2 Edge—Mill edge. Suitable for blanking.

No. 3 Edge—Slit edge. Approximately square.

TABLE 64

DEFINITION AND CLASSIFICATION

Cold Rolled Strip is Produced in Coils or Cut Lengths with a Maximum Width 23$\frac{15}{16}$" from Hot Rolled Steel which has been Pickled to Remove Scale.

Widths, Inches	Thicknesses, Inches		
	0.2500 and Thicker	0.2499 to 0.0142	0.0141 and Thinner
To 12 incl.	Bar	Strip (3)	Strip (3)
Over 12 to 24 incl.	Strip (1)	Strip (1)	Strip (1)
Over 12 to 24 incl.	Sheet (2)	Sheet (2)	

(1) When a particular temper, special edge, or special finish is specified.

(2) When no special temper, edge or finish is specified.

(3) When the width is greater than the thickness with a maximum of ½ inch and a cross-sectional area not exceeding 0.05 Sq. In., and the material has rolled or prepared edges, it is classified as flat wire.

STANDARD PRACTICE TABLES

TABLE 65

CROWN

Tolerance for Thickness at Center of Strip is that of the Edge Measurement Plus the Following:

Thickness, Inches	Width, Inches		
	1 to 5 incl.	Over 5 to 12 incl.	Over 12 to 23$\frac{15}{16}$ incl.
	Additional Thickness at Center, Inches		
0.005 to 0.010 incl.	0.00075	0.001	0.0015
Over 0.010 to 0.025 incl.	0.001	0.0015	0.002
Over 0.025 to 0.065 incl.	0.0015	0.002	0.0025
Over 0.065 to 0.187 incl.	0.002	0.0025	0.003
Over 0.187 to 0.2499 incl.	0.002	0.0025	0.003

TABLE 66

THICKNESS

Measured ⅜ Inch in from Edge on 1 Inch or Wider; and on Narrower than 1 Inch at Any Place on the Strip

Specified Thickness, Inches		Variation from Specified Thickness, Plus or Minus, Inches — Widths, Inches							
Over	To and incl.	Over ½ less than 1	1 and less than 3	3 to 6 incl.	Over 6 to 9 incl.	Over 9 to 12 incl.	Over 12 to 16 incl.	Over 16 to 20 incl.	Over 20 to 23$\frac{15}{16}$ incl.
.160	.2499	.002	.003	.0035	.0035	.0035	.0045	.005	.005
.099	.160	.002	.002	.003	.003	.003	.0035	.0045	.005
.068	.099	.002	.002	.0025	.003	.003	.0035	.0035	.0035
.049	.068	.002	.002	.0025	.0025	.0025	.003	.0035	.0035
.039	.049	.002	.002	.0025	.0025	.0025	.003	.003	.003
.034	.039	.002	.002	.002	.002	.002	.002	.002	.002
.031	.034	.0015	.0015	.002	.002	.002	.002	.002	.002
.028	.031	.0015	.0015	.0015	.002	.002	.002	.002	.002
.025	.028	.001	.0015	.0015	.002	.002	.002	.002	.002
.019	.025	.001	.001	.0015	.0015	.0015	.002	.002	.002
.012	.019	.001	.001	.001	.0015	.0015	.0015	.0015	.0015
.011	.012	.001	.001	.001	.001	.0015	.0015	.0015	.0015
.009	.011	.001	.001	.001	.001	.001	.001	.001	.001
.005	.009	.00075	.00075	.00075	.001	.001	.001	.001	.001
......	.005	.0005	.0005	.0005	....	....	....	....	....

TABLE 67

WIDTH FOR No. 2 EDGE (MILL EDGE)

Specified Width, Inches		Variation from Specified Width, Plus or Minus, Inches
Over	Up to and Including	
½	2	$\frac{1}{32}$
2	5	$\frac{3}{64}$
5	10	$\frac{5}{64}$
10	15	$\frac{3}{32}$
15	20	⅛
20	23$\frac{15}{16}$	$\frac{5}{32}$

TABLE 68

WIDTH FOR No. 3 EDGE (SLIT EDGE)

Specified Thickness, Inches		Width, Inches				
Over	To and incl.	Over ½ to 6 incl.	Over 6 to 9 incl.	Over 9 to 12 incl.	Over 12 to 20 incl.	Over 20 to 2315/16 incl.
		Variations from Specified Width, Plus or Minus, Inches				
.160	.2499	.016	.020	.020	.031	.031
.099	.160	.010	.016	.016	.020	.020
.068	.099	.008	.010	.010	.016	.020
.016	.068	.005	.005	.010	.016	.020
Up to	.016	.005	.005	.010	.016	.020

TABLE 69

LENGTHS

Variations in Inches Over the Specified Length

Specified Width, Inches	24 to 60 inches incl.	Over 60 to 120 inches incl.	Over 120 to 240 inches incl.
Over ½ to 12, incl.	¼	½	¾
Over 12 to 23 15/16, incl.	½	¾	1

CAMBER

Camber is the deviation of a side edge from a straight line, and measurement is taken by placing an eight-foot straight edge on the concave side and measuring the distance between the strip edge and the straight edge.

The camber for cold rolled strip is shown below.

For strip wider than 1½″..¼″ in any 8 feet

For strip 1½″ or narrower..½″ in any 8 feet

When the camber shown above is not suitable for a particular purpose, cold rolled strip is sometimes machine straightened to specified camber. This requirement is commonly negotiated between purchaser and producer.

ORDERING PRACTICE FOR KAISER COLD ROLLED STRIP

In order to more clearly describe the material desired and to avoid misunderstanding, purchasers' inquiries and orders for Cold Rolled Strip should specify the following details:

1. Quantity.
2. Size (Cold rolled strip should be ordered to decimal thickness).
3. Temper, edge, finish.
4. Any special requirements such as special tolerances or special killed steel.
5. End use.
6. Required inspection, if other than mill inspection.
7. Special loading practices, if applicable.
8. Shipping destination.
9. Required routing.
10. Requested delivery.
11. Distribution of shipping notices, invoices, and bills of lading.

Cold rolled strip is invoiced on mill scale weights. In check-weighing by the purchaser, a variation in invoiced weights up to one per cent may be expected due to differences in kind, type, location, and accuracy of the scales.

NOTES

Hot rolled strip for tin plate enters the five-stand mill slowly at .08-inch gage. It emerges from the fifth stand at an average thickness of .0095 at speeds up to 3100 feet per minute.

TIN PLATE

13

KAISER TIN PLATE

Tin plate may be defined as sheet steel coated with a thin layer of tin.

Since early times, tin, due to its lustrous appearance and non-corrosive properties, has been recognized as an attractive and protective coating for iron and other stronger metals. With the advent, during the 19th Century, of food preserving in sealed containers, thin iron sheets covered with tin quickly became the most widely used material for fabrication of containers. Hot rolled steel sheet replaced iron towards the end of the 19th Century as the base metal, and with the development of cold reduction in the 1930's, cold rolled steel sheet has become the almost exclusive base metal for tin plate.

Until the late 1930's, the only method used commercially for coating was that of dipping the base material in molten tin. Since the early 1920's, however, the industry has been experimenting with various methods of tin electroplating in order to speed up the operation and reduce the amount of tin used. Several electrolytic tinning lines were successfully operating prior to World War II; but it took the war, with its critical tin shortage, to establish this process as the major method in the industry.

The metal, tin, adheres very firmly to steel, and the resultant tin plate or sheet may be pressed, stamped, or bent into intricate shapes or forms without causing the coating to break or peel off. Modern tin plate, produced from cold rolled steel strip, possesses strength, lightness, uniformity of chemical and physical qualities, pleasing appearance, and ease of fabrication.

It is estimated that 90 per cent of the production of tin plate goes into the fabrication of sealed containers for perishable food and other products. It also has increasing application in the manufacture of toys, kitchen utensils, building materials, merchandising displays, seals, tags, signs, and art work.

TIN MILL PRODUCTS

In the steel industry tin mill products are broadly classified by the method of coating used, as hot dipped or "coke" tin plate, electrolytic tin plate, black or uncoated plate, and terne plate. Kaiser Steel Corporation produces all of these products except terne plate.

The mill products are customarily further classified into the following categories:

PRIMES—A grade designation given to tin plate free from defects readily observed by the unaided eye.

SECONDS—The grade designation commonly given to tin plate having imperfections to a moderate degree. These imperfections are coating, base material, or other manufacturing defects. Seconds are not customarily separated in packaging the finished sheets. Electrolytic tin plate is usually sold as Unassorted (U/A). Primes and Seconds are often packed together and sold as U/A. Almost all of the prime coke tin plate used by manufacturers is of the U/A quality.

MENDERS—Those tin plates having imperfections in coating which upon hot dip recoating will produce either a "prime" or "second" quality hot dipped sheet.

WASTE WASTE—A grade designation applying to tin plate sheets which have imperfections slightly greater than would permit them to be included under the term Seconds. These imperfections may be scratches, pin holes, laminations, off gage, out of square, or other such deviations from a perfect sheet. Tin plate Waste Waste is commonly sold in mixed sizes and gages. Such products find use as containers for such familiar products as tobacco, inks, paints, cosmetics, pharmaceuticals, soaps, bottle caps, toys, and novelties. World War II, with its shortages of raw materials and finished products, brought into prominence the utilization of tin plate Waste Waste in every conceivable way.

TIN PLATE REJECTS—In certain cases Waste Waste tin plate is segregated as to size and gage. When available in this form, it is called Tin Plate Rejects and is shipped one size and one gage per skid.

COBBLE—A grade designation commonly applied to tin plate sheets of a quality one grade below that of Waste Waste. The same imperfections applicable to Waste Waste are characteristic of Cobbles, but to a far greater degree.

BLACK PLATE REJECTS—A grade designation applying to the uncoated basic steel sheet of an inferior quality, not suitable for producing satisfactory tin plate. If Black Plate Rejects are packed with mixed sizes and gages of sheets on one skid, they are called Black Plate Waste Waste or Waste Wasters.

TIN PLATE STRIPS—A grade designation applied to the shearings from large sheets, which are, for the most part, prime material. Such shearings are strips ranging from a width of 2″ to 10″ and occasionally even wider, and from 18″ to 32″ in length. Tin mill strips are also available in tin mill black plate.

UNITS OF MEASURE

Unlike most steel products, tin plate is measured not only by tons or pounds, but by a unit of area, the base box. The base box originally consisted of 112 sheets, 14″ x 20″ or 31,360 square inches of surface. The gage or thickness of the sheets was designated by the weight of a base box, called the basis weight. This terminology is still used, although the industry's requirements for various sizes of sheets have resulted in adoption of a second unit of measure, the package. The package is usually 112 sheets, but the sheets may be theoretically of any size. Thickness is still designated by the basis weight and the quantity in both base boxes and packages. The relation of a package of a given size to the base box is termed the ratio, which is nothing more than the total area of the sheets in the package divided by 31,360 square inches. The amount of tin coating on the plate is likewise designated in terms of pounds or fractions of pounds of tin per base box. Thus, plate with a No. 50 coating has ½ pound of tin per base box. Tables No. 70 and No. 71 on Page 146 show the nominal weights in pounds per base box commonly produced, the increasing weight per square foot, and the approximate thicknesses for tin plate. Tin plate is customarily ordered by weight per base box.

KAISER TIN MILL PROCESSES AND FACILITIES

Kaiser tin mill products are produced from the cold reduction of hot rolled pickled and oiled coiled sheets which, by a single pass through a five-stand reduction mill, are reduced to the desired tin mill gages. The resulting coiled sheet is then electrolytically cleaned, dried, annealed, and temper rolled. If the end product is to be black plate or hot dipped tin plate, the coiled sheet is side trimmed and cut to length. The cut sheets are then hot dipped in a bath of molten tin to produce the hot dipped or "coke" tin plate. If the end product is to be electrolytic tin plate, the uncoated, coiled sheet is first side trimmed in a coil preparation line to the desired width and then passes through a facility which electrolytically coats it with tin, after which it is cut to the desired lengths.

The Kaiser producing process and facilities are described in detail, as follows:

A 50″ Continuous Pickler—in which the steel passes through a dilute acid solution and then a neutralizing and rinsing bath and dryer, which assures a clean surface for later cold reduction. It is then oiled before recoiling to prevent corrosion during storage. The speed of this operation is 350 to 400 f.p.m.

A Five-Stand, Four-High, 44″ Cold Reduction Mill—having approximate width limits of 37″ to 38″ with a maximum finished width of 36″. The pickled and oiled coils enter the rolls at .090″ gage and, after approximately 85% reduction, emerge at an average of .010″ (31 gage) to .0075″ (35 gage). This mill is rated at 4,000 f.p.m.

An Electrolytic Cleaning Line—the purpose of which is to remove residual rolling oil in preparation for the next operation, which is annealing. The speed of the line is approximately 2,500 f.p.m.

Five Annealing Furnaces—of 250-ton capacity with fifteen bases which are used to transform the full hard cold reduced coils to a soft temper. HNX gas, an inert atmosphere, is used in the annealing process to prevent surface oxidation of the steel.

A Temper Mill—a four-high, two-high tandem type, which gives the steel its final shape and finish and Rockwell hardness by rolling it in coil form. The temper values which may be secured in the Rockwell scale are given on Page 236. This unit has a rated speed of 4,000 f.p.m.

A Shear Line—in which the coiled sheet is cut into sheet sizes either for black plate or hot dipped tin plate. Prior to entering the cut-off shear, the material is side trimmed to the finished width and then cut to length. The customary tolerances for this operation allow ¼″ over on the length and ⅛″ on the width. Maximum length is 43″.

A Coil Preparation Line for Electrolytic Plate—in which the material, as it passes through the facility, is side trimmed to a predetermined width and recoiled. The coil ends are first removed and the entering coil end is welded to the trailing end of the preceding coil.

Seven 75″ Hot Dip Stacks—into which black plate, cut to length and width, is introduced by automatic feeders. The sheet is given a light pickle prior to entering the molten tin bath and is then coated with either 1.50 lbs. or 1.25 lbs. of tin per base box. Residual palm oil is left on hot dipped plate in quantities of .15 to .40 grams per base box.

An Electrolytic Line—in which the black plate coils receive a coating of tin by electrolytic deposition as the coiled sheet passes through the line at a maximum rate of 1,200 f.p.m. After coating the strip is brought up to the melting point of tin, 450° F., by resistance heating, which fuses and brightens the coating. The sheet is then cut to ordered length by a flying shear.

KAISER HOT DIPPED TIN PLATE

Kaiser Hot Dipped Tin Plate is produced by the immersion of cold rolled black plate in molten tin by mechanical means. Rollers mechanically distribute the tin to insure an even, smooth tin coating. Each finished plate is then visually inspected for imperfections in the base steel, as well as for perfect coating.

Kaiser Hot Dipped Tin Plate is available in several classes, depending upon the degree of corrosion resistance required and luster desired. Also, a wide variety of chemical compositions and tempers are available to meet varying requirements of stiffness and ductility. The tin coating weight test values produced by Kaiser Steel Corporation are shown in Table No. 71, Page 146.

KAISER ELECTROLYTIC TIN PLATE

Electrolytic Tin Plate, due to its lower cost and to the conservation of tin, is rapidly replacing hot dipped tin plate for many container uses. The electrolytic process not only produces lighter coatings than the hot dipped product, but utilizes the tin more efficiently by obtaining a more uniform coating.

Kaiser Electrolytic Tin Plate is available in a wide selection of tempers, chemical compositions, and tin coating weights to meet the varying requirements of the container industry. Kaiser Steel Corporation facilities permit electrolytic tinning of different coating weights on each side of the strip, if desired. This is known as differentially coated tin plate. The coating weights of electrolytic tin plate produced by Kaiser Steel Corporation are shown in Table No. 70, Page 146.

KAISER BLACK PLATE

Black plate was the term used in the early days of the tin plate industry to designate the small, thin plate produced by hand hammering. The application of the term today means the base steel without any tin coating. It has all of the properties of tin plate except the luster and corrosion resistance of the coated material. For this reason, black plate can be applied to many uses where sanitation and high corrosion resistance are unnecessary. Kaiser Black Plate is produced in cut lengths or coils and is available in a wide range of sizes and gages.

TABLE 70

KAISER ELECTROLYTIC TIN PLATE
Coating Weights

Class Designation	Nominal Coating Weight, lb. per base box	Approx. Average Tin Thickness Ea. Side (Millionth of In.)	Deviation from Nominal Coating Weight, lb. per base box
No. 25	0.25	15	0.03 plus or minus
No. 50	0.50	30	0.03 plus or minus
No. 75	0.75	45	0.05 plus or minus
No. 100	1.00	61	
*No. 100/25	.50/.125	61/15	

*Differentially coated tin plate.

TABLE 71

KAISER HOT DIPPED TIN PLATE
Coating Weight Test Values

Class Designation	Minimum Average Coating Weight Test Value Pounds per base box	Approx. Average Tin Thickness Each Side (Millionth of Inch)
Common Cokes (1.25 lb. Pot Yield)	0.85	67
Standard Cokes (1.50 lb. Pot Yield)	1.05	82
Best Cokes	1.19	91
Kanners Special Cokes	1.40	106
1A Charcoal	1.80	139
2A Charcoal	2.30	205
3A Charcoal	2.80	
4A Charcoal	3.50	
5A Charcoal	4.20	
Premier Charcoal	4.90	

TABLE 72

KAISER TIN PLATE TEMPER

Temper	30-T Rockwell Scale	Uses
T 1	46-52	Severe draw
T 2	50-56	Moderate draw and forming
T 3	54-60	Round can and ends
T 4	58-64	Round can and ends
T 5	62-68	Round can and ends
T 6	67-73 (aim)	Beer can ends

TABLE 73

KAISER SIZE, TYPE AND TEMPER LIMITATIONS

Ordered sizes should be specified in increments of 1/16" in both width and length. Ordered Base Weights should be specified in Standard Tin Mill Base Weights.

Type & Temper*	Basis Weight	Rolling Width**	Shear Length***
MRT2 &	75# - 80#	24" - 32"	18" - 43"
MRT2½	85# - 112#	24" - 34¼"	18" - 43"
MRT3	75# - 112#	24" - 34¼"	18" - 43"
MRT4	80# - 112#	24" - 34¼"	18" - 43"
MCT4	80# - 112 #	24" - 34¼"	18" - 43"
MCT5	80#	24" - 30"	18" - 43"
	85# - 90#	24" - 32"	18" - 43"
	95# - 112#	24" - 33"	18" - 43"

* MRT1, MCT6, and other Types & Tempers will be considered on a special inquiry basis.

** In all cases, one dimension must be within this range. If rolling direction is specified, it must be within this range.

*** This range covers either width or length, providing the other dimension is within the Rolling Width range. Widths under 18" will be considered upon a special inquiry basis only, and in all cases will have a sheared edge after coating.

STANDARD PRACTICES

TABLE 74

HOT DIPPED AND ELECTROLYTIC TIN PLATE

Weight Deviations

Quantity	Weight Deviation	
	Over, per cent	Under, per cent
Individual Plates	10	10
1 package to 15 packages, inclusive	6	4
Over 15 packages to 200 packages, inclusive	4	4
Over 200 packages	2½	2½

ROLLING DIRECTION. The greater of the two surface dimensions is considered length. Rolling direction of cold reduced plate sometimes is important. In cases where rolling direction has an influence on the ultimate use, the desired direction should be clearly indicated by the purchaser.

TEMPER is commonly considered as the hardness value of the plate. However, the combination of properties required for specific applications cannot be expressed in terms of hardness, because hardness values do not adequately describe many necessary characteristics. For this reason, knowledge of the use and fabrication to which the plate is to be subjected is essential in determining the most suitable processing practices.

SHEARING PRACTICE. The customary practice in the production of tin plate is to shear approximately to ⅛ inch in width and approximately to ¼ inch in length over the ordered dimensions.

CAMBER is the deviation of a side edge from a straight line touching both ends of the side and is customarily limited to $\frac{1}{16}$ inch for each 48 inches of length or fraction thereof.

OUT-OF-SQUARE is the deviation of an end edge from a straight line which is placed at a right angle to the side of the plate, touching one corner and extending to the opposite side. The amount of deviation is customarily limited to ⅛ inch for any end edge measurement up to 36 inches inclusive.

RESQUARING is specified when tin plate is required more accurate to size than the product of normal mill practice. After resquaring, the length and width are not less than ordered and do not exceed the ordered dimension by more than $\frac{1}{16}$ inch on each dimension and the plate is not out-of-square by more than $\frac{1}{16}$ inch.

TABLE 75

CAN MAKING QUALITY BLACK PLATE
Weight Deviations

Quantity	Weight Deviation	
	Over, per cent	Under, per cent
Individual Plates	10	10
1 package to 15 packages, inclusive	6	4
Over 15 packages to 200 packages, inclusive	4	4
Over 200 packages	2½	2½

TABLE 76

BLACK PLATE OTHER THAN CAN MAKING QUALITY
Weight Deviations

Quantity	Weight Deviation	
	Over, per cent	Under, per cent
Individual Plates	10	10
100 lbs. to 2 tons, inclusive	6	4
Over 2 tons to 20 tons, inclusive	4	4
Over 20 tons	2½	2½

SHEARING PRACTICE. The customary practice in the production of black plate is to shear approximately to ⅛ inch over the ordered width, and approximately to ¼ inch over the ordered length up to and including 60 inches, and not over ½ inch in lengths over 60 inches.

CAMBER is the deviation of a side edge from a straight line touching both ends of the side, and is usually limited to $\frac{1}{16}$ inch for each 48 inches of length or fraction thereof.

OUT-OF-SQUARE is the deviation of an end edge from a straight line which is placed at a right angle to the side of the plate, touching one corner and extending to the opposite side. The amount of deviation is customarily limited to ⅛ inch for any end edge measurement up to 36 inches inclusive.

RESQUARING is specified when black plate is required more accurate to size than the product of normal mill practice. After resquaring, the length and width are not less than ordered and do not exceed the ordered dimension by more than $\frac{1}{16}$ inch on each dimension, and the plates are not out-of-square by more than $\frac{1}{16}$ inch.

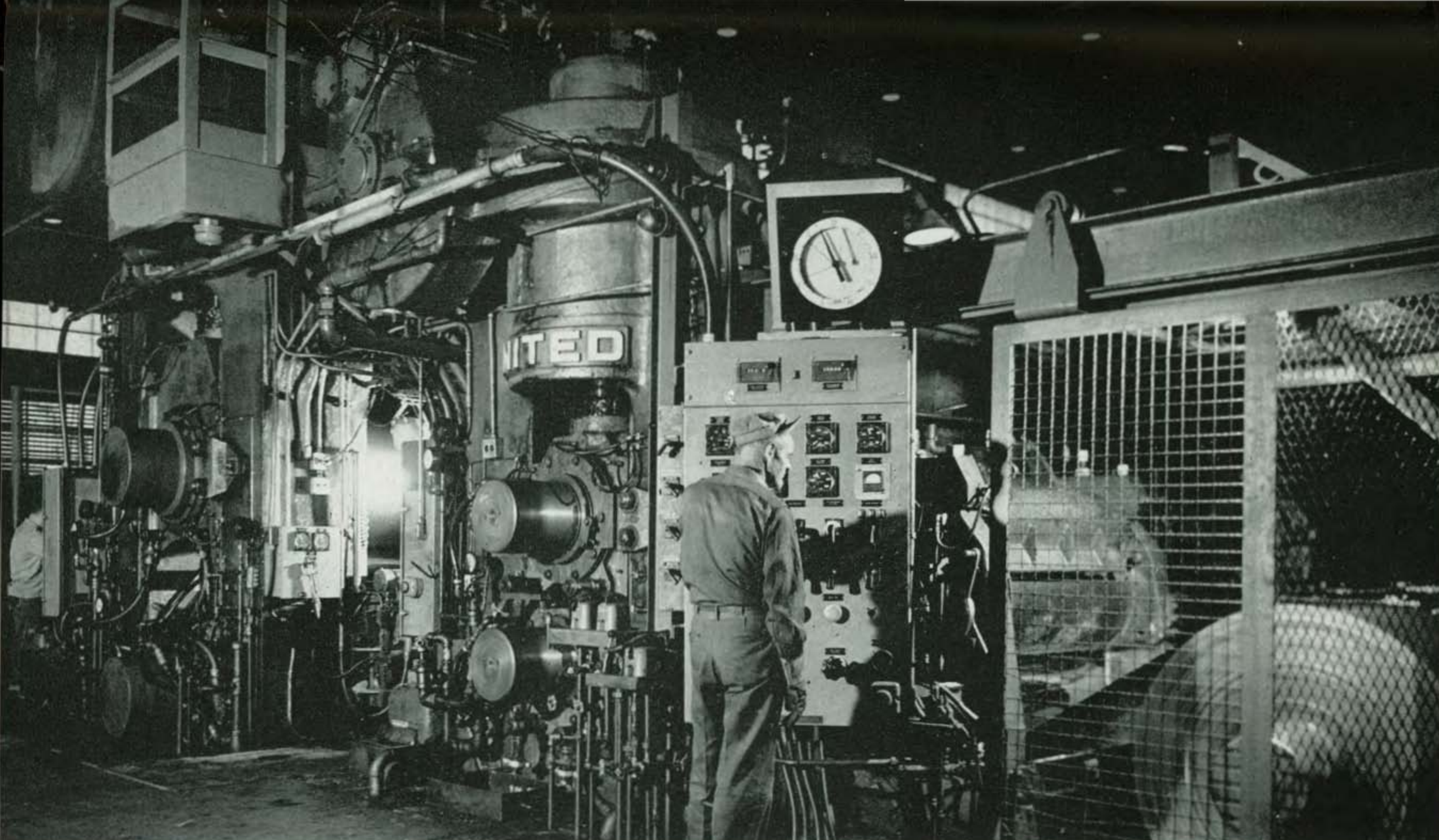
ORDERING PRACTICE FOR KAISER TIN PLATE

In order to more clearly describe the material desired and to avoid misunderstanding, purchasers' inquiries and orders for Tin Plate should specify the following details:

1. Quantity in base boxes and packages.
   If secondary products, quantity in pounds.
2. Type of product, i.e., electrolytic or hot dipped and coating weight per base box.
3. Size, i.e., dimension of plate in inches.
4. Rolling width.
5. Drip edge.
6. Grade and temper.
7. End use (detailed as required to provide correct steel analysis).
8. Applicability of menders if electrolytic tin plate.
9. Special loading or bundling practice.
10. Destination.
11. Routing requested.
12. Delivery requested.
13. Distribution of shipping notices, invoices, and bills of lading.

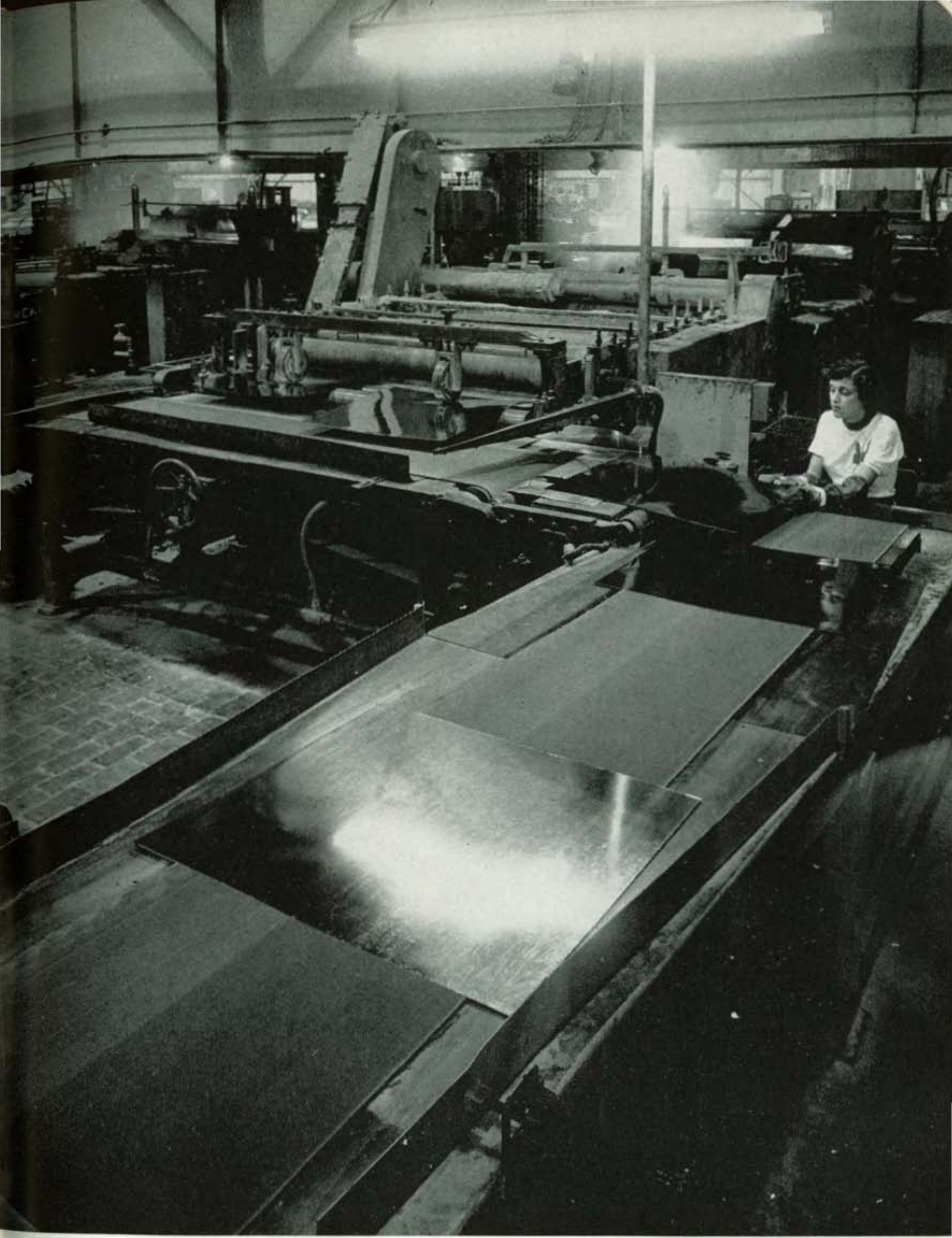
Prime tin plate is invoiced on the basis of a package price.

Secondary tin plate products are invoiced on the basis of a quoted price per cwt.



After steel strip destined to become tin plate is annealed to remove brittleness it becomes "dead soft". It regains toughness after being run through temper mill, above.

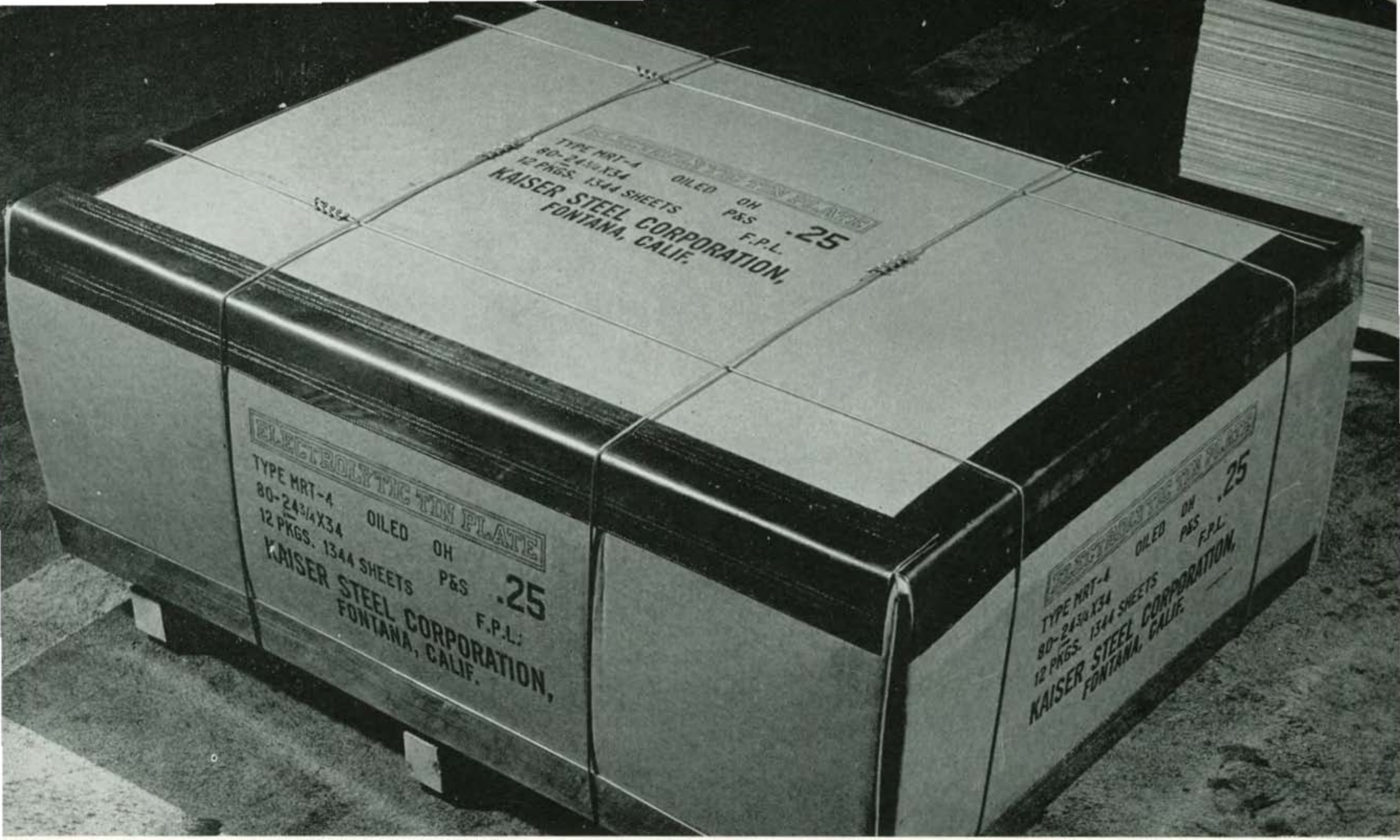
At the exit end of the electrolytic line, tin plate is sheared, inspected, sorted and stacked. Electrolytic tinning requires less tin than hot dip method.



Tin plate emerging from one of Kaiser Steel's hot dip tinning lines is carefully inspected. Hot dipping process is used where thicker tin coatings are required.

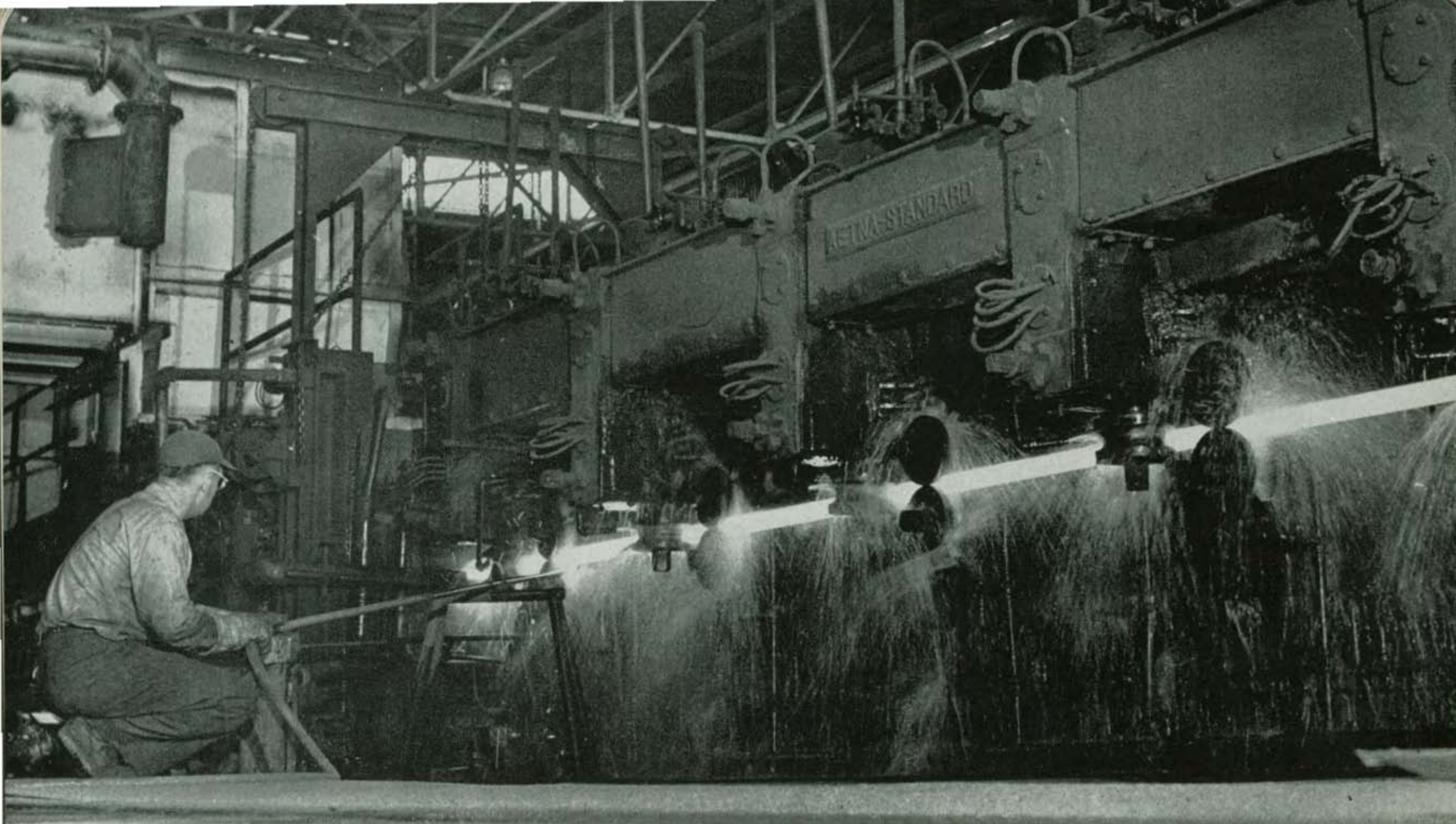
As the final step before packaging, each sheet of finished tin plate is individually inspected on both sides by women who wear heavy gloves to protect their hands.

In the tin plate warehouse at Fontana, large stocks are maintained to insure rapid delivery on orders during the seasonal canning periods.



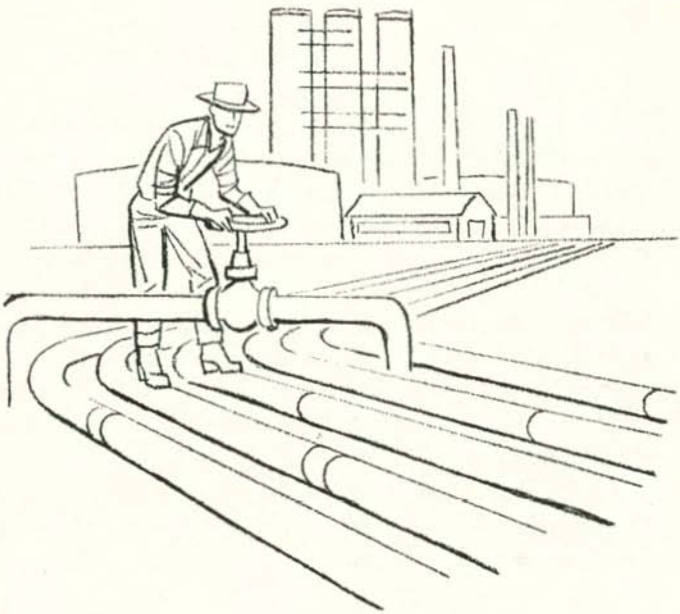
Specially designed packaging protects surfaces, edges and corners of tin plate during shipping.

NOTES



Standard pipe, either galvanized or black, is produced at Fontana in diameters from ½ to 4 inches, by the continuous-weld process which insures high quality pipe of uniform wall thickness.

TUBULAR PRODUCTS



KAISER TUBULAR PRODUCTS

Steel tubular products are those cylindrical forms designated as pipe or tubing which are generally used for conveying gases or liquids and for a diversity of mechanical and structural purposes. Kaiser Tubular Products are used throughout the West for plumbing, heating and ventilating systems in homes, schools, hotels, apartments and factories. They are extensively used in the petroleum industry and by public utilities for the transportation of oil, gas, water and other liquids. Kaiser Tubular Products are also used for many structural purposes such as stanchions, columns and trusses in buildings. The general terms pipe, tubes and tubing are not sharply defined within the industry and are therefore used interchangeably.

At Fontana, California, Kaiser Steel Corporation is engaged in a fully integrated pipe production program involving both continuous welded steel pipe and electric resistance welded steel pipe. The skelp used for these pipe mills is rolled to the desired sizes and standards on the Company's own mills.

Continuous welded steel pipe is rolled in nominal sizes from ½ to 4 inches, inclusive, on a modern continuous weld type mill. It is supplied in 21-foot uniform lengths and in random lengths, either plain end or threaded and coupled and either black or galvanized. Both standard and extra strong weights are produced.

Electric resistance welded pipe is rolled in sizes from 5$\frac{9}{16}$ inches O.D. to 14 inches O.D. inclusive, on a Yoder type welding unit of latest design. This pipe can be produced in wall thickness from .188 to .400 inch inclusive, depending on the outside diameter. The maximum lengths produced are 55 feet.

In conjunction with the Steel Division of the Basalt Rock Company at Napa, California, Kaiser Steel Corporation is in a position to offer fusion welded pipe in sizes from 14 to 30 inches O.D. inclusive, in lengths approximately 40 feet long. Wall thicknesses range from .250 to .500 inches. The pipe is manufactured by the press-forming method. Sizes 14 through 18 inches O.D. inclusive, are cold sized after welding. Pipe in sizes 20 to 30 inches O.D. inclusive, is hydraulically expanded to size after welding. Both methods make possible the production of high-strength line pipe.

All the above described pipe will meet the latest applicable industry specifications. A more detailed description of the manufacturing process involved will be found on succeeding pages.

KAISER CONTINUOUS WELD PIPE

Kaiser Continuous Weld Pipe is made in both standard and extra strong weights. Nominal sizes range from ½ to 4 inches, inclusive. The skelp used in making continuous weld pipe comes from the rolling department of the steel mill in coils with a specified width and thickness, according to the size of the pipe to be made. The edges of the skelp are slightly beveled so that the surface of the skelp which is to become the inside of the pipe is not quite as wide as that which forms the outside; thus, when the edges are brought together, they meet squarely, as indicated in the adjacent figure.

In order to produce pipe by the continuous weld process, the steel is rolled in coils containing 185 to 550 feet of skelp weighing from 600 to 1800 pounds depending on the size of the pipe being made. As these coils are paid out one at a time, the skelp passes through a roller leveler which flattens it. When the tail of one coil reaches the flash welding machine, the starting end of the next coil is flash welded to it, thereby forming a continuous ribbon. Following a trimming process where the excess welding metal is removed, the skelp is drawn through the gas fired reheating furnace which raises it to a welding temperature in a minimum of 30 seconds. The edges of the steel approach a softening point in order to insure proper welding. As it leaves the furnace, jets of air impinge on the edges of the skelp, increasing the temperature 100 to 200 degrees or up to the mean welding temperature. The skelp then passes through a forming roll. Welding and sizing is completed by ten pairs of grooved rolls arranged in five sets, each set consisting of a pair of vertical and a pair of horizontal rolls.

After the pipe is rolled into shape, it is cut to lengths of approximately 21 feet by means of a flying hot saw. The pipe is then fed into three pairs of rolls, where the final sizing is done and scale is loosened and removed both internally and externally. After further cooling, the pipe is recut to more uniform 21 foot lengths. After final cooling, the pipe goes into the finishing department where it is straightened and the ends finished, followed by hydrostatic testing to specification. It may then either be pickled and galvanized or finished black. Threading is done on modern high-speed threading machines. Black pipe is furnished either coated or uncoated, as required by the purchaser.

All sizes are supplied either black or galvanized for use in the transmission of air, gas, steam, water, oil and other fluids and for miscellaneous purposes. Standard pipe intended for ordinary uses such as low-pressure steam, water, air or gas lines is tested hydrostatically in accordance with latest industry specifications. When intended for special purposes such as bending or coiling, Kaiser Steel Pipe is subject to bending, flattening and tensile tests as well as hydrostatic tests. Black continuous weld pipe is also manufactured for line pipe and is available either with plain ends or threaded and coupled.

Kaiser Continuous Weld Standard Pipe is furnished as may be desired, with threaded ends and couplings, threaded ends without couplings, plain ends, or ends beveled for welding. It is furnished in either 21 foot uniform lengths or in random lengths up to 44 feet long. Threaded and coupled pipe is furnished with one coupling screwed on one end and the length of each pipe is measured over all, including the coupling.

TABLE 77

KAISER STANDARD WEIGHT PIPE

Black and Galvanized

Dimensions, Weights and Test Pressures

Nom. Size	Wt. per Foot		Pipe			Threads per Inch	Couplings			Test Pressure Psi
	T & C	Plain Ends	Thickness	Diameters			Length	Ext. Diameter	Wt.	
				Ext.	Int.					
In.	Lb.	Lb.	In.	In.	In.		In.	In.	Lb.	Lb.
½	.85	.85	.109	.840	.622	14	1 9/16	1.063	.17	700
¾	1.13	1.13	.113	1.050	.824	14	1 5/8	1.313	.26	700
1	1.68	1.68	.133	1.315	1.049	11½	2	1.576	.40	700
1¼	2.28	2.27	.140	1.660	1.380	11½	2 1/16	1.900	.48	800
1½	2.73	2.72	.145	1.900	1.610	11½	2 1/16	2.200	.67	800
2	3.68	3.65	.154	2.375	2.067	11½	2 1/8	2.750	1.05	800
2½	5.82	5.79	.203	2.875	2.469	8	3 1/8	3.250	2.09	800
3	7.62	7.58	.216	3.500	3.068	8	3¼	4.000	3.35	800
*3½	9.20	9.11	.226	4.000	3.548	8	3 3/8	4.625	4.82	1200
4	10.89	10.79	.237	4.500	4.026	8	3½	5.000	4.61	1200

TABLE 78

KAISER EXTRA STRONG WEIGHT PIPE

Nominal Size	Weight, per Foot, Plain Ends	Thickness	Diameters		Test Pressure Psi
			External	Internal	
In.	Lb.	In.	In.	In.	Lb.
½	1.09	.147	.840	.546	850
¾	1.47	.154	1.050	.742	850
1	2.17	.179	1.315	.957	850
1¼	3.00	.191	1.660	1.278	1100
1½	3.63	.200	1.900	1.500	1100
2	5.02	.218	2.375	1.939	1100
2½	7.66	.276	2.875	2.323	1100
3	10.25	.300	3.500	2.900	1100
*3½	12.51	.318	4.000	3.364	1700
4	14.98	.337	4.500	3.826	1700

*This size is not regularly produced. Orders for same are subject to negotiation.

TABLE 79

KAISER BLACK LINE PIPE

Dimensions, Weights and Test Pressures

Nom. Size	Wt. per Foot		Pipe			Threads per Inch	Couplings			Test Pressure Psi
	T & C	Plain Ends	Thickness	Diameters			Length	Ext. Diameter	Wt.	
				Ext.	Int.					
In.	Lb.	Lb.	In.	In.	In.		In.	In.	Lb.	Lb.
1/2	.86	.85	.109	.840	.622	14	2 1/8	1.063	.24	700
3/4	1.14	1.13	.113	1.050	.824	14	2 1/8	1.313	.34	700
1	1.70	1.68	.133	1.315	1.049	11 1/2	2 5/8	1.576	.54	700
1 1/4	2.30	2.27	.140	1.660	1.380	11 1/2	2 3/4	2.054	1.03	800
1 1/2	2.75	2.72	.145	1.900	1.610	11 1/2	2 3/4	2.200	.90	800
2	3.75	3.65	.154	2.375	2.067	11 1/2	2 7/8	2.875	1.86	800
2 1/2	5.90	5.79	.203	2.875	2.469	8	4 1/8	3.375	3.27	800
3	7.70	7.58	.216	3.500	3.068	8	4 1/4	4.000	4.09	800
3 1/2	9.25	9.11	.226	4.000	3.548	8	4 3/8	4.625	5.92	1200
4	11.00	10.79	.237	4.500	4.026	8	4 1/2	5.200	7.59	1200

Kaiser Black T & C Line Pipe is manufactured by the continuous weld process for use under conditions where increased pressure or stress requires pipe with the heavier, recessed line pipe coupling. The dimensions and data on this pipe are shown in the table above.

Terms relating to diameters, wall thicknesses, or foot-weights, and the terms *actual* and *nominal* in reference to sizes always carry the qualifying conditions imposed by manufacturing tolerances. The term *nominal* as used herein refers to a named or given dimension as distinguished from the actual or real dimension. There are some wide differences between actual and nominal dimensions, and published tables should be consulted. For example, ½ inch standard weight pipe has an actual outside diameter of 0.840 inch and an inside diameter of 0.622 inch.

KAISER STANDARD WEIGHT PIPE

Weight Estimating Table

TABLE 80

Plain End, 21 ft. Uniform lengths

Nom. Size In.		1 Bdl.	2 Bdl.	3 Bdl.	4 Bdl.	5 Bdl.	6 Bdl.	7 Bdl.	8 Bdl.	9 Bdl.	15 Bdl.	25 Bdl.	35 Bdl.	45 Bdl.
½	Ft.	252	504	756	1008	1260	1512	1764	2016	2268	3780	6300	8820	11340
	Lb.	214	428	643	857	1071	1285	1499	1714	1928	3213	5355	7497	9639
¾	Ft.	147	294	441	588	735	882	1029	1176	1323	2205	3675	5145	6615
	Lb.	166	332	498	664	831	997	1163	1329	1495	2492	4153	5814	7475
1	Ft.	105	210	315	420	525	630	735	840	945	1575	2625	3675	4725
	Lb.	176	353	529	706	882	1058	1235	1411	1588	2646	4410	6174	7938
1¼	Ft.	63	126	189	252	315	378	441	504	567	945	1575	2205	2835
	Lb.	143	286	429	572	715	858	1001	1144	1287	2145	3575	5005	6435
1½	Ft.	63	126	189	252	315	378	441	504	567	945	1575	2205	2835
	Lb.	171	343	514	685	857	1028	1200	1371	1542	2568	4279	5990	7700

Nom. Size In.		1 Pc.	2 Pcs.	3 Pcs.	4 Pcs.	5 Pcs.	6 Pcs.	7 Pcs.	8 Pcs.	9 Pcs.	15 Pcs.	25 Pcs.	35 Pcs.	45 Pcs.
2	Ft.	21	42	63	84	105	126	147	168	189	315	525	735	945
	Wt.	77	153	230	307	383	460	537	613	690	1150	1916	2683	3449
2½	Ft.	21	42	63	84	105	126	147	168	189	315	525	735	945
	Wt.	122	243	365	486	608	730	851	973	1094	1824	3040	4256	5472
3	Ft.	21	42	63	84	105	126	147	168	189	315	525	735	945
	Wt.	159	318	478	637	796	955	1114	1273	1433	2388	3980	5571	7163
4	Ft.	21	42	63	84	105	126	147	168	189	315	525	735	945
	Wt.	227	453	680	906	1133	1360	1586	1813	2039	3399	5665	7931	10197

KAISER STANDARD WEIGHT PIPE

Weight Estimating Table

TABLE 81

Threaded and Coupled, 21 ft. Uniform Lengths

Nom. Size In.		1 Bdl.	2 Bdl.	3 Bdl.	4 Bdl.	5 Bdl.	6 Bdl.	7 Bdl.	8 Bdl.	9 Bdl.	15 Bdl.	25 Bdl.	35 Bdl.	45 Bdl.
½	Ft.	252	504	756	1008	1260	1512	1764	2016	2268	3780	6300	8820	11340
	Lb.	214	428	643	857	1071	1285	1499	1714	1928	3213	5355	7497	9639
¾	Ft.	147	294	441	588	735	882	1029	1176	1323	2205	3675	5145	6615
	Lb.	166	332	498	664	831	997	1163	1329	1495	2492	4153	5814	7475
1	Ft.	105	210	315	420	525	630	735	840	945	1575	2625	3675	4725
	Lb.	176	353	529	706	882	1058	1235	1411	1588	2646	4410	6174	7938
1¼	Ft.	63	126	189	252	315	378	441	504	567	945	1575	2205	2835
	Lb.	144	287	431	575	718	862	1005	1149	1293	2155	3591	5027	6464
1½	Ft.	63	126	189	252	315	378	441	504	567	945	1575	2205	2835
	Lb.	172	344	516	688	860	1032	1204	1376	1548	2580	4300	6020	7740

Nom. Size In.		1 Pc.	2 Pcs.	3 Pcs.	4 Pcs.	5 Pcs.	6 Pcs.	7 Pcs.	8 Pcs.	9 Pcs.	15 Pcs.	25 Pcs.	35 Pcs.	45 Pcs.
2	Ft.	21	42	63	84	105	126	147	168	189	315	525	735	945
	Wt.	77	155	232	309	386	464	541	618	696	1159	1932	2705	3478
2½	Ft.	21	42	63	84	105	126	147	168	189	315	525	735	945
	Wt.	122	244	367	489	611	733	856	978	1100	1833	3056	4278	5500
3	Ft.	21	42	63	84	105	126	147	168	189	315	525	735	945
	Wt.	160	320	480	640	800	960	1120	1280	1440	2400	4001	5601	7201
4	Ft.	21	42	63	84	105	126	147	168	189	315	525	735	945
	Wt.	229	457	646	915	1143	1372	1601	1830	2058	3430	5717	8004	10291

KAISER EXTRA-HEAVY WEIGHT PIPE

Weight Estimating Table

TABLE 82

Plain End, 21 ft. Uniform Lengths

Nom. Size In.		1 Bdl.	2 Bdl.	3 Bdl.	4 Bdl.	5 Bdl.	6 Bdl.	7 Bdl.	8 Bdl.	9 Bdl.	15 Bdl.	25 Bdl.	35 Bdl.	45 Bdl.
½	Ft.	252	504	756	1008	1260	1512	1764	2016	2268	3780	6300	8820	11340
	Lb.	275	549	824	1099	1373	1648	1923	2197	2472	4120	6867	9614	12361
¾	Ft.	147	294	441	588	735	882	1029	1176	1323	2205	3675	5145	6615
	Lb.	216	432	648	864	1080	1297	1513	1729	1945	3241	5402	7563	9724
1	Ft.	105	210	315	420	525	630	735	840	945	1575	2625	3675	4725
	Lb.	228	456	684	911	1139	1367	1595	1823	2051	3418	5696	7975	10253
1¼	Ft.	63	126	189	252	315	378	441	504	567	945	1575	2205	2835
	Lb.	189	378	567	756	945	1134	1323	1512	1701	2835	4725	6615	8505
1½	Ft.	63	126	189	252	315	378	441	504	567	945	1575	2205	2835
	Lb.	229	457	686	915	1143	1372	1601	1830	2058	3430	5717	8004	10291

Nom. Size In.		1 Pc.	2 Pcs.	3 Pcs.	4 Pcs.	5 Pcs.	6 Pcs.	7 Pcs.	8 Pcs.	9 Pcs.	15 Pcs.	25 Pcs.	35 Pcs.	45 Pcs.
2	Ft.	21	42	63	84	105	126	147	168	189	315	525	735	945
	Wt.	105	211	316	422	572	633	738	843	949	1581	2636	3690	4744
2½	Ft.	21	42	63	84	105	126	147	168	189	315	525	735	945
	Wt.	161	322	483	643	804	965	1126	1287	1448	2413	4022	5630	7239
3	Ft.	21	42	63	84	105	126	147	168	189	315	525	735	945
	Wt.	215	431	646	861	1076	1292	1507	1722	1937	3229	5381	7534	9686

STANDARD PIPE MILL PRACTICES

The weights of steel tubular products are calculated on the basis of 0.2833 lb. per cu. in. and are commonly expressed as weights per foot.

The outside diameter of a given size of pipe is the same regardless of weight per foot. Variations in weight or wall thickness affect the inside diameter only. The standard weight per foot of pipe with threads and couplings is based on a length of 20 feet over all when the coupling is pulled tight.

All pipe in sizes 2 inches and larger is shipped loose. Double length pipe is shipped loose but single length pipe in sizes 1½ inches and under are bundled as per the following table.

TABLE 83

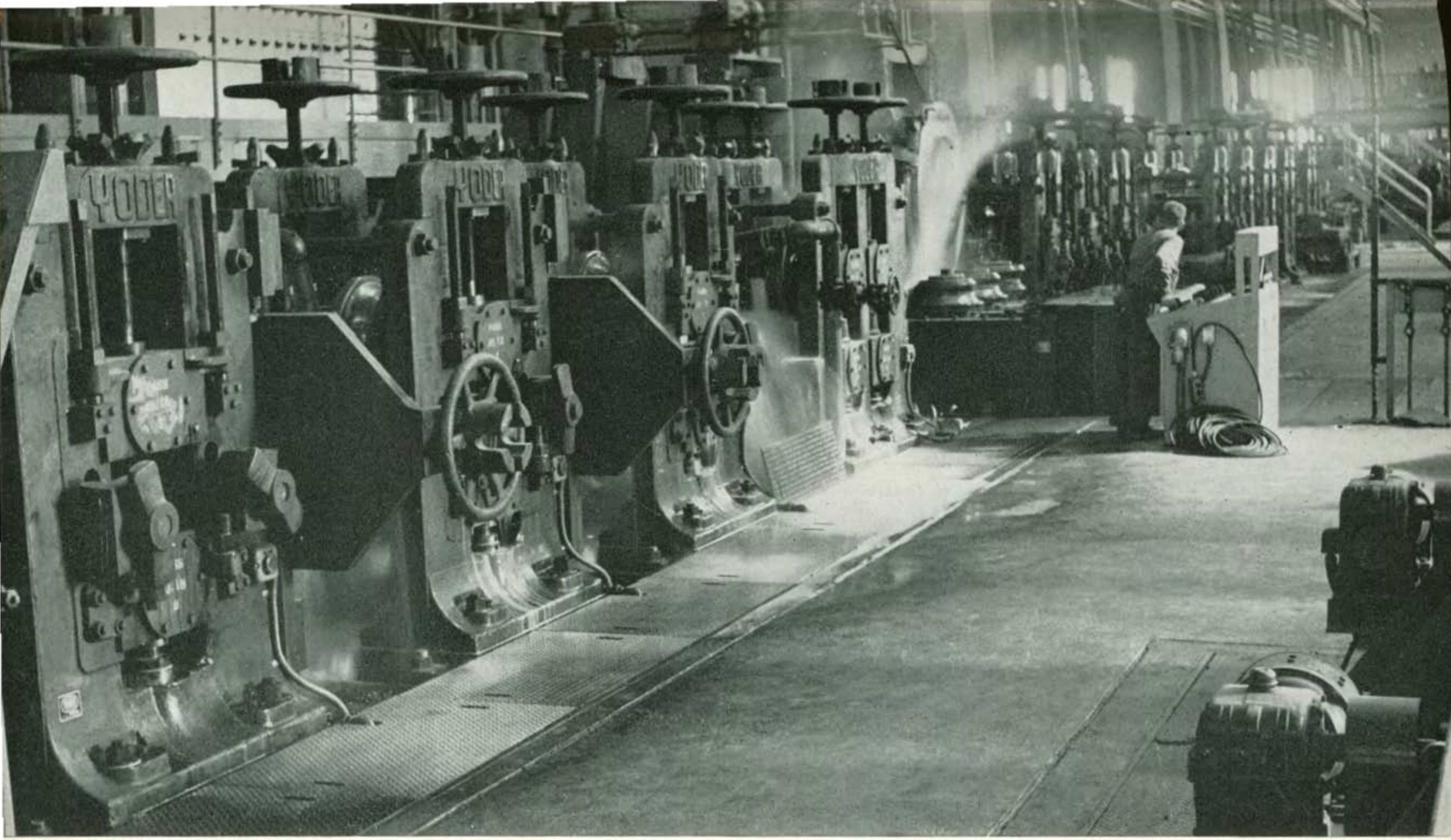
BUNDLING TABLE

21′ Uniform Lengths

Nominal Size Inches	Footage Per Ton (Nearest Foot)		Pieces Per Bundle	Footage Per Bundle (Nearest Foot)	Weight Per Bundle (Pounds)
	T. and C.	Plain End			
½	2353	2353	12	252	214
¾	1770	1770	7	147	166
1	1190	1190	5	105	176
1¼	877	881	3	63	144
1½	733	735	3	63	172
2	543	548	Pipe 2″ and over is not bundled		
2½	344	345			
3	262	264			
4	184	185			

Pipe is furnished reasonably straight as common practice. When specific straightness is desired, the mill should be so advised on the order.

On plain end pipe ordered beveled for welding, it is standard to bevel to an angle of 30° from vertical on the outside with an average flat width at the end of the pipe of $\frac{1}{16}$ inch.



Steel pipe from $5\frac{9}{16}$ inches to 14 inches O.D. is formed and resistance welded in this Yoder welding unit in lengths up to 55 feet. Perfect welds and uniform wall thicknesses are characteristics of Kaiser pipe.

KAISER ELECTRIC WELD PIPE

Regular Weight—Plain End

Kaiser Electric Resistance Welded Pipe is produced from cold, flat skelp. Since the pipe forming operations do not alter the thickness of the plate, the wall thickness of the finished pipe is uniform, and the inside and outside surfaces are concentric.

The skelp is first passed through a roller leveler to achieve a smooth, flat surface. From the leveler operation, the skelp undergoes an edge cleaning which prepares the metal for good contact with the welding electrodes and insures free passage of the welding current. A thorough cleaning is accomplished by a steel shot blasting process under high pressure.

A perfectly straight welding surface is essential and a uniform width must be maintained throughout the full length of the skelp. To insure this, the skelp is passed through rotary shears which trim both edges to close tolerances immediately before the forming and welding operations. During this process the skelp is carefully inspected for surface defects. In effect, this means close inspection of both surfaces of the finished pipe.

The skelp is passed from the edge trimmer directly into a series of forming rolls which progressively form it, without undue strain, into an open tube. The tube is moved into the welding unit where revolving circular electrodes contact the steel close to each edge and transmit the current which generates the welding heat. By careful control of current, speed and pressure, the edges are bonded to produce a weld of the same strength and properties of the parent metal, extruding just enough metal both inside and outside of the tube to insure a complete weld. The extruded weld metal is immediately removed by stationary cutters, leaving a perfectly smooth wall of the same gage throughout.

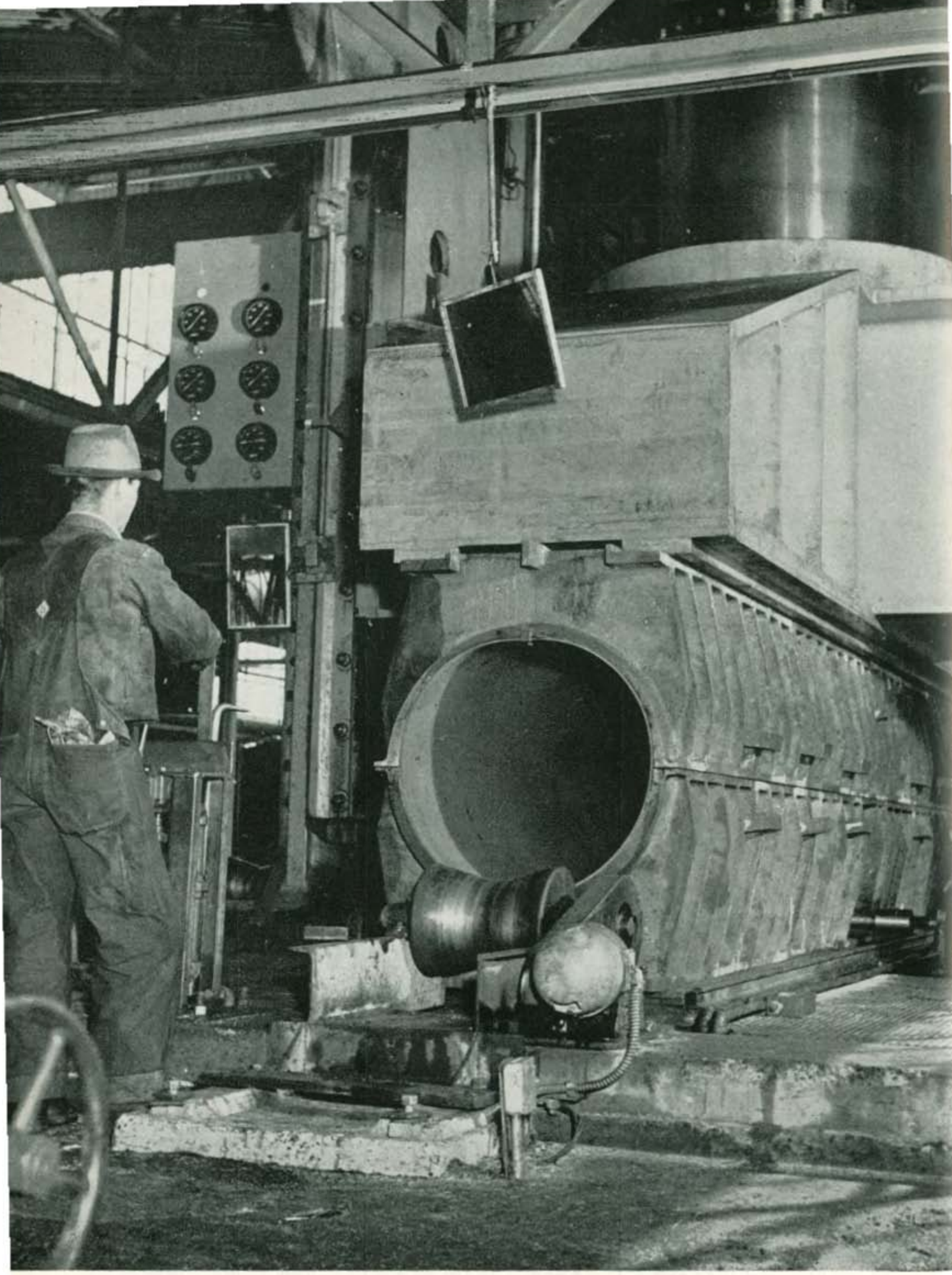
The welded pipe is passed through several stands of rolls which slightly reduce the diameter and insure correct size and straightness. Final roll straightening is done prior to a thorough visual inspection of each length of pipe for surface imperfections. The pipe is then magnetically inspected for weld quality. Throughout the production process, Kaiser Electric Weld Pipe is carefully tested and controlled so that final properties will conform in all respects to applicable industrial specifications. Following inspection and flattening tests, the pipe ends are beveled, grooved or left plain, as required by the buyer. These operations are performed before the final hydrostatic tests are run. While under pressure, the pipe is struck with pneumatic hammers near the ends of the pipe and again checked for possible defects. After final inspection to insure conformance to specification, each length is measured and marked in preparation for shipment to the customer. It is standard mill practice to coat each length of pipe unless otherwise specified.

The following table lists the dimensions, weights and test pressures pertaining to Kaiser Plain End Electric Weld Line Pipe available for sale and shipment from our Fontana mill.

TABLE 84
KAISER ELECTRIC WELD PIPE
Regular Weight Plain End Line Pipe
Dimensions, Weights and Test Pressures

Size O. D.	Size I. D.	Wall Thickness	Weight per Foot	Grade A	Grade B
In.	In.	In.	Lb.	Psi	Psi
5 9/16	5.187	0.188	10.76	1200	1400
5 9/16	5.125	0.219	12.49	1400	1700
5 9/16	5.047	0.258	14.62-s	1700	1900
5 9/16	5.001	0.281	15.87	1800	2100
5 9/16	4.939	0.312	17.52	2000	2400
5 9/16	4.875	0.344	19.16	2200	2500
5 9/16	4.813	0.375	20.78-x	2400	2500
6 5/8	6.249	0.188	12.89	1000	1200
6 5/8	6.187	0.219	14.97	1200	1400
6 5/8	6.125	0.250	17.02	1400	1600
6 5/8	6.065	0.280	18.97-s	1500	1800
6 5/8	6.001	0.312	21.07	1700	2000
6 5/8	5.937	0.344	23.06	1900	2200
6 5/8	5.875	0.375	25.03	2000	2400
8 5/8	8.249	0.188	16.90	800	900
8 5/8	8.187	0.219	19.64	900	1100
8 5/8	8.125	0.250	22.36	1000	1200
8 5/8	8.071	0.277	24.70-s	1200	1300
8 5/8	8.001	0.312	27.74	1300	1500
8 5/8	7.981	0.322	28.55-s	1300	1600
8 5/8	7.937	0.344	30.40	1400	1700
8 5/8	7.875	0.375	33.04	1600	1800
10 3/4	10.374	0.188	21.15-*	650	750
10 3/4	10.312	0.219	24.60	750	850
10 3/4	10.250	0.250	28.04	850	1000
10 3/4	10.192	0.279	31.20-s	1000	1200
10 3/4	10.136	0.307	34.24-s	1000	1200
10 3/4	10.062	0.344	38.20	1100	1300
10 3/4	10.020	0.365	40.48-s	1200	1400
12 3/4	12.312	0.219	29.28-*	600	700
12 3/4	12.250	0.250	33.38	700	800
12 3/4	12.188	0.281	37.45	800	950
12 3/4	12.126	0.312	41.51	900	1000
12 3/4	12.090	0.330	43.77-s	1000	1200
12 3/4	12.062	0.344	45.55	1000	1200
12 3/4	12.000	0.375	49.56-s	1100	1200
14	13.500	0.250	36.71-*	650	750
14	13.438	0.281	41.21-*	700	850
14	13.376	0.312	45.68	800	950
14	13.312	0.344	50.14	900	1000
14	13.250	0.375	54.57-s	950	1100

I.D. is a theoretical dimension only. s=Standard Wt. x=Extra Strong Wt. *=Special Wt.



Basalt-Kaiser line pipe up to 30 inches O.D. is formed in this giant press. Final sizing is by cold reduction or hydraulic expansion, effecting a cold working of the metal for improved physical qualities.

BASALT-KAISER LINE PIPE

Basalt-Kaiser Line Pipe is produced and marketed under a joint manufacturing and sales agreement between the steel division of the Basalt Rock Company, Napa, California, and the Kaiser Steel Corporation. This large diameter welded steel pipe is offered in sizes ranging from 14 to 30 inches outside diameter and in lengths up to 40 feet. All sizes meet applicable industry specifications.

The plate is first cut to the exact width desired and edges are trimmed so as to insure a good weld. It is then descaled and cleansed in a pickling bath, dried and inspected. The sized and pickled plate is automatically conveyed through the first machine, the edge pre-former, where a series of alloy rollers shape the edges of the plate to prepare it for the forming presses. The material then continues through the "U"-ing press which shapes it into an approximate "U" in a single operation. Both these machines were specially designed to provide exceptional precision and to maintain highest quality through an automatic conveying system.

Before the final step in forming a pipe, the "U"-ed shape is automatically sprayed with oil to assist easy forming in the 40-foot dies of the main press. This machine is actually two separate presses aligned and synchronized. Its hydraulic rams press the "U" shaped plate into a round shape in a single operation with edges aligned for welding. Before welding the formed pipe is conveyed through a degreasing bath, then into one of two types of welding machines, depending upon the specification.

LINE PIPE 14 - 18 INCHES

Fusion welded pipe in sizes from 14 to 18 inches outside diameter is produced by a single pass submerged arc weld with 100 per cent penetration. The same sizes through 18 inches may also be produced on an electric resistance welding unit. This welding equipment heats the two edges of the formed plate to the proper welding temperature, and the welding operation is completed by pressure rolls. The combination of heat and pressure makes a sound, continuous weld the entire length of the pipe. "Flash" is removed both inside and outside the pipe by a cutting tool which leaves smooth, flush surfaces.

After careful inspection of the weld the pipe moves to the sizing and straightening machine. In this operation the pipe is passed through a series of transverse rolls which size, straighten and cold reduce the pipe to finished dimensions. The ends are then squared or beveled for welding.

Before the pipe reaches the hydrostatic tester all laboratory checks for physical properties have been completed. These include bend and tensile strength tests which are run continuously on each order. In final testing operations, each pipe section is subjected to a predetermined internal hydraulic pressure and carefully checked after heavy hammer blows along the entire length of the weld to detect any flaws.

Final inspection includes checking every dimension of each length of pipe for compliance with specifications. Each pipe is stenciled with the markings required by the order. After final inspection and marking, the finished pipe is given a protective coating or left bare, according to specifications. Shipping preparations include carefully planned loading practice to insure safe delivery at destination.

TABLE 85

BASALT-KAISER LINE PIPE

Black Plain End

Dimensions, Weights and Test Pressures

Size O. D.	Size I. D.	Wall Thickness	Weight per Foot	Grade A	Grade B	Grade X-42
In.	In.	In.	Lb.	Psi	Psi	Psi
14	13.500	0.250	*36.71	650	750	1280
14	13.438	0.281	*41.21	700	850	1440
14	13.376	0.312	45.68	800	950	1600
14	13.312	0.344	50.14	900	1000	1760
14	13.250	0.375	54.57	950	1100	1920
14	13.124	0.438	63.37	1100	1300	2240
14	13.000	0.500	72.09	1300	1500	2550
16	15.500	0.250	*42.05	550	650	1120
16	15.438	0.281	*47.22	650	750	1260
16	15.376	0.312	52.36	700	800	1400
16	15.312	0.344	57.48	750	900	1540
16	15.250	0.375	62.58	850	1000	1680
16	15.124	0.438	72.72	1000	1100	1960
16	15.000	0.500	82.77	1100	1300	2240
18	17.500	0.250	*47.39	500	600	1000
18	17.438	0.281	*53.22	550	650	1120
18	17.376	0.312	59.03	600	750	1240
18	17.312	0.344	64.82	700	800	1370
18	17.250	0.375	70.59	750	900	1490
18	17.124	0.438	82.06	900	1000	1740
18	17.000	0.500	93.45	1000	1200	1990

I.D. is a theoretical dimension only. *Special weight.

Test pressures on grades X-46 and X-52 may be obtained upon request.

BASALT-KAISER EXPANDED LINE PIPE

Sizes 20 - 30 Inches

Pipe in sizes from 20 to 30 inches O.D. inclusive, is fusion welded and hydraulically expanded to size.

Plate for this pipe, in 40 foot lengths, is cut to size, pickled, edge conditioned, press formed to cylindrical shape and cleaned of oil and grease as previously described. Tabs are attached to the seam ends to facilitate longitudinal welding.

The first weld pass is made on the inside of the pipe. In this operation the pipe is fixed in position while the welding head, mounted on a boom, movably positioned with positive accuracy over the longitudinal seam, traverses the length of pipe and completes the inside weld. The outside weld is made as the pipe is drawn through a stationary welding fixture in which the electrodes are mounted. Very accurate positioning of the outside weld is maintained in this operation by reason of the unhampered visual observation afforded the weld operator for making radial adjustment of the seam under the electrodes.

When welding is completed, the tabs are removed and the pipe is placed in the expander. This is double purpose equipment in which the extreme ends of the pipe are first expanded mechanically and the body of the pipe is expanded hydraulically, within restraining dies, to a very accurate diameter, concentricity and straightness. Cold working of the metal during expansion increases its strength and produces pipe whose physical properties meet the requirements of the high yield strength specifications.

After expansion to size, the pressure is dropped to the hydrostatic test pressure, the dies are opened and the pipe while under test pressure is struck hammer blows of measured impact along the seam to further test the soundness of the weld. The ends of the pipe are then milled and beveled to prepare them for girth welding. The pipe receives a final careful visual inspection, dimensional checks are made, and test coupons are taken and tests made as prescribed by the specifications.

TABLE 86
BASALT-KAISER EXPANDED LINE PIPE
Dimensions, Weights and Test Pressures

Size O. D.	Size I. D.	Wall Thickness	Weight per Foot	Grade X-42
Inches	Inches	Inches	Pounds	Psi
20	19.500	0.250	*52.73	900
20	19.438	0.281	*59.23	1010
20	19.376	0.312	65.71	1120
20	19.312	0.344	72.16	1230
20	19.250	0.375	78.60	1340
20	19.188	0.406	85.01	1450
20	19.124	0.438	91.41	1570
20	19.000	0.500	104.13	1790
22	21.500	0.250	*58.07	820
22	21.438	0.281	*65.24	920
22	21.376	0.312	72.38	1020
22	21.312	0.344	79.51	1120
22	21.250	0.375	86.61	1220
22	21.188	0.406	93.69	1320
22	21.124	0.438	100.75	1430
22	21.000	0.500	114.81	1630
24	23.500	0.250	*63.41	750
24	23.438	0.281	*71.25	840
24	23.376	0.312	79.06	930
24	23.312	0.344	86.85	1030
24	23.250	0.375	94.62	1120
24	23.188	0.406	102.37	1210
24	23.124	0.438	110.10	1310
24	23.000	0.500	125.49	1490
26	25.500	0.250	*68.75	690
26	25.438	0.281	*77.25	780
26	25.376	0.312	85.73	860
26	25.312	0.344	94.19	950
26	25.250	0.375	102.63	1030
26	25.188	0.406	111.05	1120
26	25.124	0.438	119.44	1210
26	25.000	0.500	136.17	1380
30	29.500	0.250	*79.43	600
30	29.438	0.281	*89.27	670
30	29.376	0.312	99.08	750
30	29.312	0.344	108.88	820
30	29.250	0.375	118.65	900
30	29.188	0.406	128.40	970
30	29.124	0.438	138.13	1050
30	29.000	0.500	157.53	1200

I.D. is a theoretical dimension only. *Special weight.
Test pressures on grades X-46 and X-52 may be obtained upon request.

STRUCTURAL PROPERTIES

TABLE 87

STRUCTURAL PROPERTIES OF KAISER STEEL PIPE

Outside Dia.	Thickness	Weight per Foot	Moment of Inertia	Section Modulus	Area of Metal	Bore Area	Radius of Gyration
In.	In.	Lb.	$In.^4$	$In.^3$	$In.^2$	$In.^2$	In.
.840	.109	.850	.01709	.04069	.2503	.3039	.2613
.840	.147	1.087	.02008	.04780	.3200	.2342	.2505
1.050	.113	1.130	.03704	.07055	.3326	.5333	.3337
1.050	.154	1.473	.04479	.08531	.4335	.4324	.3214
1.315	.133	1.678	.08734	.1328	.4939	.8642	.4205
1.315	.179	2.171	.1056	.1606	.6388	.7193	.4066
1.660	.140	2.272	.1947	.2346	.6685	1.4957	.5397
1.660	.191	2.996	.2418	.2913	.8815	1.2327	.5237
1.900	.145	2.717	.3099	.3262	.7995	2.0358	.6226
1.900	.200	3.631	.3912	.4118	1.068	1.767	.6052
2.375	.154	3.652	.6657	.5606	1.075	3.355	.7871
2.375	.218	5.022	.8679	.7309	1.477	2.953	.7665
2.875	.203	5.793	1.539	1.064	1.704	4.788	.9474
2.875	.276	7.661	1.924	1.339	2.254	4.238	.9241
3.500	.216	7.575	3.017	1.724	2.228	7.393	1.164
3.500	.300	10.252	3.894	2.225	3.016	6.605	1.136
4.000	.226	9.109	4.788	2.394	2.680	9.886	1.337
4.000	.318	12.505	6.280	3.140	3.678	8.888	1.307
4.500	.237	10.790	7.233	3.214	3.174	12.730	1.520
4.500	.337	14.983	9.610	4.271	4.407	11.497	1.477
5.563	.1875	10.764	11.45	4.117	3.166	21.140	1.902
5.563	.219	12.490	13.15	4.727	3.686	20.629	1.890
5.563	.250	14.185	14.76	5.305	4.173	20.133	1.881
5.563	.258	14.617	15.16	5.451	4.300	20.006	1.878
5.563	.281	15.870	16.31	5.864	4.665	19.650	1.870
5.563	.3125	17.523	17.83	6.409	5.155	19.151	1.860
5.563	.344	19.160	19.31	6.942	5.642	18.673	1.849
5.563	.375	20.778	20.67	7.431	6.112	18.194	1.839
6.625	.1875	12.891	19.66	5.935	3.792	30.680	2.277
6.625	.21875	14.966	22.61	6.826	4.403	30.069	2.266
6.625	.250	17.021	25.47	7.690	5.007	29.465	2.256
6.625	.280	18.974	28.14	8.496	5.581	28.891	2.245
6.625	.3125	21.068	30.94	9.342	6.197	28.275	2.235
6.625	.344	23.076	33.57	10.14	6.788	27.684	2.224
6.625	.375	25.030	36.09	10.90	7.367	27.119	2.214

TABLE 87 (Continued)

STRUCTURAL PROPERTIES OF KAISER STEEL PIPE

Outside Dia.	Thickness	Weight per Foot	Moment of Inertia	Section Modulus	Area of Metal	Bore Area	Radius of Gyration
In.	In.	Lb.	In.^{4}	In.^{3}	In.^{2}	In.^{2}	In.
8.625	.188	16.940	44.36	10.29	4.983	53.443	2.984
8.625	.21875	19.639	51.06	11.84	5.777	52.649	2.973
8.625	.250	22.361	57.72	13.38	6.578	51.848	2.962
8.625	.277	24.696	63.35	14.69	7.265	51.161	2.953
8.625	.3125	27.743	70.59	16.37	8.161	50.265	2.941
8.625	.322	28.554	72.49	16.81	8.399	50.027	2.938
8.625	.34375	30.402	76.80	17.81	8.943	49.483	2.930
8.625	.375	33.041	82.86	19.21	9.719	48.707	2.920
8.625	.438	38.256	94.56	21.93	11.25	47.18	2.899
8.625	.500	43.388	105.7	24.51	12.76	45.67	2.878
10.750	.188	21.15	87.0	16.18	6.238	84.527	3.735
10.750	.21875	24.604	100.4	18.67	7.237	83.526	3.724
10.750	.250	28.035	113.7	21.16	8.247	82.516	3.713
10.750	.279	31.201	125.9	23.42	9.178	81.585	3.702
10.750	.307	34.240	137.4	25.57	10.07	80.69	3.694
10.750	.344	38.200	150.4	27.98	11.25	79.55	3.683
10.750	.348	38.661	154.0	28.65	11.37	79.39	3.680
10.750	.365	40.483	160.7	29.90	11.91	78.85	3.674
10.750	.438	48.19	189.0	35.16	14.19	76.58	3.649
10.750	.500	54.74	212.0	39.43	16.10	74.66	3.628
12.750	.21875	29.276	169.1	26.52	8.612	119.065	4.431
12.750	.250	33.375	191.8	30.09	9.817	117.860	4.420
12.750	.28125	37.453	214.2	33.60	11.02	116.66	4.409
12.750	.3125	41.510	236.3	37.06	12.21	115.47	4.399
12.750	.330	43.773	248.5	38.97	12.88	114.80	4.393
12.750	.34375	45.547	258.0	40.46	13.40	114.28	4.388
12.750	.375	49.562	279.3	43.82	14.58	113.10	4.377
12.750	.438	57.53	321.5	50.43	16.94	110.74	4.330
12.750	.500	65.415	361.5	56.71	19.24	108.44	4.335
14.000	.250	36.424	253.4	36.20	10.71	143.23	4.862
14.000	.281	41.208	285.3	40.75	12.12	141.82	4.851
14.000	.3125	45.682	314.9	44.98	13.44	140.50	4.841
14.000	.314	50.140	316.4	45.20	13.50	140.44	4.837
14.000	.34375	50.136	344.0	49.14	14.75	139.19	4.830
14.000	.375	54.568	372.8	53.25	16.05	137.89	4.819

TABLE 87 (Continued)

STRUCTURAL PROPERTIES OF KAISER STEEL PIPE

Outside Dia.	Thickness	Weight per Foot	Moment of Inertia	Section Modulus	Area of Metal	Bore Area	Radius of Gyration
In.	In.	Lb.	$In.^4$	$In.^3$	$In.^2$	$In.^2$	In.
14.000	.438	63.441	429.5	61.36	18.66	135.28	4.797
14.000	.500	72.091	483.8	69.11	21.21	132.73	4.776
16.000	.250	42.053	383.7	47.96	12.37	188.69	5.569
16.000	.28125	47.215	429.1	53.64	13.89	187.17	5.558
16.000	.3125	52.357	474.0	59.25	15.40	185.66	5.547
16.000	.34375	57.478	518.3	64.79	16.91	184.15	5.537
16.000	.375	62.579	562.1	70.26	18.41	182.65	5.526
16.000	.4375	72.716	648.1	81.01	21.39	179.67	5.504
16.000	.500	82.771	731.9	91.49	24.35	176.71	5.483
18.000	.250	47.393	549.1	61.02	13.94	240.53	6.276
18.000	.28125	53.223	614.6	68.28	15.66	238.81	6.265
18.000	.3125	59.032	679.3	75.47	17.36	237.11	6.254
18.000	.34375	64.821	743.3	82.59	19.07	235.40	6.244
18.000	.375	70.589	806.6	89.63	20.76	233.71	6.233
18.000	.4375	82.061	931.3	103.5	24.14	230.33	6.211
18.000	.500	93.451	1053.0	117.0	27.49	226.98	6.190
20.000	.250	52.73	756.6	75.66	15.52	298.76	6.983
20.000	.28125	59.231	847.0	84.70	17.42	296.74	6.972
20.000	.3125	65.708	936.7	93.67	19.33	294.83	6.961
20.000	.34375	72.164	1026.0	102.6	21.23	292.93	6.951
20.000	.375	78.599	1113.0	111.3	23.12	291.04	6.940
20.000	.4375	91.407	1287.0	128.7	26.89	287.27	6.918
20.000	.500	104.131	1457.0	145.7	30.63	283.53	6.897

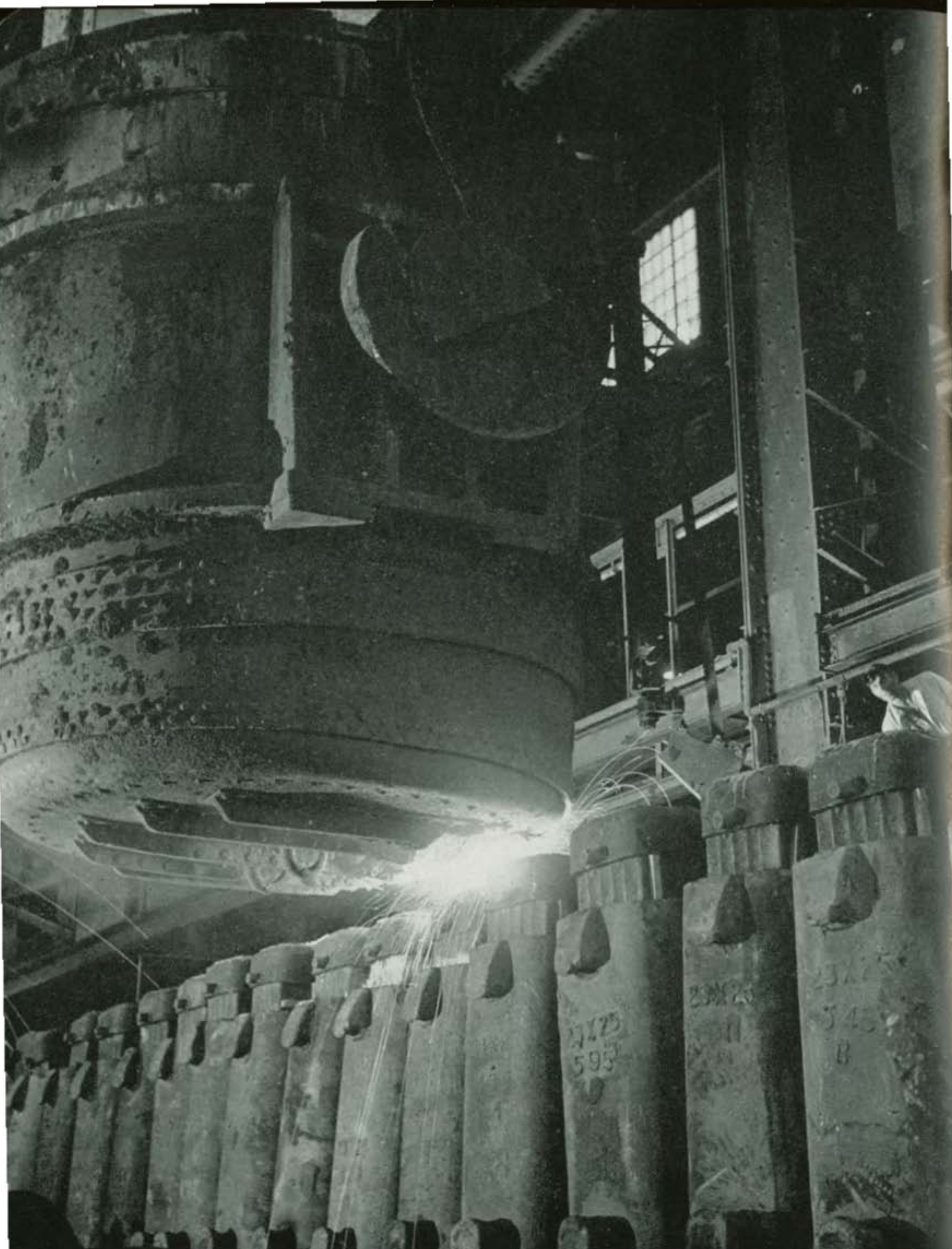
ORDERING PRACTICE FOR KAISER TUBULAR PRODUCTS

In order to more clearly describe the material desired and to avoid misunderstanding, purchasers inquiries and orders for Kaiser Tubular Products should specify the following details:

1. Quantity (in linear feet, number of pieces or bundles, or weight).
2. Size (O.D. or nominal).
3. Foot-weight or wall thickness.
4. Method of manufacture (continuous welded, electric welded, etc.).
5. Class of material (standard pipe, line pipe, etc.).
6. End finish (threaded and coupled, plain end, threaded only, etc.).
7. If plain end, method of joining to be used.
8. Grade of steel, where specifications provide this option.
9. Length (single random, double random, average, definite cut, or uniform).
10. Type of coating or lining, if any.
11. Applicable specifications.
12. Purpose for which material is intended (flanging, bending, high temperature service, etc.).
13. Delivery date desired.
14. Type of inspection required (mill inspection, outside inspection, agency, etc.).

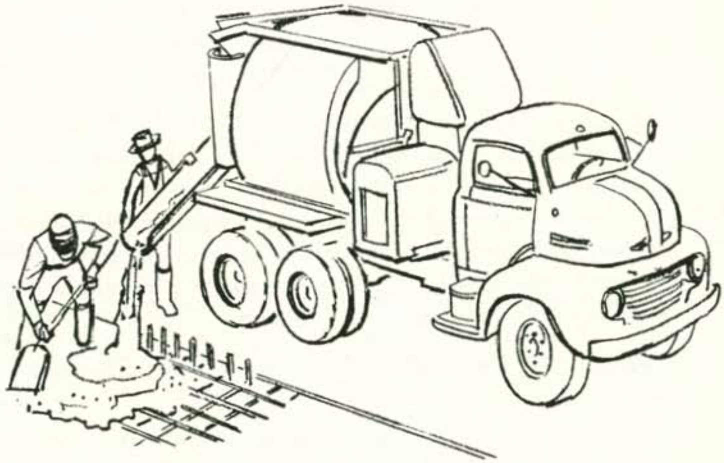
Tubular products are invoiced on the basis of the quoted price per one hundred feet.

A truck load of Kaiser C W pipe being expedited to a customer's plant.



Alloy and special steels require particular care in production, beginning with the pouring of "hot top" ingots.

ALLOY AND SPECIAL STEELS



KAISER ALLOY AND SPECIAL STEELS

The steel industry definition of alloy steel is given on Page 27 of this catalog. The alloy content of a large number of standard and special alloy steels has been established by the industry. Tables of standard alloy steels are published by the American Iron & Steel Institute. Kaiser Steel Corporation rolls alloy steels into blooms, billets, plates, structurals and bars including spring steel flats and precision rounds.

Kaiser Hot Rolled Alloy Steels have many applications in industry. In the construction of railway and automotive equipment, farm implements, construction, rock, gravel and material handling fields and in mechanical applications, Kaiser Alloy Steel products have wide and increasing uses.

The special properties imparted by alloys to steel, while beneficial to the steel, increase the hazards both to the steel and the equipment during processing. Kaiser Alloy Steels, therefore, receive special care and many precautions are taken during production to insure satisfactory hot rolled products. They are rolled from double converted, semi-finished products, carefully inspected and conditioned so that the finished steels are sound and exceptionally free of surface imperfections.

Kaiser Alloy Blooms, Billets, Plates, Structurals and Bars are available in many analyses and are furnished in most of the sizes in which the corresponding carbon steel products are rolled. They are produced subject to the allowable variation in chemical analysis and to standard practice variations for dimensions and workmanship. They are normally supplied in the as-rolled condition without heat treatment except that flats may be packed annealed during cooling after rolling.

Alloy steels are specified for individual applications for which the type of service or experience in use determines the necessity for specific quality or properties. It is always helpful and often essential to have complete information regarding fabrication, heat treatment and the service of the final steel part, to plan the processing of the alloy steel to produce the desired end product. Inquiries for alloy steels which include information regarding the processing of the end product and its heat treatment will more promptly develop specific replies regarding their production and delivery.

Kaiser Steel Corporation invites inquiries for alloy and special steels.

KAISALOY

High Strength Steel

KAISALOY was developed by Kaiser Steel Corporation to meet the needs of western engineers, fabricators, and manufacturers, for a low-alloy, high strength steel. KAISALOY is designed for use where greater yield strength is needed and less weight is wanted. It is recommended for constructional purposes where steel of superior physical properties is required and where cold forming, welding, and ease of fabrication are essential.

KAISALOY is available in four regular grades. Each grade is consistent with the special end use requirements of the application. KAISALOY is also produced as low-alloy structural steel to American Society for Testing Materials designation A-242, and for automotive applications to the Society of Automotive Engineers specification number 950. The superior properties of KAISALOY are inherent in the steel as rolled. Heat treatment is not necessary to develop them.

THE CHEMICAL COMPOSITION OF KAISALOY

In its chemical composition KAISALOY utilizes the metallurgical principle that optimum strengthening of steel is effected by adding smaller amounts of a larger number of scientifically selected alloying elements. The maximum beneficial characteristics of a low alloy steel have thus been incorporated in KAISALOY to give the steel high yield strength, ductility, toughness, workability and weldability. All grades have improved corrosion and abrasion resistance and those grades, especially developed for these properties, have atmospheric corrosion or wear resistance remarkably improved.

TABLE 88

REGULAR GRADES OF KAISALOY

Designation	Code Letters
KAISALOY—Forming Quality	KAISALOY—F. Q.
KAISALOY—Moderate Forming Structural Grades	KAISALOY—M. F. S.
KAISALOY—Corrosion Resistant Grade	KAISALOY—C. R.
KAISALOY—Wear Resistant Grade	KAISALOY—W. R.

TABLE 89

LIMITING CHEMICAL RANGE

KAISALOY Code	C Max.	Mn Max.	P Max.	S Max.	Si Max.	Cu Max.	Ni Max.	Cr Max.	Mo Max.	V Min.	Ti Min.	Al Min.
F. Q.	.12	.80	.040	.040	.35	.35	.30	.25	.10	.02	.005	...
M. F. S.	.20	1.50	.040	.050	.35	.35	.30	.25	.10	.02	.005	.25
C. R.	.30	1.50	.070	.050	.35	.60	.50	.25	.30	.02	.005	.25
W. R.	.20 Min.	1.20 Min.	.070	.050	.35	.35	.30	.25	.30	.02	.005	.25

THE MECHANICAL PROPERTIES OF KAISALOY

The mechanical properties of KAISALOY are consistent with the grade produced. The minimum physical properties are given in Table 90.

TABLE 90

MINIMUM PHYSICAL PROPERTIES

KAISALOY Code	Yield Strength	Tensile Strength	Bends Inside Radius
F.Q.	45,000	60,000	Flat. Either Direction
M. F. S.	50,000*	70,000*	To 1/4" Thick — R = 2T. Over 1/4" Thick — R = 3T.
C. R.	50,000*	70,000*	To 1/4" Thick — R = 2T. Over 1/4" Thick — R = 3T.
W. R.	55,000*	75,000*	Not recommended for cold bending.

*Higher strength levels for approved applications.

KAISALOY IN HEAVY SECTIONS

KAISALOY maintains its high yield strength and tensile properties when rolled into heavy sections.

TABLE 91

TYPICAL CHEMICAL ANALYSIS—KAISALOY IN HEAVY SECTIONS

C	Mn	P	S	Si	Cu	Ni	Cr	Mo	V	Ti
.15	1.11	.023	.026	.22	.22	.27	.11	.025	.05	.011

TABLE 92

MINIMUM PHYSICAL PROPERTIES KAISALOY IN HEAVY SECTIONS

Produced in Hot Rolled Condition

Section Thickness	1″ & Under	Over 1″ to 2″ Incl.	Over 2″ to 4″ Incl.
Yield Point min. psi	50,000	47,000	45,000
Tensile Strength min. psi	70,000	67,000	65,000
Elong. in 2″ min. per cent	22	....	....
Elong. in 8″ min. per cent	1,500,000 TS	1,500,000 TS	1,500,000 TS

IMPACT VALUES OF KAISALOY

The good low temperature impact values of KAISALOY illustrate the toughness of the steel. This property recommends KAISALOY for low temperature service and for notch resistant applications.

TABLE 93

IMPACT VALUES OF KAISALOY

(0.5″ Thick Plate)
(Key-Hole Charpy Specimen)

Temperature °F.	As Rolled Foot Pounds	Normalized 1700° F. Foot Pounds
100°	49	60
70°	43	60
30°	40	60
15°	40	58
0°	39	54
—10°	35	53
—25°	33	50
—35°	32	46
—50°	32	47
—60°	31	43
—70°	24	41

KAISALOY CHARACTERISTICS

WORKABILITY—KAISALOY can be satisfactorily formed in press brakes and other cold-forming equipment. It is generally found, however, that consistent with its higher strength, greater force is required for bending and increased radius of bends will prove an advantage. KAISALOY may be easily hot-formed and its physical properties are not materially altered by heating for forming.

GAS CUTTING—No problems are presented by the gas cutting of KAISALOY since it does not flame-harden in normal gas cutting operations. Speeds and torch adjustments when gas cutting KAISALOY, are much the same as used in cutting ordinary steels of comparable thickness.

WELDING—KAISALOY does not require special handling or procedure for welding. It may be welded, by any of the methods used in welding ordinary structural steels. For metal arc welding, covered electrodes of the E-60 group will give ductile welds of adequate strength. If higher strength welds are desired, covered electrodes of the E-70 group will provide satisfactory welds. KAISALOY is readily joined by submerged arc welding. The rod ordinarily used for structural steels has generally provided entirely satisfactory welds.

ENDURANCE STRENGTH AND NOTCH SENSITIVITY—KAISALOY will be found to have a higher endurance strength and increased resistance to notch sensitivity when compared with ordinary structural steels. Improvement in these properties reflects the inherent superior physical characteristics of KAISALOY resulting from its composition and controlled manufacture.

CORROSION RESISTANCE—Since varying conditions of service and exposure to corrosion have a marked bearing on the service life of steel, the production of a high yield strength, low alloy steel having improved resistance to corrosion was an impelling objective in the development of KAISALOY. The substantial improvement in resistance to corrosion incorporated in this steel is an important factor in influencing its selection for use over ordinary steels.

ABRASION RESISTANCE—While mechanical conditions of wear are necessarily the controlling factors in abrasion, it will be found that KAISALOY, due to its higher strength, its structure, and composition, will provide appreciably increased life under abrasive conditions.

KAISER ABRASION RESISTING STEEL

The advantage of abrasion resisting steel in cutting costs of handling abrasive materials is well established. It is indispensable for many applications, such as dredge pipe, digging and stacking ladders for dredges, road machinery, and farm machinery; sand and gravel, coal and concrete aggregate handling equipment, conveyors, chutes, liners for ore bins and dust collecting systems.

The ability of abrasion resisting steels to keep equipment operating for longer periods, to lessen shut down time and to decrease maintenance costs gives it new economic importance in view of present day increasing costs.

Kaiser Abrasion Resisting Steel is furnished in the following chemical analysis range:

Carbon	Manganese	Phosphorus	Sulphur	Silicon
35/50	1.20/1.70	.05 maximum	.05 maximum	.20 aim

Kaiser Abrasion Resisting Steel of the above analysis may be expected to have a Brinell hardness of 200 to 250.

KAISER HARD ROLLED SHEETS FOR WATER WELL CASING

By variation of its composition or method of production, physical properties and characteristics may be developed in sheet steel which make it particularly adaptable to water well casing. Kaiser Hard Rolled Sheets for water well casing are supplied in medium carbon grade for cold shaping and fusion welding into tubular form. Kaiser Hard Rolled Sheets roll readily without loose scale. They are produced to meet the demands of the trade for water well casing for welding, driving and perforating. They are normally rolled as 12 gage, 10 gage and 8 gage sheets in widths from 36 to 48 inches.

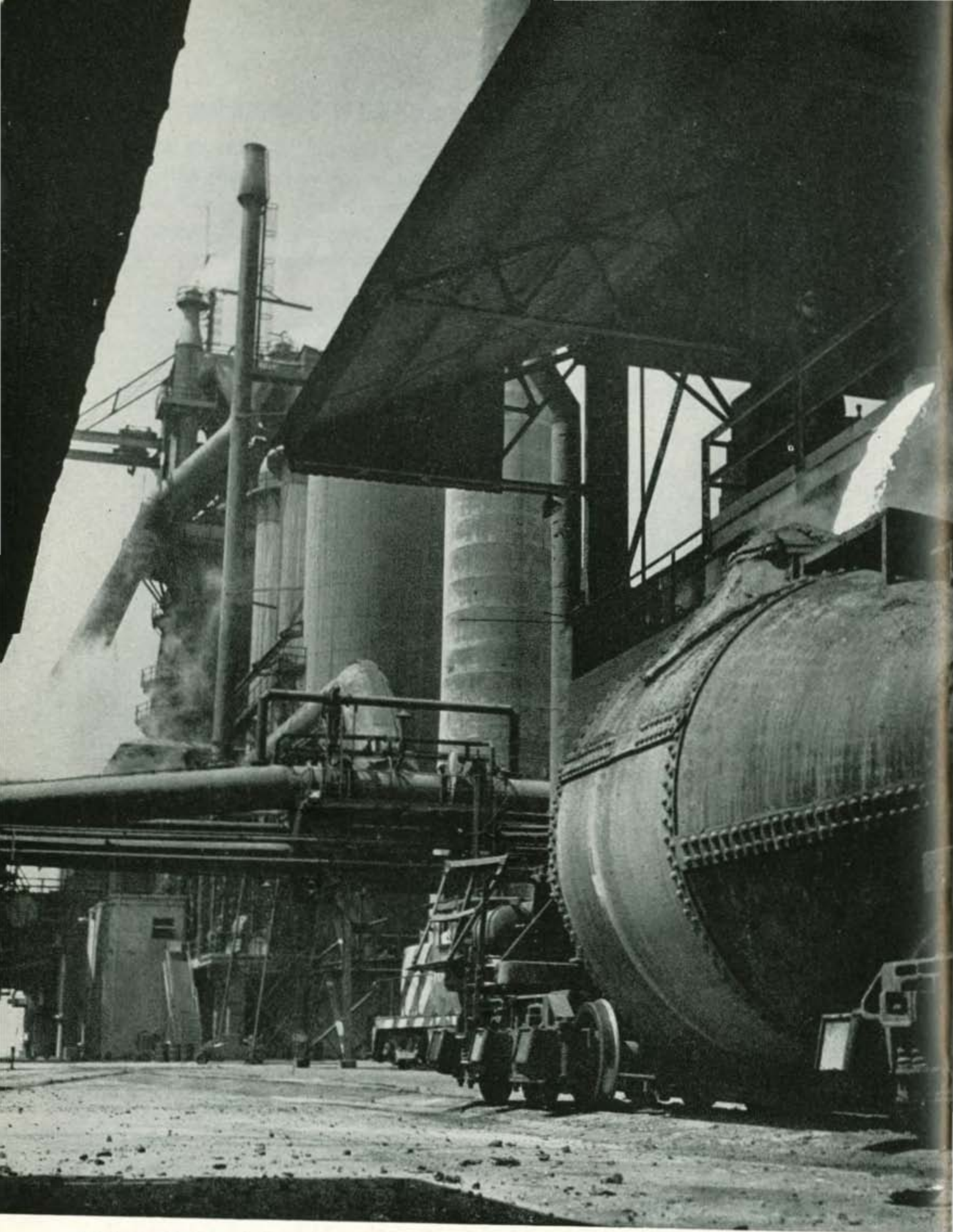
Further information regarding the properties and availability of these sheets will be furnished upon inquiry.

KAISER FREE MACHINING STEELS

Kaiser Free Machining Steels are furnished in several analyses and grades to provide the degree of machinability desired and to meet the physical requirements of the finished product.

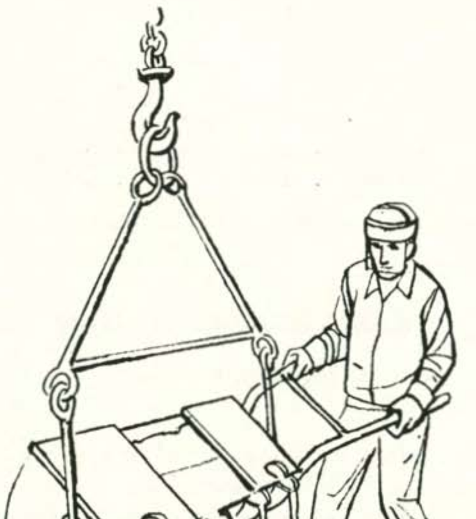
Free machining steels may be purchased as bars for cold drawing, forging and machining, and as plate for machining and heat treating.

Inquiries are invited for these steels.



Molten pig iron is transferred in 150-ton torpedo ladles from the blast furnaces to the open hearths or to the ingot mold foundry or pig casting machines.

PIG IRON



KAISER PIG IRON

Pig iron is the product resulting from the reduction of iron ore in the blast furnace. It is classified and graded according to its intended uses.

Kaiser Steel Corporation produces Basic Pig Iron largely for its own use in the manufacture of steel. Merchant pig iron is offered for general sale in both basic and foundry analyses. It is sold by the gross ton (2240 lbs.) and is available for either truck or rail shipment in quantities of 50 gross tons or more.

KAISER BASIC PIG IRON

Basic Pig Iron is used in making steel by the basic open hearth process. Inquiries are invited on any specifications covering Basic Pig Iron. The following ranges are normally produced at Fontana:

	Range
Silicon	.90/1.75
Sulphur	.05 max.
Phosphorus	.20/.35
Manganese	.40/1.00

Basic grade notched pigs are produced in weights averaging 60 pounds each.

KAISER FOUNDRY PIG IRON

Foundry Pig Iron is used for remelting to produce a wide variety of iron castings such as:

(1) Light, thin castings, including stove plate, radiator castings, plumbing supplies and hardware specialties.
(2) Miscellaneous light and heavy castings which are to be machined.
(3) Heavy castings not to be machined.
(4) Chilled castings.
(5) Castings requiring density of grain and dependable strength for steam and hydraulic cylinders and similar uses.

The silicon, phosphorous and manganese limits of Foundry Pig Iron are modified to meet the special requirements of these various products and uses. The extreme ranges of foundry grades being maintained in stock are as follows:

	Range
Silicon	1.75/3.25
Sulphur	.05 max.
Phosphorus	.17/.70
Manganese	.60/1.00

Silicon is available in ranges of .25 points. Phosphorus and manganese are supplied in .20 point ranges. Notched foundry pigs weigh an average of 40 pounds each.

KAISER INGOT MOLDS AND STOOLS

Ingot molds are cast iron forms used for the casting of ingots. Stools are the cast iron tables upon which the ingot molds are placed for pouring. The stool acts as a form for the bottom of the mold. Kaiser Steel Corporation not only produces all its own ingot molds and steels, but produces them for other steel mills, forge shops, and foundries.

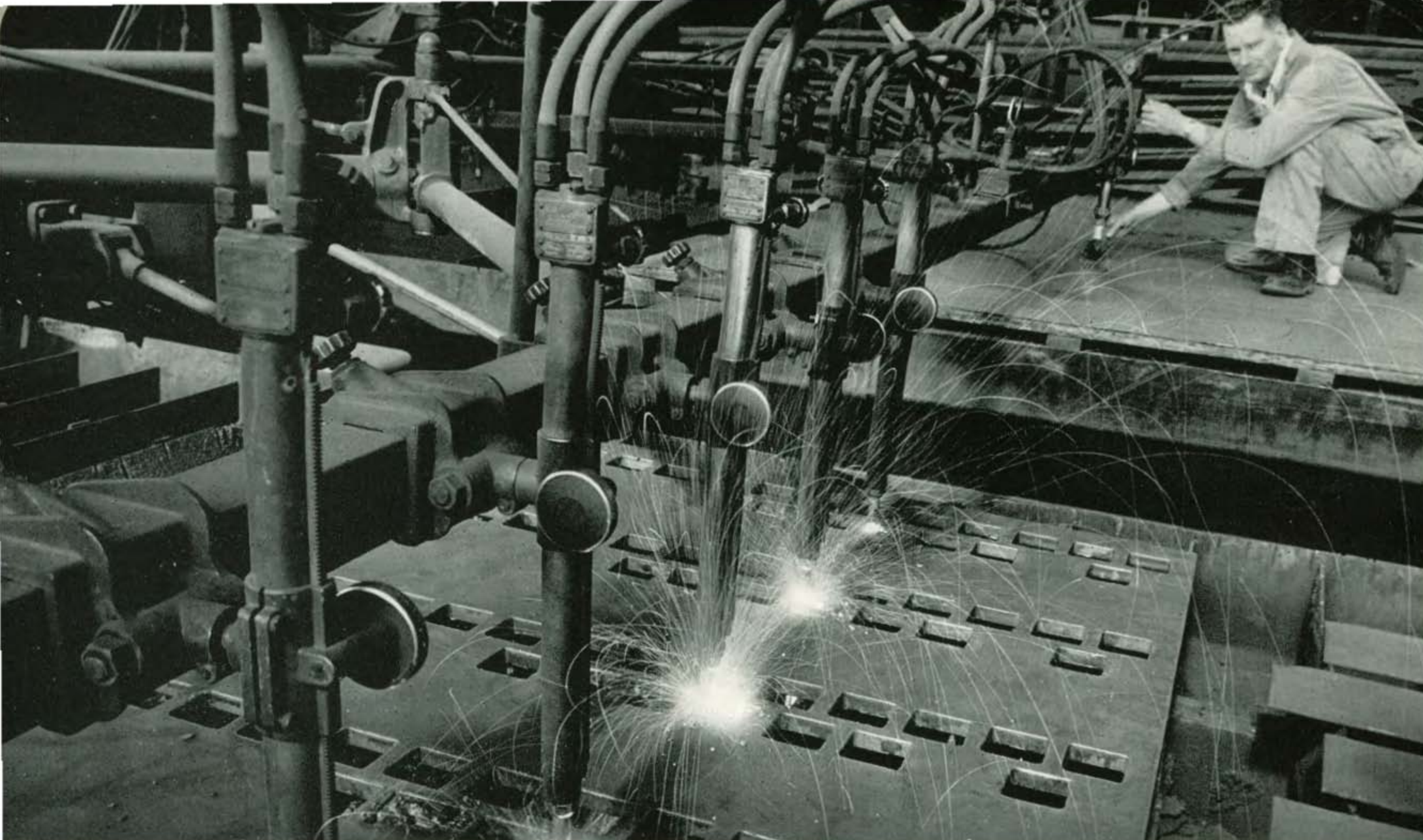
Kaiser Steel Corporation has a fully equipped, modern ingot mold and stool foundry capable of producing molds and stools weighing from 2,000 lbs. to 50,000 lbs. each. Inquiries for larger molds are invited.

ORDERING PRACTICE FOR KAISER PIG IRON

In order to more clearly describe the material desired and to avoid misunderstanding, purchasers' inquiries and orders for Kaiser Pig Iron should specify the following details:

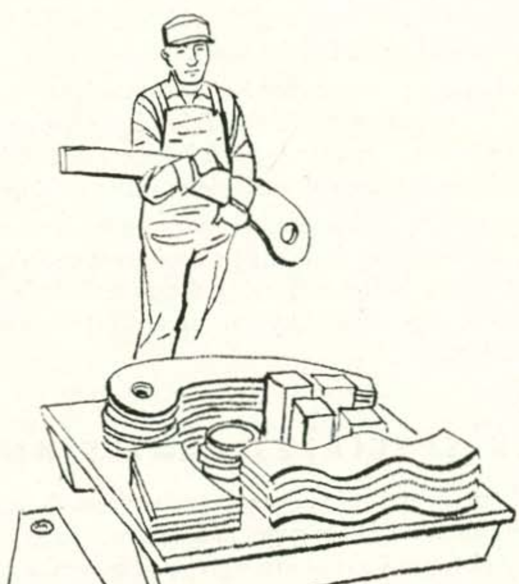
1. Quantity.
2. Chemistry.
3. Special loading practices applicable—truck or rail.
4. Shipping destination.
5. Required routing.
6. Requested delivery.
7. Distribution of shipping notices, invoices, and bills of lading.

Pig Iron is invoiced on mill scale weights and is priced on the basis of a gross ton of 2,240 lbs.



In the specialties products section, above, a single operator can cut numerous specially ordered small plate shapes at once using a travograph cutting device.

SPECIALTY PRODUCTS



KAISER SPECIALTY PRODUCTS

Specialty products, as produced by Kaiser Steel Corporation, may be defined as the usuable end products reclaimed from prime or secondary material generated in the production of steel. These products are produced from prime material which has had defective portions removed. This material, after being so processed, is suitable for many uses in industry. At the present time, Kaiser Steel Corporation produces specialty products only in the form of flat rolled products (plates and sheets) and tubular products.

Structural fabricators can use specialty flat rolled products for many parts of bridges and buildings, such as gusset plates, filler plates, splice plates, and base plates. The production of machinery, farm implements, contractors' equipment, tanks, and chemical and refinery equipment requires the assembly of many small parts of plate, sheet, and bars. In producing such products, manufacturers can use flat rolled specialties cut to standard forms, such as circles, rectangles and triangles, or to other special shapes.

Specialty pipe can be used for fence posts, sign posts, playground equipment, steel furniture, wheelbarrow handles, structural columns, storage racks, conveyor rollers, and for similar structural purposes.

All Kaiser specialty products are sold in carload quantities. Random size specialty products are sold on a negotiated basis. Specialty products cut to customer's order are sold on an inquiry basis.

Many manufacturing concerns use Kaiser cut-to-size specialty products in their manufacturing assemblies with little additional processing required and with a resulting saving in costs. Structural steel fabricators find their productive capacity amplified by this ready source of small pieces with resulting economy.

The facilities used by Kaiser Steel Corporation in the production of flat rolled specialty products consist of flame cutting equipment and plate leveling and shearing equipment, which includes squaring shears and circle shears. The facilities used in the reclamation of specialty tubular products consist of pipe cut-off and threading machines.

KAISER SPECIALTY PLATES AND SHEETS

Specialty plates are available in gages ranging from $\frac{3}{16}$ to 4 inches in thickness. Specialty sheets are available in gages ranging from 18 gage to $\frac{1}{8}$ inch in thickness. Specialty plates and sheets are segregated generally into three categories:

Those Having An Area of Over 32 Square Feet—These plates and sheets, the chemical and physical properties of which can be furnished, are identified and sold as random size prime material.

Those Having An Area of Over 16 Square Feet to 32 Square Feet—These plates and sheets are segregated by thickness and chemistry, where possible, and are sold as random sizes in bundles identified with the size and specification of each plate or sheet.

Those Having An Area of Not Over 16 Square Feet—These plates and sheets are used for producing specific cut-to-size orders for fabricators and manufacturers. The preponderance of specialty flat rolled products is in this category. Such products are sheared or flame cut to order and specifications, and the customer is invited to submit lists of desired gages and sizes of material along with blueprints, sketches, or other details, where necessary. Material in this category is normally not sold to chemical analyses or physical tests. Cut-to-specified size material can not be accepted in areas over 16 square feet.

KAISER SPECIALTY PIPE

Reclaimed specialty pipe is almost entirely untested pipe and is, therefore, not suitable for carrying liquids or gases. The product description is, "Kaiser C.W. Standard Pipe, Untested." It is produced to Specification ASTM A-120, Modified, Untested. Both black and galvanized pipe are available in standard pipe sizes from 1 to 4 inches inclusive. Specialty pipe must be cut-to-length at the mill for some definite, specified, genuine, structural purpose and is sold only to bonafide end users of structural pipe. In general, the maximum lengths which will be accepted cut to customer's order are 16 feet for standard pipe and 12 feet for thin wall pipe, but shorter lengths are always more readily obtainable because better cutting yields are obtained. Occosionally, however, random lengths of reclaimed specialty pipe are offered for sale in lengths from 4 to 16 feet inclusive.

Kaiser Tubular Fence Posts—This product is offered in standard pipe sizes from 1 to 2 inches inclusive. The product description is, "Kaiser C.W. Tubular Fence Posts and Railings, not suitable for threading or bending." It is produced to Specification ASTM A-120, Modified Untested. This material is sold only for fence posts or similar structural uses.

STANDARD PRACTICES

In general, industry standard tolerances applicable to prime products apply to specialty products. Cut-to-specified order material can be flame cut or sheared to the tolerances used in the structural steel fabricating industry or as required by a specific machinery manufacturer's operation. Minimum cutting tolerances are normally plus or minus $\frac{1}{16}$ of an inch. Inquiries, however, with restrictive tolerances are invited.

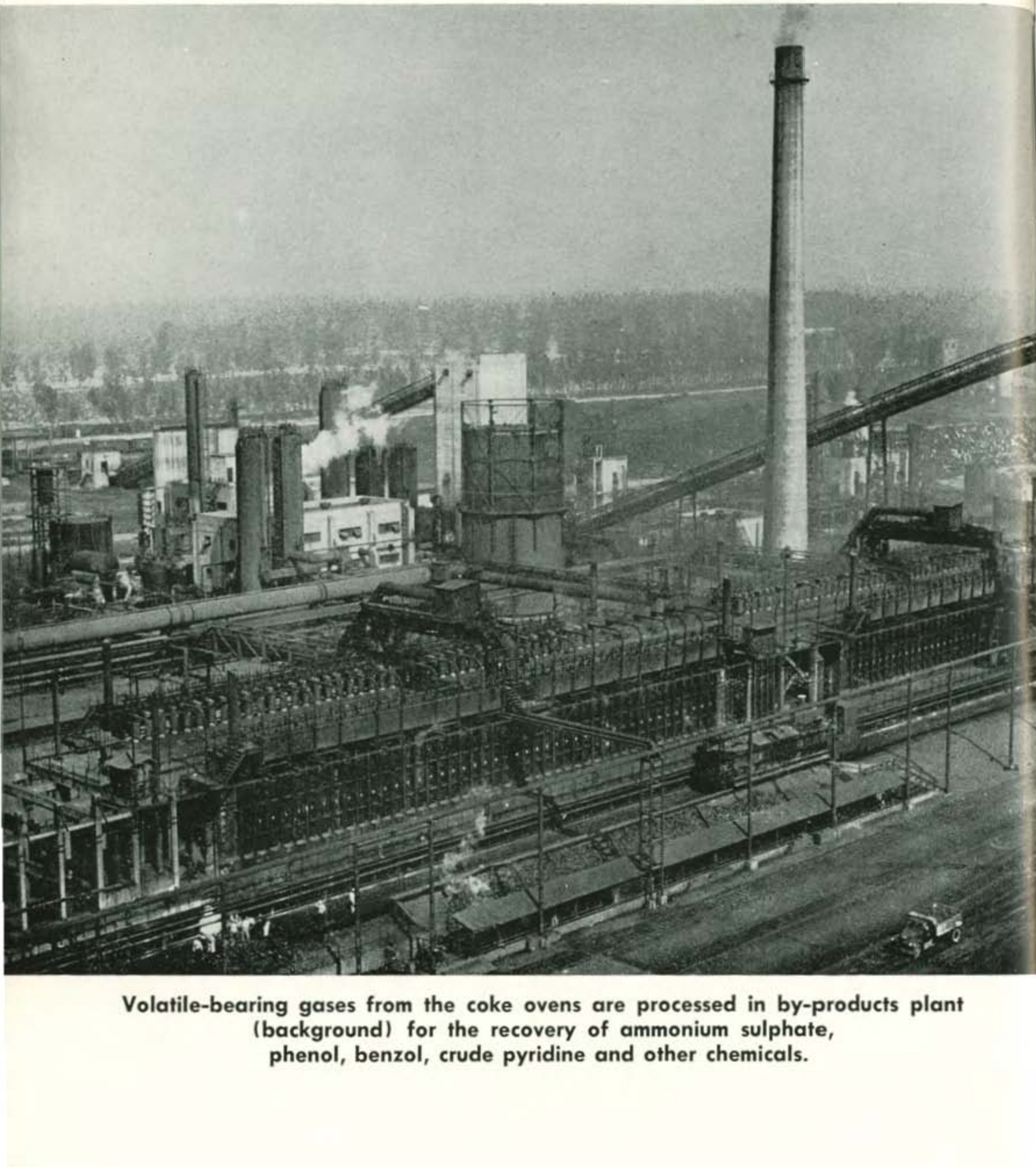
ORDERING PRACTICE FOR KAISER SPECIALTY PRODUCTS

In order to more clearly describe the material and to avoid misunderstanding, purchasers' inquiries and orders for specialty products should specify the following details:

1. Quantity.
2. Size and description.
3. Specification.
4. End use and fabricating process.
5. Inspection required if other than mill.
6. Destination.
7. Routing.
8. Delivery requested.
9. Special cutting tolerances, if any.
10. Blueprints, drawings, sketches, etc., if required.
11. Distribution of invoices, shipping notices, bills of lading, etc.
12. Physical or chemical test reports, if desired.

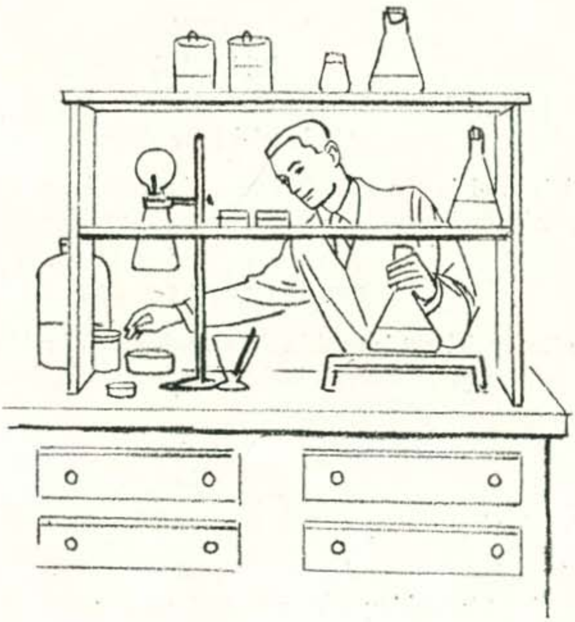
Specialty Products are sold on a lump sum or price per piece basis.

NOTES



Volatile-bearing gases from the coke ovens are processed in by-products plant (background) for the recovery of ammonium sulphate, phenol, benzol, crude pyridine and other chemicals.

COAL CHEMICALS



KAISER COAL CHEMICALS

Coke is made from coal by heating in sealed ovens in the absence of air. During the hot process of coke formation in the Kaiser coke ovens, valuable by-products are volatilized and driven off the coal. These gases are carried by large overhead collecting pipes to the by-products department where they are recovered and purified by a series of complex chemical processes. Kaiser coal chemicals have proven an important new source of supply to the chemical, plastic, explosive, paint and other industries of the West. The following products are now being marketed by Kaiser Steel Corporation as a result of the Company's by-product operation:

BENZOL

(C_6H_6)

Industrial Pure Benzene (Benzol) to be commonly known as "Industrial Pure Benzol"

Benzol is used in the manufacture of paint, varnish, lacquer, synthetic drugs, perfumes, organic chemicals, indigo dyes, dry cleaning preparations, paint and varnish removers, solvent for celluloid and rubber, and also for enriching gasoline.

TOLUOL

$(CH_3C_6H_5)$

Industrial Pure Toluene (Toluol) to be commonly known as "Industrial Pure Toluol"

Toluol is used in the manufacture of intermediates, organic chemicals, explosives, stains and enamels, and as a solvent for rubber, varnishes and resin.

CRUDE HEAVY SOLVENT

Crude Heavy Solvent is used in the manufacture of rubber solvents, linoleum, oil cloth and as a general solvent in the manufacture of paint, varnish and enamels.

XYLOL

$C_6H_4(CH_3)_2$

Nitration Xylene (Xyol) to be commonly known as "Industrial Xylol"

Xylol is used in the manufacture of dyestuffs, intermediates, organic chemicals and as a solvent in making rubber, cement, lacquer and varnishes.

CRUDE PHENOL

Crude Phenol is used, without further refining, to make Phenol Aldehyde resins for phenolic plybonds. These are adhesives in film form which make lasting and mildew resisting synthetic resin bonds for veneer or plies of wood. It is also used to make industrial phenolic plastics.

CRUDE PYRIDINE

Crude Pyridine is combined with other chemicals in industry to produce Rimifon and Nydrazid. These are trade names for the new tuberculosis wonder drug.

AMMONIUM SULPHATE
$(NH_4)_2\ SO_4$

Ammonium Sulphate is used principally as an ingredient in almost all fertilizers or as a simple for direct application to the soil. Kaiser Ammonium Sulphate is guaranteed to contain a minimum of 20.5 per cent Nitrogen, and is available in either bulk or bags.

COKE AND COKE BREEZE

Various grades of Beehive Furnace Coke as well as various sizes of Beehive Coke Breeze are available from Kaiser Steel Corporation's Sunnyside coke oven operations.

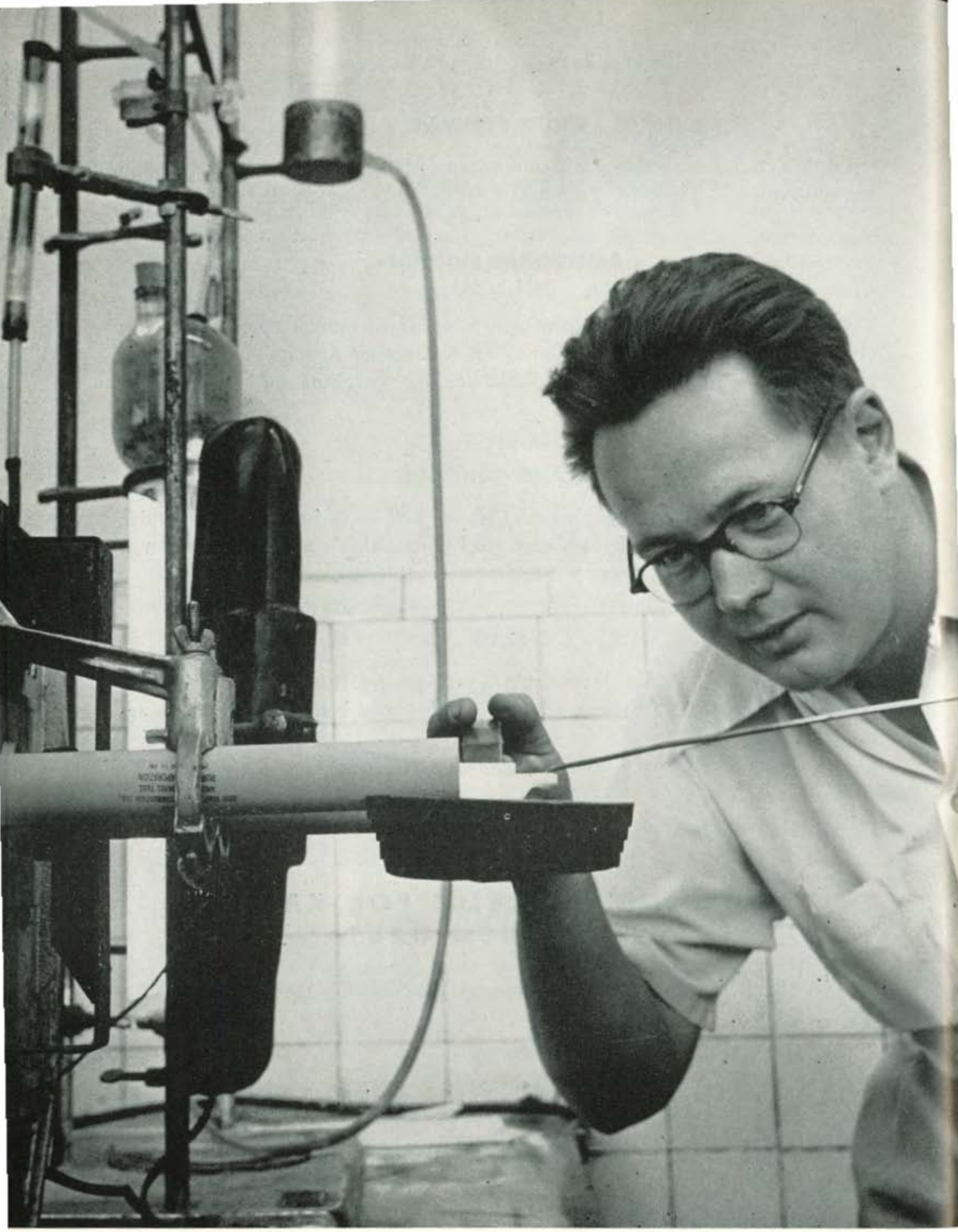
SLAG

Kaiser Blast Furnace Slag is available in various sizes. It is used in industry for making rock wool, as a roofing granule, and for road ballast and concrete aggregates.

ORDERING PRACTICE FOR KAISER COAL CHEMICALS

1. Quantity.
2. Quality.
3. End use.
4. Required inspection, if other than mill inspection.
5. Special loading practices, if applicable.
6. Shipping destination.
7. Required routing.
8. Requested delivery.
9. Distribution of shipping notices, invoices, and bills of lading.

Coal chemicals are available in tank car quantities or for shipment by convenient truck and trailer. They are invoiced on the basis of mill scale weights or gallons.



Metallurgical and chemical laboratory staffs check each step in the production of Kaiser Steel. Numerous analyses, tests and inspections are conducted to insure compliance with specifications.

STANDARD STEELS AND SPECIFICATIONS

STANDARD STEELS AND SPECIFICATIONS

STANDARD STEELS

The evergrowing variety of chemical compositions and quality requirements of steel specifications have resulted in several thousand different combinations of chemical elements being specified to meet individual demands of purchasers of steel products.

The American Iron and Steel Institute has standardized the nomenclature for identification of various chemical compositions of steel showing the carbon ranges and combinations of other elements which have been accepted as standard by the industry. The Society of Automotive Engineers, S.A.E., has also revised most of its specifications to coincide with those of the American Iron and Steel Institute.

These classifications are given as follows:

Prefix Letters—

(A) Indicates basic open-hearth alloy steel.
(B) Indicates acid Bessemer carbon steel.
(C) Indicates basic open-hearth carbon steel.
(E) Indicates electric furnace steel.
(NE) Indicates National Emergency Alloys.

Number Designations—

(10XX series) Basic open-hearth and acid Bessemer Carbon Steel grades, non-sulphurized and non-phosphorized.
(11XX series) Basic open-hearth and acid Bessemer Carbon Steel grades, sulphurized but not phosphorized.
(1300 series) Manganese 1.60 to 1.90%.
(23XX series) Nickel 3.50%.
(31XX series) Nickel 1.25%—Chromium .60%.
(32XX series) Nickel 1.75%—Chromium 1.00%.
(40XX series) Molybdenum.
(41XX series) Chromium Molybdenum.
(43XX series) Nickel—Chromium—Molybdenum.
(46XX series) Nickel 1.65%—Molybdenum .25%.
(48XX series) Nickel 3.25%—Molybdenum .25%.
(61XX series) Chromium Vanadium.
(52XXX series) Chromium and High Carbon.
(86XXX series) Low Nickel—Chromium—Molybdenum Steel.
(92XXX series) Silicon 1.80/2.20.

CHEMICAL COMPOSITION LIMITS, PER CENT					
AISI No.	C	Mn	P Max.	S Max.	Corresponding SAE No.
C 1005	0.06 max.	0.35 max.	0.040	0.050	....
C 1006	0.08 max.	0.25/0.40	0.040	0.050	1006
C 1008	0.10 max.	0.25/0.50	0.040	0.050	1008
C 1010	0.08/0.13	0.30/0.60	0.040	0.050	1010
C 1011	0.08/0.13	0.60/0.90	0.040	0.050	....
C 1012	0.10/0.15	0.30/0.60	0.040	0.050	....
C 1013	0.11/0.16	0.50/0.80	0.040	0.050	....
C 1015	0.13/0.18	0.30/0.60	0.040	0.050	1015
C 1016	0.13/0.18	0.60/0.90	0.040	0.050	1016
C 1017	0.15/0.20	0.30/0.60	0.040	0.050	1017
C 1018	0.15/0.20	0.60/0.90	0.040	0.050	1018
C 1019	0.15/0.20	0.70/1.00	0.040	0.050	1019
C 1020	0.18/0.23	0.30/0.60	0.040	0.050	1020
C 1021	0.18/0.23	0.60/0.90	0.040	0.050	1021
C 1022	0.18/0.23	0.70/1.00	0.040	0.050	1022
C 1023	0.20/0.25	0.30/0.60	0.040	0.050	....
C 1024	0.19/0.25	1.35/1.65	0.040	0.050	1024
C 1025	0.22/0.28	0.30/0.60	0.040	0.050	1025
C 1026	0.22/0.28	0.60/0.90	0.040	0.050	1026
C 1027	0.22/0.29	1.20/1.50	0.040	0.050	1027
C 1029	0.25/0.31	0.60/0.90	0.040	0.050	....
C 1030	0.28/0.34	0.60/0.90	0.040	0.050	1030
C 1031	0.28/0.34	0.30/0.60	0.040	0.050	....
C 1032	0.30/0.36	0.60/0.90	0.040	0.050	....
C 1033	0.30/0.36	0.70/1.00	0.040	0.050	1033
C 1034	0.32/0.38	0.50/0.80	0.040	0.050	1034
C 1035	0.32/0.38	0.60/0.90	0.040	0.050	1035
C 1036	0.30/0.37	1.20/1.50	0.040	0.050	1036
C 1037	0.32/0.38	0.70/1.00	0.040	0.050	....
C 1038	0.35/0.42	0.60/0.90	0.040	0.050	1038
C 1039	0.37/0.44	0.70/1.00	0.040	0.050	1039
C 1040	0.37/0.44	0.60/0.90	0.040	0.050	1040
C 1041	0.36/0.44	1.35/1.65	0.040	0.050	1041
C 1042	0.40/0.47	0.60/0.90	0.040	0.050	1042
C 1043	0.40/0.47	0.70/1.00	0.040	0.050	1043
C 1045	0.43/0.50	0.60/0.90	0.040	0.050	1045
C 1046	0.43/0.50	0.70/1.00	0.040	0.050	1046
C 1049	0.46/0.53	0.60/0.90	0.040	0.050	1049
C 1050	0.48/0.55	0.60/0.90	0.040	0.050	1050
C 1051	0.45/0.56	0.85/1.15	0.040	0.050	....
C 1052	0.47/0.55	1.20/1.50	0.040	0.050	1052
C 1053	0.48/0.55	0.70/1.00	0.040	0.050	....
C 1054	0.50/0.60	0.50/0.80	0.040	0.050	....
C 1055	0.50/0.60	0.60/0.90	0.040	0.050	1055
C 1057	0.50/0.61	0.85/1.15	0.040	0.050	....
C 1059	0.55/0.65	0.50/0.80	0.040	0.050	....
C 1060	0.55/0.65	0.60/0.90	0.040	0.050	1060

CHEMICAL COMPOSITION LIMITS, PER CENT					
AISI No.	C	Mn	P Max.	S Max.	Corresponding SAE No.
C 1061	0.54/0.65	0.75/1.05	0.040	0.050	....
C 1062	0.54/0.65	0.85/1.15	0.040	0.050	1062
C 1064	0.60/0.70	0.50/0.80	0.040	0.050	1064
C 1065	0.60/0.70	0.60/0.90	0.040	0.050	1065
C 1066	0.60/0.71	0.85/1.15	0.040	0.050	1066
C 1069	0.65/0.75	0.40/0.70	0.040	0.050	....
C 1070	0.65/0.75	0.60/0.90	0.040	0.050	1070
C 1071	0.65/0.76	0.75/1.05	0.040	0.050	....
C 1072	0.65/0.76	1.00/1.30	0.040	0.050	....
C 1074	0.70/0.80	0.50/0.80	0.040	0.050	1074
C 1075	0.70/0.80	0.40/0.70	0.040	0.050	....
C 1078	0.72/0.85	0.30/0.60	0.040	0.050	1078
C 1080	0.75/0.88	0.60/0.90	0.040	0.050	1080
C 1084	0.80/0.93	0.60/0.90	0.040	0.050	....
C 1085	0.80/0.93	0.70/1.00	0.040	0.050	1085
C 1086	0.82/0.95	0.30/0.50	0.040	0.050	1086
C 1090	0.85/0.98	0.60/0.90	0.040	0.050	1090
C 1095	0.90/1.03	0.30/0.50	0.040	0.050	1095
C 1106	0.08 max.	0.30/0.60	0.040	0.08/0.13	....
C 1108	0.08/0.13	0.50/0.80	0.040	0.08/0.13	....
C 1109	0.08/0.13	0.60/0.90	0.040	0.08/0.13	1109
C 1110	0.08/0.13	0.30/0.60	0.040	0.08/0.13	....
C 1111	0.08/0.13	0.60/0.90	0.040	0.16/0.23	....
C 1113	0.10/0.16	1.00/1.30	0.040	0.24/0.33	....
C 1114	0.10/0.16	1.00/1.30	0.040	0.08/0.13	1114
C 1115	0.13/0.18	0.60/0.90	0.040	0.08/0.13	1115
C 1116	0.14/0.20	1.10/1.40	0.040	0.16/0.23	1116
C 1117	0.14/0.20	1.00/1.30	0.040	0.08/0.13	1117
C 1118	0.14/0.20	1.30/1.60	0.040	0.08/0.13	1118
C 1119	0.14/0.20	1.00/1.30	0.040	0.24/0.33	1119
C 1120	0.18/0.23	0.70/1.00	0.040	0.08/0.13	1120
C 1125	0.22/0.28	0.60/0.90	0.040	0.08/0.13	....
C 1126	0.23/0.29	0.70/1.00	0.040	0.08/0.13	1126
C 1132	0.27/0.34	1.35/1.65	0.040	0.08/0.13	1132
C 1137	0.32/0.39	1.35/1.65	0.040	0.08/0.13	1137
C 1138	0.34/0.40	0.70/1.00	0.040	0.08/0.13	1138
C 1140	0.37/0.44	0.70/1.00	0.040	0.08/0.13	1140
C 1141	0.37/0.45	1.35/1.65	0.040	0.08/0.13	1141
C 1144	0.40/0.48	1.35/1.65	0.040	0.24/0.33	1144
C 1145	0.42/0.49	0.70/1.00	0.040	0.04/0.07	1145
C 1146	0.42/0.49	0.70/1.00	0.040	0.08/0.13	1146
C 1148	0.45/0.52	0.70/1.00	0.040	0.04/0.07	....
C 1151	0.48/0.55	0.70/1.00	0.040	0.08/0.13	1151
C 1211	0.13 max.	0.60/0.90	0.07/0.12	0.08/0.15	....
C 1212	0.13 max.	0.70/1.00	0.07/0.12	0.16/0.23	....
C 1213	0.13 max.	0.70/1.00	0.07/0.12	0.24/0.33	....

Kaiser Steel Corporation is regularly producing many of the steels with chemical compositions as shown in the preceding tables, as well as steel products to both standard and special specifications including but not limited to those briefly described on the following pages.

A.S.T.M. SPECIFICATIONS

STEEL FOR BRIDGES AND BUILDINGS
A.S.T.M. Designation A 7-52T

This specification is used for plates, shapes and bars of structural quality for general structural purposes. It provides a minimum yield point that is one-half of the tensile strength but not less than 33,000 lbs. per square inch, except in the case of rolled base plates over 1½" in thickness for bearing purposes. These are specified to a carbon range of .20/.33%. A tensile strength of 60/72,000 lbs. per square inch is provided. The steel must withstand a 180 degree bend around a pin, the diameter of which is related to the thickness of the test specimen as detailed in the A.S.T.M. specification. Physical tests are not required for rolled base plates over 1½" in thickness which are to be used for bearing purposes.

STRUCTURAL SILICON STEEL
A.S.T.M. Designation A 94-52T

This specification covers a special high-strength structural steel intended primarily for use as main stress-carrying structural members: Material ordered to this specification must meet a tensile range requirement of 80,000 to 95,000 lbs. per square inch with a minimum yield point of 45,000 lbs. per square inch. The maximum carbon content is .40% and the silicon content must not be under .20% on ladle analysis.

STRUCTURAL STEEL FOR LOCOMOTIVES AND CARS
A.S.T.M. Designation A 113-52T

This specification is for carbon steel shapes, plates and bars (other than boiler and firebox plates), to be used for locomotive and car construction. Material ordered to this specification must meet a tensile range requirement. Grade A 60/72,000, Grade B 50/62,000, Grade C Cold Pressing Plates 48/58,000. Minimum yield points on these three are respectively 33,000, 27,000 and 26,000. Bend test requirements related to thickness of material are specified.

CARBON-SILICON STEEL PLATES OF ORDINARY TENSILE RANGES
A.S.T.M. Designation A 201-52aT

This specification covers carbon-silicon steel plates in two ordinary tensile ranges designated as Grades A and B. Grade A calls for a tensile strength of 55/65,000 lbs. per square inch, and Grade B, 60/72,000 lbs. per square inch. It is a specification for steel for locomotive boiler shells, stationary boilers and other pressure vessels, and is intended particularly for fusion welding. A definite silicon content is specified. Under this specification, the maximum thickness of flange quality plates is two inches. The maximum thickness of firebox quality plates is 12 inches when made to the Grade A specification, and 8 inches when made to the Grade B specification.

CARBON-SILICON STEEL PLATES OF HIGH TENSILE STRENGTH
A.S.T.M. Designation A 212-52aT

This specification covers carbon-silicon steel plates in two high tensile strength ranges as follows: Grade A, tensile strength 65/77,000 lbs. per square inch, and Grade B, tensile strength 70/85,000 lbs. per square inch. It is a specification for flange and firebox quality steel plates for use in locomotive boiler shells, stationary boilers and other pressure vessels. Under this specification, the maximum thickness of flange quality plates is two inches and of A and B firebox quality plates, 6 inches. A definite silicon content is specified and the steel is suitable for fusion welding.

CARBON STEEL STRUCTURAL PLATE
A.S.T.M. Designation A-283-52T

This specification covers four grades of carbon steel plate of structural quality for general applications in thicknesses up to 2″ inclusive. The specification prescribes four grades. A to D, in which the ranges of tensile strength increase by increments of 5,000 lbs. as follows:

	Tensile Strength, Psi	Min. Yield Strength, Psi
Grade A	45,000 to 55,000	24,000
Grade B	50,000 to 60,000	27,000
Grade C	55,000 to 65,000	30,000
Grade D	60,000 to 72,000	33,000

Bend requirements are related to the thickness but for Grades A, B and C plate ¾″ thick and lighter must bend flat upon itself, while for Grade D a 180° bend is required to be made around a pin having a diameter ½ the plate thickness.

CARBON-SILICON STEEL PLATES OF LOW AND INTERMEDIATE TENSILE STRENGTH FOR MACHINE PARTS AND GENERAL CONSTRUCTION.
A.S.T.M. Designation A-284-52T

This specification covers four grades of carbon steel plate for machine parts and general construction by gas cutting, welding, or other methods. Silicon content is specified to limit the carbon consistent with tensile strength and thickness. The tensile requirements are as follows:

	Tensile Strength, Psi	Min. Yield Strength, Psi
Grade A	50,000	25,000
Grade B	55,000	27,500
Grade C	60,000	30,000
Grade D	60,000	33,000

Bend test requirements related to the thickness of plate are specified.

CARBON STEEL PLATES OF LOW AND INTERMEDIATE TENSILE STRENGTH FOR FLANGE AND FIREBOX QUALITIES.
A.S.T.M. Designation A-285-52aT

These specifications cover three grades of carbon steel plate of flange and firebox qualities of low and intermediate tensile strengths intended for fusion welding for use in pressure vessels. The maximum thickness of plates covered by these specifications is 2″. These specifications cover three grades of plates in both flange and firebox quality with tensile strengths and minimum yield strengths as follows:

	Tensile Strength, Psi	Min. Yield Strength, Psi
Grade A	45,000 to 55,000	24,000
Grade B	50,000 to 60,000	27,000
Grade C	55,000 to 65,000	30,000

The tensile test taken from the top of firebox plate is allowed to exceed these limits by a maximum of 5,000 psi. Bend tests are taken from the middle of the top of the plate at right angles to the direction of rolling. Bend requirements are dependent upon plate thickness, and plate including 1″ in thickness must make a 180° bend around a pin equal to the plate thickness. A maximum manganese content of .80 per cent is established and maximum carbon contents are set up for the grades and thicknesses of firebox quality to insure strength and weldability.

Low Alloy Structural Steel
A.S.T.M. Designation A-242-52T

This specification covers low alloy structural steel for welded or riveted construction, intended primarily for use as stress carrying material of structural members where savings in weight and atmospheric corrosion resistance are important. This specification is limited to material not under 3/16″ and not over 2″ thick.

A maximum carbon content of 0.20 per cent and maximum manganese of 1.25 per cent is prescribed, while the sulphur present must not exceed .05 per cent. Alloying elements are added to improve the corrosion resistance and develop physical properties as required by the specification. The principal physical property characteristic of the steel is its high ratio of yield strength to tensile strength as illustrated by the specification requirements.

Thickness	Min. Tensile Strength	Min. Yield Strength
3/16″ to 3/4″ incl.	70,000 psi.	50,000 psi.
Over 3/4″ to 1 1/2″ incl.	66,000 psi.	45,000 psi.
Over 1 1/2″ to 2″ incl.	63,000 psi.	40,000 psi.

Bend requirements of the specification for plate 3/16″ to 3/4″ thick inclusive are met when 180° bends are made over a pin equal the thickness of the material. (Kaisaloy meets all the requirements of this specification.)

Billet Steel Bars for Concrete Reinforcement
A.S.T.M. Designation A 15-52T

This specification is the generally accepted standard for this class of material and covers three grades of deformed and cold twisted bars, namely, structural, intermediate and hard. Open Hearth, Electric Furnace and Acid Bessemer Steel are permitted by the specifications, the phosphorus being the only element shown in the specification subject to limitation. The tensile requirement for the structural grade is 55,000 to 75,000 lbs. per square inches and for the intermediate grade, 70,000 to 90,000 lbs. per square inch. The hard grade must conform to a minimum tensile requirement of 80,000 lbs. per square inch.

Minimum Requirements for the Deformations of Deformed Steel Bars for Concrete Reinforcement
A.S.T.M. Designation A 305-50T

This specification defines the dimensional requirements for deformed concrete reinforcement bars, including the maximum spacing of the deformations, their minimum height and position relative to the axis. The requirements are based on recommendations of the Committee of Reinforced Concrete Research of the American Iron and Steel Institute, that the design of the deformation shall provide for a bearing area of the deformations against the concrete, in square inches per lineal inch length of bar when projected on a plane normal to the axis of the bar, of approximately 15% of the nominal size of the bar expressed in inches.

Standard Specification for Hot Rolled Carbon Steel Bars
A.S.T.M. Designation A 107-52aT

This specification covers hot rolled carbon steel bars produced in accordance with good mill practice for general purposes including heat treatments. The sections covered are rounds, squares, and hexagons of all sizes, and flats.

PIPE

Welded and Seamless Pipe for Special Uses
A.S.T.M. Designation A-53-52T

This specification covers black and galvanized, welded or seamless nominal wall steel pipe intended for bending, coiling, flanging, or other special purposes. Because of the varied applications for pipe made to this specification, the end use must be given so that the manufacturer is able to supply the correct chemical analysis. The tensile requirements are as follows:

	Furnace-Welded		Seamless or Electric-Resistance-Welded	
	Acid-Bessemer	Open-Hearth or Electric-Furnace	Grade A	Grade B
Tensile strength, min., psi	50,000	45,000	48,000	60,000
Yield Point, min., psi . .	30,000	25,000	30,000	35,000

Pipe 2″ and under in diameter shall stand 90° bend tests if ordered for bending, and 180° bend tests if ordered for coiling. All sizes are subject to controlled flattening and hydrostatic tests as detailed in the specification.

Kaiser Steel Corporation produces butt-welded pipe, either black or galvanized, on its continuous weld mill to meet this specification in nominal sizes ½″ to 4″. However, butt-welded pipe is not intended for flanging.

Welded and Seamless Steel Pipe for Ordinary Uses
A.S.T.M. Designation A-120-47

This specification covers black and galvanized, welded or seamless, nominal wall steel pipe intended for ordinary uses in steam, water, gas, and air lines, but not intended for close coiling, bending, or high temperature service. It covers pipe made to three wall thickness classifications: "standard weight," "extra strong," and "double extra strong." No mechanical tests are specified, but each length must be hydrostatically tested to a pressure which varies directly with the diameter and thickness classification of the pipe. Kaiser Steel Corporation makes butt-welded pipe either black or galvanized on its continuous weld mill to meet this specification in nominal sizes ½″ to 4″.

Electric Resistance Welded Steel Pipe
A.S.T.M. Designation A-135-51T

This specification covers two grades of electric resistance welded steel pipe 30″ and under in diameter, intended for conveying liquids, gas, or vapors. Tensile requirements are as follows: Grade A minimum tensile strength 48,000 psi, and minimum yield point 30,000 psi. Grade B minimum tensile strength 60,000 psi, and minimum yield point 35,000 psi. Standard flattening tests and hydrostatic tests up to 2,500 psi are performed on each length of pipe. Kaiser Steel Corporation makes electric resistance welded steel pipe to this specification in sizes 5 9/16″ through 14″ O. D.

Electric Fusion Welded Steel Pipe
A.S.T.M. Designation A-139-51T

This specification covers two grades of electric fusion welded straight-seam or spiral-seam steel pipe 4″ and over in diameter with nominal wall thicknesses up to ⅝″ inclusive, and is intended for conveying liquid, gas, or vapors, but only Grade A is adapted for flanging and bending. Tensile requirements are as follows: Grade A minimum tensile strength 48,000 psi and minimum yield point 30,000 psi; Grade B minimum tensile strength 60,000 psi, and minimum yield point 35,000 psi. Standard flattening tests and hydrostatic tests up to 2800 psi are performed on each length of pipe.

Kaiser Steel Corporation makes pipe to this specification in sizes 14″ to 30″ O. D. inclusive.

A.P.I. SPECIFICATIONS

Line Pipe
A.P.I. Standard 5L

This specification covers seamless and welded steel pipe, seamless and welded open hearth iron pipe, and welded wrought iron pipe suitable for use in conveying gas, water, and oil, and made by the seamless, electric weld, lap-welded or butt-welded process. Chemical requirements and physical properties are indicated for the various classifications and grades in the accompanying table:

		CHEMICAL REQUIREMENTS					
STEEL PIPE	Carbon % Max.	Manganese % Min.	Manganese % Max.	Phos. % Max.	Sulphur % Max.	Yield Strength Min. psi	Tensile Strength Min. psi
SEAMLESS OR ELECTRIC WELDED							
Grade A		.30	.90	.045	.060	30,000	48,000
Grade B	.30	.35	1.50	.045	.060	35,000	60,000
Grade C		.35	1.50	.045	.060	45,000	75,000
LAP WELDED OR BUTT WELDED							
Electric-Furnace		.30	.60	.045	.060	25,000	45,000
Open Hearth—Class 1 . .		.30	.60	.045	.060	25,000	45,000
—Class 2 . .		.30	.60	.080	.060	28,000	48,000
Bessemer		.30	.60	.110	.065	30,000	50,000
IRON PIPE						24,000	42,000

Pipe made to this specification is also subject to flattening tests and hydrostatic pressure tests, with bend tests performed on sizes 2⅜″ and under in diameter. Kaiser Steel Corporation is prepared to meet this specification with butt-welded pipe in nominal sizes ½″ to 4″, and electric resistance welded pipe $5\frac{9}{16}$″ to 14″ O. D. Kaiser Steel Corporation also produces sizes 14″ O. D. to 18″ O. D. inclusive to this specification as modified by a one pass complete penetration fusion weld.

High Test Line Pipe
A.P.I. Standard 5LX

The purpose of this specification is to provide standards for more rigorously tested line pipe having greater tensile and bursting strengths than pipe manufactured for A.P.I. Standard 5L. It may be manufactured by either the seamless, electric-flash welding, continuous electric resistance welding or submerged arc welding methods. Various grades of pipe made under this specification are designated by the letter X followed by the first two digits of the specified minimum yield strength, i.e., X42 designates the grade having a specified minimum yield strength of 42,000 psi. Chemical and physical properties of the three most commonly used grades are given below:

	CHEMICAL				PHYSICAL	
	Carbon Max. %	Manganese Max. %	Phosphorus Max. %	Sulphur Max. %	Minimum Tensile Strength	Minimum Yield Strength
X42	.30	1.25	.045	.060	60,000 psi	42,000 psi
X46	.30	1.25	.045	.060	63,000 psi	46,000 psi
X52	.30	1.25	.045	.060	66,000 psi	52,000 psi

This pipe is also subject to controlled flattening and hydrostatic pressure tests, with bend tests performed upon agreement between the purchaser and the manufacturer. Kaiser Steel Corporation meets this specification with electric resistance weld pipe sizes $5\frac{9}{16}$″ to 14″ O. D. and submerged arc welded pipe sizes 20″ to 30″ O.D. Sizes 14″ to 18″ are also made to all applicable parts of this specification except that the one pass submerged arc weld method is used.

A.A.R. SPECIFICATIONS

BLOOMS, BILLETS AND SLABS FOR FORGINGS
A.A.R. Specification M-105-45

Requirements of this specification are covered by A.S.T.M. Specification A-273-52T for carbon steel and A.S.T.M. Specification A-274-52T for alloy steel.

STEEL BARS, CARBON, FOR RAILWAY SPRINGS
A.A.R. Specification M-112-49

This specification covers carbon steel bars to be used for the manufacture of railway springs and provides for a carbon range of .90/1.05%, and a minimum silicon content of .15%.

STEEL, STRUCTURAL SHAPES, PLATES AND BARS
A.A.R. Specification M-116-52

This specification covers structural steel shapes, plates (except boiler and firebox plates) and bars intended primarily for use in locomotive and car construction. There are three grades shown in the specification: namely, Grade A, tensile strength 60,000 to 72,000 lbs. per square inch; Grade B, tensile strength 50,000 to 62,000 lbs. per square inch, and Grade C, Cold Pressing Quality for plates only, tensile strength 48/58,000 lbs. per square inch.

OTHER SPECIFICATIONS

A.B.S. HULL QUALITY

This specification covers structural steel plates, shapes and bars for use in the construction of the hulls of vessels. Open hearth or electric furnace processes are permitted. The maximum carbon is 0.25 and manganese 0.90. Tensile strength is required as follows:

	Rolled Bars and Shapes	Structural Steel Plates	Rivet Steel and Steel for Cold Flanging
Tensile Strength, psi	58,000–70,000	59,000–70,000	55,000–65,000
Yield Point, min. psi	32,000	32,000	30,000

A bend test of 180 degrees related to the thickness of the speciman is required.

In addition to the commonly used specifications listed above, there are a number of other standard specifications for carbon steels produced by Kaiser Steel Corporation. Our metallurgists are also prepared to advise customers in the case of requirements not covered by standard specifications.

Kaiser Steel general offices are located in the Kaiser Building, Oakland, California.

SALES AND PRICE POLICY

SALES AND PRICE POLICY

PRICE

Kaiser Steel Corporation's lists of base prices and extras in effect at time of shipment are applicable and subject to change without notice. Base price and extra lists will be furnished upon request. For those readers who may not be familiar with steel industry pricing structure, the following definitions are included.

BASE PRICE: A charge to cover the basic cost of manufacturing a specific steel product.

EXTRAS: Charges to cover additional manufacturing costs incurred in producing to specific requirements, e.g., size, chemical and/or physical requirements, quality, etc. which require additional labor and/or result in higher manufacturing costs due to the inclusion of costlier chemical compounds, due to excessive roll-wear in the production of difficult-to-roll sizes, a lower than normal yield realization, etc.

CONDITIONS OF SALE

The following conditions are always part of Kaiser Steel Corporation's sales agreements.

TERMS OF PAYMENT

At any time payment in advance, or satisfactory security or guarantee that invoices will be promptly paid when due, may be required. The right is reserved by us to withhold further deliveries or terminate the agreement of sale when payments are delinquent. All payments shall be made at par in Oakland, California, Exchange. In computing allowable cash discounts, freight charges and/or taxes are excluded. If payment is not made according to the terms of the order, interest will be charged on any overdue portion at the rate of 6 per cent annually.

MANUFACTURING PRACTICE

All products are manufactured to American Iron and Steel Institute standard specifications and allowable variations, except as otherwise specified and accepted, and no claim other than for non-compliance therewith will be recognized. We will assume no liability for any failure of the customer's specifications to meet the customer's requirements.

DELIVERY AND SHIPMENT

The mode of transportation is selected by and agreed to by the customer. If transportation charges are prepaid, such charges generally will be for the account of the customer and are payable upon presentation of our invoices for such charges. Upon delivery of products F.O.B. railroad cars or trucks at our mill, all risk of loss, damage and other incidents of ownership pass to the customer, but title to such products is retained by us as security until payment in full is received.

Shipments are loaded according to standard loading practices of the Association of American Railroads. Except where otherwise mutually agreed, weights of shipments are determined by reference to the carrier's receipt for such shipments at the mill.

Any reasonable storage expense incurred by us is chargeable to the customer if he fails to furnish shipping instructions within thirty (30) days after our notification of availability of material for shipment.

If acceptance of an order indicates that the products are for export, the same shall be exported by the customer and any resale or shipment of same shall be confined to foreign destinations. Failure on the part of the customer to comply with this provision will subject all contracts to cancellation at our option. A copy of the export declaration and ocean bill of lading as evidence of compliance may be required.

GENERAL LIABILITY

Kaiser Steel Corporation is not liable for failure or delay in performance from causes not within its control, including fire; strikes; labor troubles; riot; insurrection; war; windstorms; explosions; sabotage; damage, destruction, breakdowns or failure of any kind to its equipment or facilities necessary for the performance agreed upon arising from any cause whatever; failure of usual sources of supply; acts of God; shortage of railroad cars or trucks; acts of the public enemy; any governmental action in pursuance of present or future laws; directives or policies, including any actions affecting priorities; restrictions, allotments, allocations, prorations, limitations or substitutions under any involuntary programs; any other governmental laws or acts of any Federal or State agency, or Federal corporation, or bureau, affecting manufacture and/or delivery which shall cause delay or prevent performance of any order.

CLAIMS

Any claims or exceptions must be made promptly after the customer's receipt of the product, and reasonable opportunity should be accorded us for investigation. We will in no event be held liable for any amount in excess of the purchase price of the product, and will not be liable for consequential, special or contingent damages. Products claimed to be defective may not be returned without our consent.

MISCELLANEOUS CONDITIONS

No order will be binding on us unless accepted in writing and such written acceptance will constitute the sale and entire agreement.

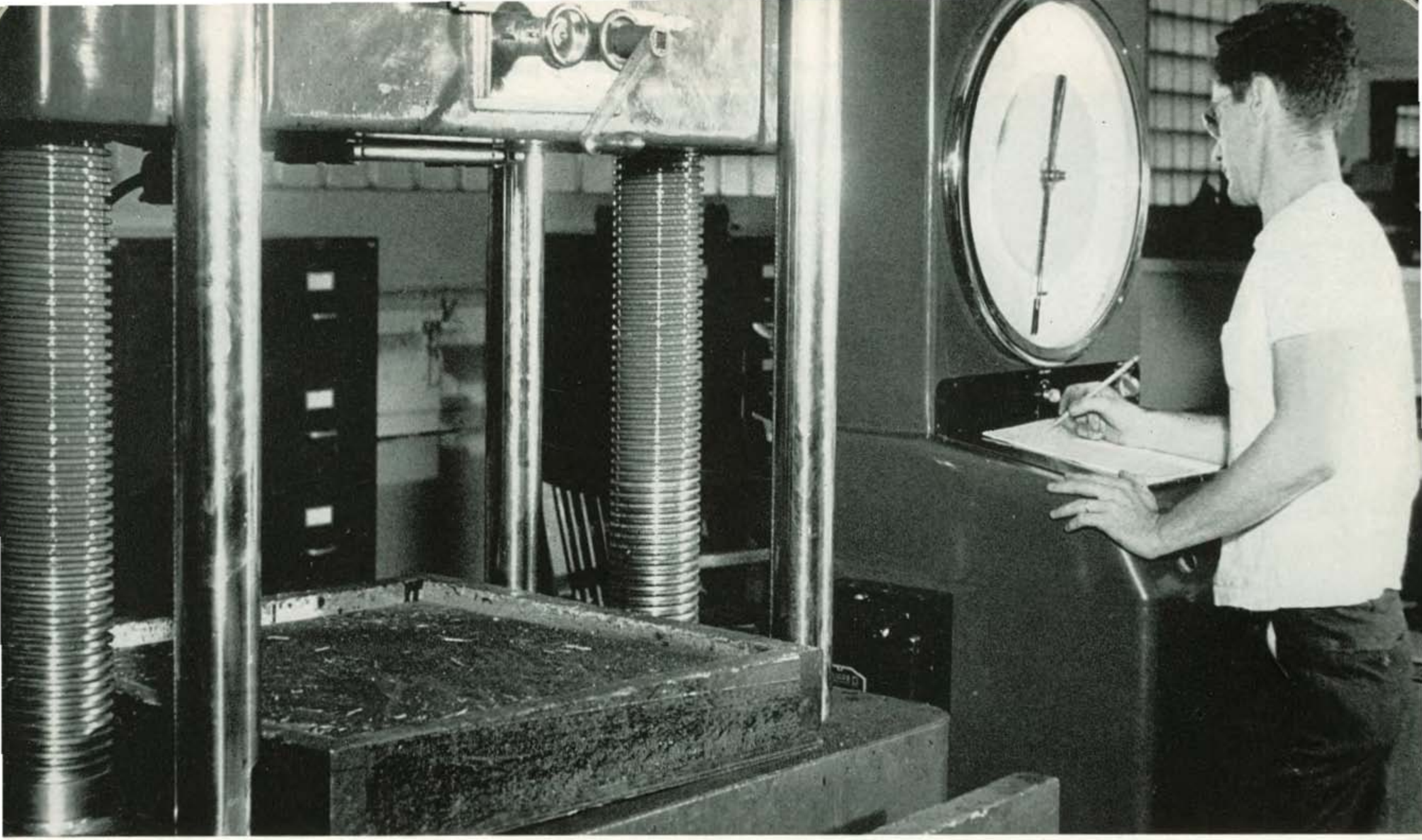
Our waiver of any term, provision or condition may not be construed to be a waiver of any other term, condition or provision, nor may such waiver be deemed a waiver of a subsequent breach of the same term, condition, or provision nor any other condition on any subsequent order. In case of any discrepancy between the terms and conditions we specify and those set forth in the customer's order, our terms will govern and control.

All orders and contracts are subject to the approval of our credit department and general sales office.

All drawbacks of duties paid on materials entering into the manufacture of products shall accrue to us and the customer will agree to furnish all documents and accord any further cooperation necessary toward our obtaining payment of such drawbacks.

Any taxes payable on account of any sale and in effect at time of shipment are for the customer's account.

The Kaiser Steel Corporation Sales Department — at your service.



Fully equipped testing laboratories at Fontana are used continually in checking and testing steel products.

USEFUL TECHNICAL INFORMATION AND REFERENCE TABLES

USEFUL TECHNICAL INFORMATION AND REFERENCE TABLES

Title *Page No.*

GENERAL FACTS ABOUT STEEL

Steel is a mixture of compounds of iron and carbon with small quantities of other elements, including manganese, phosphorus, sulphur, silicon, etc. The carbon-content controls the hardness and strength of the steel. Less than 0.10% of carbon is present in the soft steels, which have most of the characteristics of wrought iron; while steel with more than 0.40% carbon is capable of being tempered, it cannot be welded and is very much stronger. Manganese acts as a cleanser during the process of manufacture, and increases the forgeability of the steel. Phosphorus and sulphur are harmful in their effects, phosphorus making steel brittle under sudden loading and sulphur making it hot-short or brittle when heated.

ELONGATION AND ELASTIC BEHAVIOR—The percentage of elongation decreases as the carbon-content and ultimate strength increase. An approximate relation is

$$\text{percentage of elongation in 8 in.} = \frac{1{,}500{,}000}{\text{tensile strength}}$$

Since the total elongation of a ruptured specimen is due to the local stretching at the point of rupture and the uniform elongation over the whole gage-length, it is necessary to report the gage length when reporting this result. Since the local elongation is the same for a 2- or an 8-in. length the percentage of elongation for the same material, tested on a 2-in. gage-length, is greater than if measured on an 8-in length.

The elastic behavior of a specimen of steel loaded to rupture is best shown by a stress-strain diagram on which the stresses are plotted as vertical ordinates and the elongations or strains as abscissas. Five significant results are shown:

(1) The Modulus of Elasticity (E). The relation between the stress and the strain or elongation is called the Modulus of Elasticity. It is equal to the unit stress divided by the unit strain or deformation and is represented graphically by the tangent of the angle of the initial line with the horizontal. Its value for steel for tension is about 30,000,000 lb. per sq. in.

(2) The Elastic Limit (E.L.) is that unit stress beyond which the ratio of stress to strain ceases to be constant, or beyond which the curve ceases to be a straight line.

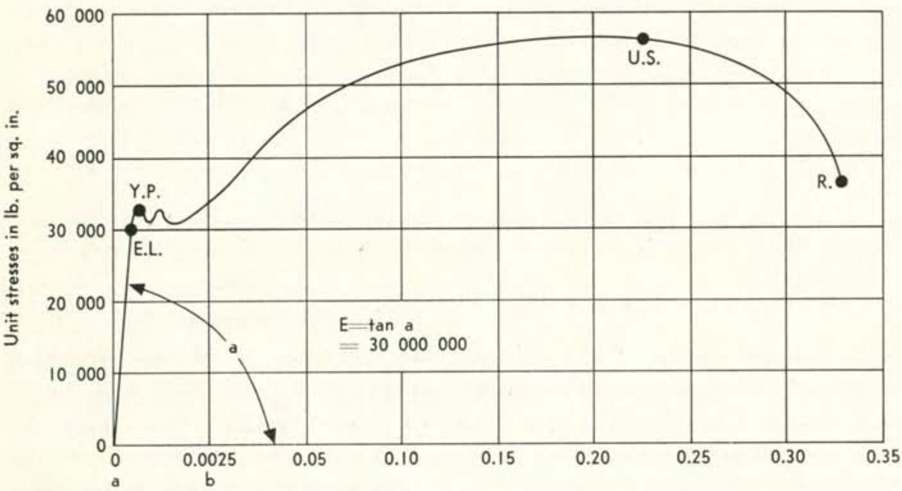
(3) The Yield-Point (Y.P.), slightly above or beyond the elastic limit, is that unit stress at which the specimen begins to stretch without increase in the load. This stress may be determined from a test without the use of delicate measuring-apparatus by the drop of the beam of lever-type testing-machines or halt in the gage of hydraulic-type testing machines.

(4) The Ultimate Strength (U.S.) is the greatest unit stress the specimen can sustain. (Total load divided by the original area.)

(5) The Rupture-Stress (R) is the unit stress at the time of failure. This is the unit stress at the point of failure after the area of the cross-section of the specimen

has been reduced; and because of the rapid dropping off of the load it is difficult to determine. It is not regularly observed in testing, attention being called to it merely to emphasize the fact that the ultimate strength of steel is not the stress at the time of failure of the specimen.

STRESS-STRAIN DIAGRAM OF TEST ON STEEL SPECIMENS



UNIT ELONGATION

The horizontal scale for the distance a b is ten times greater than for the remaining distance.

The working stress for structural steel in tension in buildings and bridges is 18,000 lb. per sq. in. in most specifications and building laws. For members subject to constant load some designers use working stresses up to 24,000 lb. per sq. in.

EFFECTS OF ALLOYING ELEMENTS ON STEEL

ALUMINUM has been used as an alloy in steels to promote nitriding but its major use in steel making is as a deoxidizer. It may be used alone, as in low carbon steels where exceptional drawability is desired, or more commonly in conjunction with other deoxidizers. It effectively restricts grain growth and its use as a deoxidizer to control grain size is widely practiced in the steel industry.

VANADIUM is a mild deoxidizer and its addition to steel results in fine grain structure which is maintained at high temperature. It has very strong carbide forming tendencies and very effectively promotes strength at high temperatures. Vanadium steels have improved fatigue values and excellent response to heat treatment. In unhardened steels it is particularly beneficial in strengthening the metal.

CHROMIUM contributes to the heat treatment of steel by increasing its strength and hardness. Its carbides are very stable and chromium may be added to high carbon steels subject to prolonged anneals to prevent graphitization. Chromium increases resistance to corrosion and abrasion and chromium steels maintain strength at elevated temperatures.

MOLYBDENUM has a pronounced effect in promoting hardenability. It raises the coarsening temperature of steel, increases the high temperature strength, improves the resistance to creep and enhances the corrosion resistance of stainless steels.

NICKEL is soluble in iron and, in combination with other elements, improves the hardenability of steel and toughness after tempering. It is especially effective in strengthening unhardened steels and improving impact strength at low temperatures. It is used in conjunction with chromium in stainless steels.

SULPHUR is added to steel to increase machinability. Because of its tendency to segregate it may decrease the ductility of low carbon drawing steel. Its detrimental effect in hot rolling is offset by manganese.

PHOSPHORUS strengthens steel but reduces its ductility. It improves the machinability of high sulphur steels and under some conditions may confer some increase in corrosion resistance.

SILICON is one of the principal steel deoxidizers and is commonly added to steel for this purpose although in amounts up to about 2.5% it increases the hardenability of steels. Specified coarse grain steels are silicon killed. In lower carbon electrical steels, silicon is used to promote the crystal structure desired in annealed sheets.

IRON is the principal element and makes up the body of steel. In commercial production iron always contains varying quantities of other elements. Production of pure iron is accomplished with difficulty and generally in small quantities. Iron does not have great strength, is soft, ductile and can be appreciably hardened only by cold work.

CARBON, although not generally considered an alloying element, is by far the most important element in steel. As carbon is added to steel up to about .90 per cent its response to heat treatment and its depth of hardening increases. In the "as rolled" condition, increasing the carbon content increases the hardness, strength and abrasion resistance of steel but its ductility, toughness, impact properties and machinability decrease.

MANGANESE makes it possible to roll hot steel by its chemical interaction with sulphur and oxygen. It is next in importance to carbon as an alloying element. It has a strengthening effect upon iron and also a beneficial effect upon steel by increasing its response to heat treatment. It increases the machinability of free machining steels but tends to decrease the ductility of low carbon drawing steels.

TITANIUM is an extremely effective carbide former and is used in stainless steels to stabilize the steel by holding carbon in combination. Titanium is used for special single coat enameling steels. In low alloy structural steels its use in combination with other alloys promotes fine grain structure and improves the strength of the steel in the "as rolled" condition.

APPROXIMATE PHYSICAL PROPERTIES

Commercial Iron, Rolled Steel and Cast Iron

Name	Approximate Per Cent Carbon	Physical Properties				Brinell Hardness
		Specific Gravity	Weight per Cu. Ft.	Melting Point Deg. Fahr.	Average Coefficient of Expansion per Deg. Fahr. 70° to 600° F.	
Iron	0.03	7.86	491	2790	.0000072	60
Soft Steel	0.10	7.85	490	2780	.0000074	120
Medium Steel	0.25	7.85	490	2765	.0000072	150
Hard Steel	0.40	7.84	489	2740	.0000067	180
Tool Steel	0.90	7.82	488	2700	.0000064	260
Gray Cast Iron	3.50	7.20	446	2000±	.0000059	150

APPROXIMATE MECHANICAL PROPERTIES

Commercial Iron, Rolled Steel and Cast Iron

Name	Approximate Per Cent Carbon	Mechanical Properties				Brinell Hardness
		Ultimate Strength Lb. per Sq. In.	Yield Strength Lb. per Sq. In.	Elongation in 2 In. Per Cent	Modulus of Elasticity Lb. per Sq. In.	
Iron	0.03	44000	27500	46	29,500,000	60
Soft Steel	0.10	50000	30000	35	29,100,000	120
Medium Steel	0.25	60000	36000	30	28,900,000	150
Hard Steel	0.40	80000	50000	25	28,600,000	180
Tool Steel	0.90	130000	75000	8	28,000,000	260
Gray Cast Iron	3.50	22000	17000	..	13,000,000	150

PROPERTIES OF STEELS AT LOW TEMPERATURES

The lowering of the temperature of steels below room temperature is generally accompanied by an increase in the tensile strength and yield point and a lesser decrease in elongation and reduction of area as measured in a tension test bar. The property which is affected most by lowering temperature is the resistance to shock.

TENSION TEST PROPERTIES—There is a large amount of data available on tension test results on various compositions at low temperatures. Selected results are given below covering carbon steels and alloy steels.

TENSILE STRENGTH OF STEELS AT LOW TEMPERATURES

CARBON STEELS

Authority	Material	Treatment °F.	Test Temp., °F.	Tensile Strength, psi	Yield Point, psi	Elong., % in 2 In.	Red. Area, %	Brinell
Colbeck MacGillivray Manning	Iron C 0.035%	As rec'd.	Room —4 —58 —94 —148 —184 —292	45,700 53,750 59,400 61,700 66,800 77,000 112,000	.... 30,700 42,200 43,400 57,200 66,700	27.9 42.0 43.0 37.5 26.5 17.0 Nil	73.2 75.0 74.0 72.0 70.0 68.0 Nil	.. ..
Colbeck, etc.	C 0.13%	As rec'd.	Room —85 —292	66,300 80,700 121,300	54,700 67,700	29.7 33.6 26.5	71.8 70.3 55.0	.. .. ..
Hadfield	Carbon steel C 0.14%, Mn 0.07%	Annealed 1472	Room —296 —423	45,700 137,000 155,000	42,700 155,000	27.5 7.5 0.3	77.5 ...... 2.5	114 281 326
Sands	C 0.21%	As rec'd.	Room —114	62,600 69,000	39,800 47,780	35.5 35.5	53.0 56.8	.. ..
Bull	Carbon forging C 0.26%, Mn 0.46%		Room —114	57,300 72,840	38,940 50,325	34.0 36.0	54.7 53.2	.. ..
Hadfield	Carbon steel C 0.37%, Mn 0.20%	Annealed 1472	Room —296 —423	76,200 148,000 151,000	 151,000	20.0 17.0 Nil	63.0 39.0 Nil	157 294 316
Strauss	C 0.40%	Annealed	Room Liq. air	79,400 139,400	45,800 114,100	30.8 7.3	49.0 7.1	.. ..

TENSILE STRENGTH OF STEELS AT LOW TEMPERATURES

CARBON STEELS

Authority	Material	Treatment °F.	Test Temp., °F.	Tensile Strength, psi	Yield Point, psi	Elong., % in 2 In.	Red. Area, %	Brinell
Strauss	C 0.40%	Treated	Room Liq. air	104,400 160,400	76,900 150,000	25.0 9.8	61.3 9.4	.. ..
Bull	Carbon forging C 0.40%, Mn 0.52%		Room —114	77,440 83,310	44,670 47,075	29.0 30.8	45.3 44.9	.. ..
Hadfield	Carbon steel C 0.78%, Mn 0.10%	Annealed 1472	Room —296 —423	99,000 154,700 123,000	95,000 123,000	12.0 Nil 0.2	35.0 ...... Nil	194 325 244

SOME ALLOY STEELS

Authority	Material	Treatment °F.	Test Temp., °F.	Tensile Strength, psi	Yield Point, psi	Elong., % in 2 In.	Red. Area, %	Brinell
Colbeck etc.	C 0.33% Cr 0.67% Ni 2.45% Mo 0.64%	1560 1185 oil tempered	Room —6 —76 —90 —141 —292	152,000 154,500 164,000 163,000 170,000 201,500	137,700 141,000 143,300 145,500 149,000 183,500	14.0 15.6 14.0 15.6 16.4 17.0	65.0 64.0 63.0 62.0 61.0 63.0	.. ..
Hadfield	C 0.35% Cr 0.71% Ni 3.34%	Oil quench, 1200 tempered	Room —423	146,000 243,000	133,000 243,000	13.5 4.5	59.5 48.5	.. ..
Nickel Steel Topics	C 1.27% Mn 12.69%		Room —296 —426	148,000 137,000 146,000	77,800 146,000	44.5 2.5 Nil	39.0 ...... Nil	.. .. ..
Colbeck, etc.	C 0.06% Cr 13.45% Ni 10.05% Mn 4.07%	Water quenched 2010	Room —292	80,400 197,500	38,500 89,500	59.5 47.0	75.5 60.0	.. ..
Nickel Steel Topics	C 0.56% Ni 24.6%		Room —112	120,500 160,000	....	20.4 14.1	....	.. ..
Russell	Ni 26%	Annealed	Room Liq. air	99,800 205,000	52,900 157,800	38.3 11.5	52.1 9.7	.. ..
Russell	C 0.56% Ni 24.6% Mn 1.18%		—64 —112	120,500 160,000	71,200 105,000	20.4 14.1	67.4 64.0	.. ..

EXPANSION OF STEEL BY HEAT

The coefficient of linear expansion is the change in length, per unit of length, for a change of one degree of temperature. The coefficient of surface expansion is approximately two times the linear coefficient, and the coefficient of volume expansion for solids, is approximately three times the linear coefficient.

The change in length of a bar as the result of a change in temperature can be expressed as etl, where e is the coefficient of linear expansion, t the change in temperature, and l the length of the bar.

The following table gives the coefficient of linear expansion for 1° F. of temperature change.

Example: A bar of hard steel is 30′ long at 50° F. Find the length at 110° F. assuming the ends are free to move.

Change of length $= etl = .0000067 \times 60 \times 30 = .01206$

The length at 110° F. = 30.01206.

Approximate Coefficients of Expansion Per 1 Degree Fahrenheit Temperature Change

Name	Approximate Per Cent Carbon	Coefficients
Iron	0.03	.0000072
Soft Steel	0.10	.0000074
Medium Steel	0.25	.0000072
Hard Steel	0.40	.0000067
Tool Steel	0.90	.0000064
Gray Cast Iron	3.50	.0000059

EFFECT OF HEAT ON STRUCTURAL STEEL

Structural carbon steel such as A.S.T.M. A-7 increases in strength with a rise in temperature until, at approximately 550° F., it is about 25% stronger than at normal temperatures. At 800° F. its strength is approximately the same as at normal temperatures. At temperatures above 800° F., however, its strength falls off rapidly.

JUDGING TEMPERATURE BY COLOR

The following temper colors appear on the surface of steel when heated to the corresponding temperatures.

°F	°C	Temper Color
380-400	200	Pale yellow
420-440	220	Straw yellow
460-480	240	Yellowish brown
500-540	270	Bluish purple
540-560	285	Violet
560-580	300	Pale blue
600-640	325	Blue
		Visible Color
1000	540	Black
1100	590	Faint dark red
1200	650	Cherry red (dark)
1300	700	Cherry red (med.)
1400	760	Red
1500	815	Light red
1600	870	Reddish orange
1700	930	Orange
1800	980	Changes
1900	1040	to
2000	1090	Pale orange lemon
2100	1150	Lemon
2200	1205	Light lemon
2300	1260	Yellow
2400	1315	Light yellow
2500	1370	Yellowish gray: "white"

NOTE: The colors are for medium daylight. "Color temperatures" are useful as a rough guide though with practice surprising accuracy can be secured as long as the conditions are held constant.

STANDARD CLASSIFICATION OF FLAT ROLLED STEEL PRODUCTS

Hot Rolled

Widths, Inches	THICKNESSES, INCHES								
	0.2300 and Thicker	0.2299 to 0.2031	0.2030 to 0.1800	0.1799 to 0.0568	0.0567 to 0.0449	0.0448 to 0.0344	0.0343 to 0.0255	0.0254 to 0.0142	0.0141 and Thinner
To $3\frac{1}{2}$	Bar	Bar	Strip	Strip	Strip	Strip	Strip	Sheet*	Sheet*
Over $3\frac{1}{2}$ to 6 incl.	Bar	Bar	Strip	Strip	Strip	Strip	Sheet*	Sheet*	Sheet*
Over 6 to 12 incl.	Plate	Strip	Strip	Strip	Sheet	Sheet*	Sheet*	Sheet*	Sheet*
Over 12 to 32 incl.	Plate	Sheet	Sheet	Sheet	Sheet	Sheet*	Sheet*	Sheet*	
Over 32 to 48 incl.	Plate	Sheet	Sheet	Sheet	Sheet	Sheet*	Sheet*	Sheet*	Sheet*
Over 48	Plate	Plate	Plate	Sheet	Sheet	Sheet*	Sheet*	Sheet*	Sheet*

*Hot rolled annealed.

Cold Rolled

Width, Inches	THICKNESSES, INCHES		
	0.2500 and Thicker	0.2499 to 0.0142	0.0141 and Thinner
Over $\frac{1}{2}$ to 12 incl.	Bar	Strip	Strip
Over 12 to 24 incl.	Strip (1)	Strip (1)	Strip (1)
Over 12 to 24 incl.	Sheet (2)	Sheet (2)	Black Plate (2)
Over 24 to 32 incl.	Sheet	Sheet	Tin Mill Black Plate
Over 32	Sheet	Sheet	Sheet

(1) When a particular temper or a special edge or finish is specified.
(2) When no special temper, edge or finish is specified.

HARDNESS TESTS

BRINELL METHOD

The standard Brinell method consists in using calibrated equipment to apply a specified load to the surface of the material to be tested through a hard ball of specified diameter, and to measure the diameter of the resulting permanent impression. The Brinell hardness number is the value obtained by dividing the applied load in kilograms by the surface area of the impression in square millimeters calculated from the measured diameter of the rim of the impression. It is assumed that the impression is an imprint of the undeformed ball. The Brinell hardness number is calculated from the following formula:

$$\text{B.H.N.} = \frac{P}{\pi \frac{D}{2}\left(D - \sqrt{D^2 - d^2}\right)}$$

where:

B.H.N. = Brinell hardness number in kilograms per square millimeter,

P = applied load in kilograms,

D = diameter of the ball in millimeters, and

d = diameter of the impression in millimeters.

A standard ball 10 mm. in diameter with applied loads of 3000 kg., 1500 kg., or 500 kg. is used for Brinell hardness testing.

In the table is given the Brinell hardness number corresponding to various diameters of impression for 500, 1500, and 3000-kg. loads, making it unnecessary to calculate for each test the value of the Brinell hardness number by the above formula.

BRINELL HARDNESS NUMBERS

Steel Ball, 10 mm. in Diameter, Pressure of 500, 1500, and 3000 kg.

Diameter of Indentation, mm.	Brinell Hardness Number			Diameter of Indentation, mm.	Brinell Hardness Number			Diameter of Indentation, mm.	Brinell Hardness Number		
	500-kg. Load	1500-kg. Load	3000-kg. Load		500-kg. Load	1500-kg. Load	3000-kg. Load		500-kg. Load	1500-kg. Load	3000-kg. Load
2.00	158	473	945	3.65	46.1	138	277	5.35	20.5	61.5	123
2.05	150	450	899	3.70	44.9	135	269	5.40	20.1	60.3	121
2.10	143	428	856	3.75	43.6	131	262	5.45	19.7	59.1	118
2.15	136	408	817	3.80	42.4	127	255	5.50	19.3	57.9	116
2.20	130	390	780	3.85	41.3	124	248	5.55	18.9	56.8	114
2.25	124	372	745	3.90	40.2	121	241	5.60	18.6	55.7	111
2.30	119	356	712	3.95	39.1	117	235	5.65	18.2	54.6	109
2.35	114	341	682	4.00	38.1	114	229	5.70	17.8	53.5	107
2.40	109	327	653	4.05	37.1	111	223	5.75	17.5	52.5	105
2.45	104	313	627	4.10	36.2	109	217	5.80	17.2	51.5	103
2.50	100	301	601	4.15	35.3	106	212	5.85	16.8	50.5	101
2.55	96.3	289	578	4.20	34.4	103	207	5.90	16.5	49.6	99.2
2.60	92.6	278	555	4.25	33.6	101	201	5.95	16.2	48.7	97.3
2.65	89.0	267	534	4.30	32.8	98.3	197	6.00	15.9	47.7	95.5
2.70	85.7	257	514	4.35	32.0	95.9	192	6.05	15.6	46.8	93.7
2.75	82.6	248	495	4.40	31.2	93.6	187	6.10	15.3	46.0	92.0
2.80	79.6	239	477	4.45	30.5	91.4	183	6.15	15.1	45.2	90.3
2.85	76.8	230	461	4.50	29.8	89.3	179	6.20	14.8	44.3	88.7
2.90	74.1	222	444	4.55	29.1	87.2	174	6.25	14.5	43.5	87.1
2.95	71.5	215	429	4.60	28.4	85.2	170	6.30	14.2	42.7	85.5
3.00	69.1	207	415	4.65	27.8	83.3	167	6.35	14.0	42.0	84.0
3.05	66.8	200	401	4.70	27.1	81.4	163	6.40	13.7	41.2	82.5
3.10	64.6	194	388	4.75	26.5	79.6	159	6.45	13.5	40.5	81.0
3.15	62.5	188	375	4.80	25.9	77.8	156	6.50	13.3	39.8	79.6
3.20	60.5	182	363	4.85	25.4	76.1	152	6.55	13.0	39.1	78.2
3.25	58.6	176	352	4.90	24.8	74.4	149	6.60	12.8	38.4	76.8
3.30	56.8	170	341	4.95	24.3	72.8	146	6.65	12.6	37.7	75.4
3.35	55.1	165	331	5.00	23.8	71.3	143	6.70	12.4	37.1	74.1
3.40	53.4	160	321	5.05	23.3	69.8	140	6.75	12.1	36.4	72.8
3.45	51.8	156	311	5.10	22.8	68.3	137	6.80	11.9	35.8	71.6
3.50	50.3	151	302	5.15	22.3	66.9	134	6.85	11.7	35.2	70.4
3.55	48.9	147	293	5.20	21.8	65.5	131	6.90	11.5	34.6	69.2
3.60	47.5	142	285	5.25	21.4	64.1	128	6.95	11.3	34.0	68.0
				5.30	20.9	62.8	126				

ROCKWELL METHOD

The Rockwell hardness tester is essentially a machine that measures hardness by determining the depth of penetration of a penetrator into the specimen under certain arbitrarily fixed conditions of test. The penetrator may be either a steel ball or a diamond sphero-conical penetrator. The hardness value, as read from the dial, is an arbitrary number which is related to the depth of indentation caused by two superimposed impressions, and since the scales are reversed, the number is higher the harder the material. A minor load of 10 kg. is first applied which causes an initial penetration which sets the penetrator on the material and holds it in position. The dial is set at zero on the black-figure scale, and the major load is applied. This major load is the total load applied and the depth measurement depends solely on the increase in depth due to increase from minor to major load. This major load is customarily 60 kg. or 100 kg. when a steel ball is used as a penetrator, but other loads may be used when found necessary, and usually 150 kg. when a diamond sphero-conical penetrator is employed. The ball penetrator is $\frac{1}{16}$ in. in diameter normally but other penetrators of larger diameter such as $\frac{1}{8}$ or $\frac{1}{4}$ in. may be employed for soft metals. A variety of loads and penetrators are thus provided and experience decides the best combination for use.

After the major load is applied and removed, according to standard procedure, the reading is taken while the minor load is still in position.

ROCKWELL HARDNESS SCALES

Scale Symbol	Penetrator	Major Load, kg.	Dial Figures
Group One			
B	$\frac{1}{16}$ in. ball	100	Red
C	"Brale"	150	Black
Group Two			
A	"Brale"	60	Black
D	"Brale"	100	Black
E	$\frac{1}{8}$ in. ball	100	Red
F	$\frac{1}{16}$ in. ball	60	Red
G	$\frac{1}{16}$ in. ball	150	Red
H	$\frac{1}{8}$ in. ball	60	Red
K	$\frac{1}{8}$ in. ball	150	Red
Group Three			
L	$\frac{1}{4}$ in. ball	60	Red
M	$\frac{1}{4}$ in. ball	100	Red
P	$\frac{1}{4}$ in. ball	150	Red
R	$\frac{1}{2}$ in. ball	60	Red
S	$\frac{1}{2}$ in. ball	100	Red
V	$\frac{1}{2}$ in. ball	150	Red

Rockwell hardness values are determined and reported according to one of the standard scales specified. In all cases the minor load is 10 kg. and the dial is adjusted after applying the minor load so that the pointer reads at "Set" (B 30).

The Rockwell hardness scales shown are offered as standard scales and designations and are intended for the convenience of the user. These scales overlap at their extremities. Therefore, it is considered good practice to use a scale that gives readings in the mid range.

In order to cover the entire range of hardness found in various metallic materials, it has been found useful to use the combinations of penetrators and loads indicated which are all available with the Rockwell hardness tester. There is no Rockwell hardness value designated by a figure alone because it is necessary to indicate which penetrator and load has been employed in making the test.

SHORE'S SCLEROSCOPE

The scleroscope is an instrument which measures the hardness of the work in terms of elasticity. A diamond-tipped hammer is allowed to drop from a known height on the metal to be tested. As this hammer strikes the metal, it rebounds, and the harder the metal, the greater the rebound. The extreme height of the rebound is recorded, and an average of a number of readings taken on a single piece will give a good indication of the hardness of the work. The surface smoothness of the work affects the reading of the instrument. The readings are also affected by the contour and mass of the work and the depth of the case, in carburized work, the soft core of light-depth carburizing, pack-hardening, or cyanide hardening, absorbing the force of the hammer fall and decreasing the rebound. The hammer weighs about 40 grains, the height of the rebound of hardened steel is in the neighborhood of 100 on the scale, or about $6\frac{1}{4}$ inches, while the total fall is about 10 inches or 255 millimeters.

VICKERS HARDNESS TEST

The Vickers test is similar in principle to the Brinell test. The standard Vickers penetrator is a square-based diamond pyramid having an included point angle of 136 degrees. The numerical value of the hardness number equals the applied load in kilograms divided by the area of the pyramidal impression. A smooth, firmly supported, flat surface is required. The load, which usually is applied for 30 seconds, may either be 5, 10, 20, 30, 50 or 120 kilograms. The 50-kilogram load is usually employed. The hardness number is based upon the diagonal length of the square impression. The Vickers test, which is considered very accurate, may, with proper load regulation, be applied to thin sheets as well as to larger sections.

The diamond pyramid hardness is determined as follows:

$$\text{D.P.H.} = \frac{2L \sin \frac{a}{2}}{d^2}$$

D.P.H. = diamond pyramid hardness,
d = length of average diagonal in millimeters,
a = apex angle = 136 deg., and
L = load in kilograms.

HARDNESS CONVERSION TABLE

Approximate Relations Between Brinell, Rockwell, Shore and Vickers Hardnesses and the Tensile Strengths of Carbon and Alloy Steels.

Brinell		Vickers Diamond Pyramid Hardness No.	Rockwell		Shore Scleroscope No.	Tensile Strength 1000 psi
Dia. in mm., 3000 kg. Load 10 mm. Ball	Hardness No.		C 150 kg. Load Brale Penetrator	B 100 kg. Load 1/16″ Diamond Ball		
2.25	745	840	65.3	...	91	...
2.30	712	...	...	...	...	...
2.35	682	737	61.7	...	84	...
2.40	653	697	60.0	...	81	...
2.45	627	667	58.7	...	79	323
2.50	601	640	57.3	...	77	309
2.55	578	615	56.0	...	75	297
2.60	555	591	54.7	...	73	285
2.65	534	569	53.5	...	71	274
2.70	514	547	52.1	...	70	263
2.75	495	528	51.0	...	68	253
2.80	477	508	49.6	...	66	243
2.85	461	491	48.5	...	65	235
2.90	444	472	47.1	...	63	225
2.95	429	455	45.7	...	61	217
3.00	415	440	44.5	...	59	210
3.05	401	425	43.1	...	58	202
3.10	388	410	41.8	...	56	195
3.15	375	396	40.4	...	54	188
3.20	363	383	39.1	...	52	182
3.25	352	372	37.9	(110.0)	51	176
3.30	341	360	36.6	(109.0)	50	170
3.35	331	350	35.5	(108.5)	48	166
3.40	321	339	34.3	(108.0)	47	160
3.45	311	328	33.1	(107.5)	46	155
3.50	302	319	32.1	(107.0)	45	150
3.55	293	309	30.9	(106.0)	43	145
3.60	285	301	29.9	(105.5)	...	141
3.65	277	292	28.8	(104.5)	41	137
3.70	269	284	27.6	(104.0)	40	133
3.75	262	276	26.6	(103.0)	39	129
3.80	255	269	25.4	(102.0)	38	126
3.85	248	261	24.2	(101.0)	37	122
3.90	241	253	22.8	100.0	36	118
3.95	235	247	21.7	99.0	35	115
4.00	229	241	20.5	98.2	34	111
4.05	223	234	(18.8)	97.3	...	...
4.10	217	228	(17.5)	96.4	33	105
4.15	212	222	(16.0)	95.5	...	102
4.20	207	218	(15.2)	94.6	32	100

HARDNESS CONVERSION TABLE

(Continued)

Brinell		Vickers Diamond Pyramid Hardness No.	Rockwell		Shore Scleroscope No.	Tensile Strength 1000 psi
Dia. in mm. 3000 kg. Load 10 mm. Ball	Hardness No.		C 150 kg. Load Brale Penetrator	B 100 kg. Load 1/16" Diamond Ball		
4.25	202	212	(13.8)	93.8	31	98
4.30	197	207	(12.7)	92.8	30	95
4.35	192	202	(11.5)	91.9	29	93
4.40	187	196	(10.0)	90.7	...	90
4.45	183	192	(9.0)	90.0	28	89
4.50	179	188	(8.0)	89.0	27	87
4.55	174	182	(6.4)	87.8	...	85
4.60	170	178	(5.4)	86.8	26	83
4.65	166	175	(4.4)	86.0	...	81
4.70	163	171	(3.3)	85.0	25	79
4.80	156	163	(0.9)	82.9	...	76
4.90	149	156	...	80.8	23	73
5.00	143	150	...	78.7	22	71
5.10	137	143	...	76.4	21	67
5.20	131	137	...	74.0	...	65
5.30	126	132	...	72.0	20	63
5.40	121	127	...	69.8	19	60
5.50	116	122	...	67.6	18	58
5.60	112	117	...	65.7	15	56

Values in ( ) are beyond normal range and are given for information only.

WEIGHT OF RECTANGULAR SECTIONS

POUNDS PER LINEAR FOOT

Width Inches	THICKNESS, INCHES						
	3/16	1/4	5/16	3/8	7/16	1/2	9/16
1/4	.16	.21	.27	.32	.37	.43	.48
1/2	.32	.43	.53	.64	.74	.85	.96
3/4	.48	.64	.80	.96	1.12	1.28	1.43
1	.64	.85	1.06	1.28	1.49	1.70	1.91
1 1/4	.80	1.06	1.33	1.59	1.86	2.13	2.39
1 1/2	.96	1.28	1.59	1.91	2.23	2.55	2.87
1 3/4	1.12	1.49	1.86	2.23	2.60	2.98	3.35
2	1.28	1.70	2.13	2.55	2.98	3.40	3.83
2 1/4	1.43	1.91	2.39	2.87	3.35	3.83	4.30
2 1/2	1.59	2.13	2.66	3.19	3.72	4.25	4.78
2 3/4	1.75	2.34	2.92	3.51	4.09	4.68	5.26
3	1.91	2.55	3.19	3.83	4.46	5.10	5.74
3 1/4	2.07	2.76	3.45	4.14	4.83	5.53	6.22
3 1/2	2.23	2.98	3.72	4.46	5.21	5.95	6.69
3 3/4	2.39	3.19	3.98	4.78	5.58	6.38	7.17
4	2.55	3.40	4.25	5.10	5.95	6.80	7.65
4 1/4	2.71	3.61	4.52	5.42	6.32	7.23	8.13
4 1/2	2.87	3.83	4.78	5.74	6.69	7.65	8.61
4 3/4	3.03	4.04	5.05	6.06	7.07	8.08	9.08
5	3.19	4.25	5.31	6.38	7.44	8.50	9.56
5 1/4	3.35	4.46	5.58	6.69	7.81	8.93	10.0
5 1/2	3.51	4.68	5.84	7.01	8.18	9.35	10.5
5 3/4	3.67	4.89	6.11	7.33	8.55	9.78	11.0
6	3.83	5.10	6.38	7.65	8.93	10.2	11.5
6 1/4	3.98	5.31	6.64	7.97	9.30	10.6	12.0
6 1/2	4.14	5.53	6.91	8.29	9.67	11.1	12.4
6 3/4	4.30	5.74	7.17	8.61	10.0	11.5	12.9
7	4.46	5.95	7.44	8.93	10.4	11.9	13.4
7 1/4	4.62	6.16	7.70	9.24	10.8	12.3	13.9
7 1/2	4.78	6.38	7.97	9.56	11.2	12.8	14.3
7 3/4	4.94	6.59	8.23	9.88	11.5	13.2	14.8
8	5.10	6.80	8.50	10.2	11.9	13.6	15.3
8 1/4	5.26	7.01	8.77	10.5	12.3	14.0	15.8
8 1/2	5.42	7.23	9.03	10.8	12.6	14.5	16.3
8 3/4	5.58	7.44	9.30	11.2	13.0	14.9	16.7
9	5.74	7.65	9.56	11.5	13.4	15.3	17.2

WEIGHT OF RECTANGULAR SECTIONS

POUNDS PER LINEAR FOOT

Width Inches	THICKNESS, INCHES						
	5/8	11/16	3/4	13/16	7/8	15/16	1
1/4	.53	.58	.64	.69	.74	.80	.85
1/2	1.06	1.17	1.28	1.38	1.49	1.59	1.70
3/4	1.59	1.75	1.91	2.07	2.23	2.39	2.55
1	2.13	2.34	2.55	2.76	2.98	3.19	3.40
1 1/4	2.66	2.92	3.19	3.45	3.72	3.98	4.25
1 1/2	3.19	3.51	3.83	4.14	4.46	4.78	5.10
1 3/4	3.72	4.09	4.46	4.83	5.21	5.58	5.95
2	4.25	4.68	5.10	5.53	5.95	6.38	6.80
2 1/4	4.78	5.26	5.74	6.22	6.69	7.17	7.65
2 1/2	5.31	5.84	6.38	6.91	7.44	7.97	8.50
2 3/4	5.84	6.43	7.01	7.60	8.18	8.77	9.35
3	6.38	7.01	7.65	8.29	8.93	9.56	10.2
3 1/4	6.91	7.60	8.29	8.98	9.67	10.4	11.1
3 1/2	7.44	8.18	8.93	9.67	10.4	11.2	11.9
3 3/4	7.97	8.77	9.56	10.4	11.2	12.0	12.8
4	8.50	9.35	10.2	11.1	11.9	12.8	13.6
4 1/4	9.03	9.93	10.8	11.7	12.6	13.6	14.5
4 1/2	9.56	10.5	11.5	12.4	13.4	14.3	15.3
4 3/4	10.1	11.1	12.1	13.1	14.1	15.1	16.2
5	10.6	11.7	12.8	13.8	14.9	15.9	17.0
5 1/4	11.2	12.3	13.4	14.5	15.6	16.7	17.9
5 1/2	11.7	12.9	14.0	15.2	16.4	17.5	18.7
5 3/4	12.2	13.4	14.7	15.9	17.1	18.3	19.6
6	12.8	14.0	15.3	16.6	17.9	19.1	20.4
6 1/4	13.3	14.6	15.9	17.3	18.6	19.9	21.3
6 1/2	13.8	15.2	16.6	18.0	19.3	20.7	22.1
6 3/4	14.3	15.8	17.2	18.7	20.1	21.5	23.0
7	14.9	16.4	17.9	19.3	20.8	22.3	23.8
7 1/4	15.4	17.0	18.5	20.0	21.6	23.1	24.7
7 1/2	15.9	17.5	19.1	20.7	22.3	23.9	25.5
7 3/4	16.5	18.1	19.8	21.4	23.1	24.7	26.4
8	17.0	18.7	20.4	22.1	23.8	25.5	27.2
8 1/4	17.5	19.3	21.0	22.8	24.5	26.3	28.1
8 1/2	18.1	19.9	21.7	23.5	25.3	27.1	28.9
8 3/4	18.6	20.5	22.3	24.2	26.0	27.9	29.8
9	19.1	21.0	23.0	24.9	26.8	28.7	30.6

WEIGHT OF RECTANGULAR SECTIONS

POUNDS PER LINEAR FOOT

Width Inches	THICKNESS, INCHES						
	3/16	1/4	5/16	3/8	7/16	1/2	9/16
9 1/4	5.90	7.86	9.83	11.8	13.8	15.7	17.7
9 1/2	6.06	8.08	10.1	12.1	14.1	16.2	18.2
9 3/4	6.22	8.29	10.4	12.4	14.5	16.6	18.7
10	6.38	8.50	10.6	12.8	14.9	17.0	19.1
10 1/4	6.53	8.71	10.9	13.1	15.3	17.4	19.6
10 1/2	6.69	8.93	11.2	13.4	15.6	17.9	20.1
10 3/4	6.85	9.14	11.4	13.7	16.0	18.3	20.6
11	7.01	9.35	11.7	14.0	16.4	18.7	21.0
11 1/4	7.17	9.56	12.0	14.3	16.7	19.1	21.5
11 1/2	7.33	9.78	12.2	14.7	17.1	19.6	22.0
11 3/4	7.49	9.99	12.5	15.0	17.5	20.0	22.5
12	7.65	10.2	12.8	15.3	17.9	20.4	23.0
12 1/2	7.97	10.6	13.3	15.9	18.6	21.3	23.9
13	8.29	11.1	13.8	16.6	19.3	22.1	24.9
13 1/2	8.61	11.5	14.3	17.2	20.1	23.0	25.8
14	8.93	11.9	14.9	17.9	20.8	23.8	26.8
14 1/2	9.24	12.3	15.4	18.5	21.6	24.7	27.7
15	9.56	12.8	15.9	19.1	22.3	25.5	28.7
15 1/2	9.88	13.2	16.5	19.8	23.1	26.4	29.6
16	10.2	13.6	17.0	20.4	23.8	27.2	30.6
16 1/2	10.5	14.0	17.5	21.0	24.5	28.1	31.6
17	10.8	14.5	18.1	21.7	25.3	28.9	32.5
17 1/2	11.2	14.9	18.6	22.3	26.0	29.8	33.5
18	11.5	15.3	19.1	23.0	26.8	30.6	34.4
18 1/2	11.8	15.7	19.7	23.6	27.5	31.5	35.4
19	12.1	16.2	20.2	24.2	28.3	32.3	36.3
19 1/2	12.4	16.6	20.7	24.9	29.0	33.2	37.3
20	12.8	17.0	21.3	25.5	29.8	34.0	38.3
20 1/2	13.1	17.4	21.8	26.1	30.5	34.9	39.2
21	13.4	17.9	22.3	26.8	31.2	35.7	40.2
21 1/2	13.7	18.3	22.8	27.4	32.0	36.6	41.1
22	14.0	18.7	23.4	28.1	32.7	37.4	42.1
22 1/2	14.3	19.1	23.9	28.7	33.5	38.3	43.0
23	14.7	19.6	24.4	29.3	34.2	39.1	44.0
23 1/2	15.0	20.0	25.0	30.0	35.0	40.0	44.9
24	15.3	20.4	25.5	30.6	35.7	40.8	45.9

WEIGHT OF RECTANGULAR SECTIONS

POUNDS PER LINEAR FOOT

Width Inches	THICKNESS, INCHES						
	5/8	11/16	3/4	13/16	7/8	15/16	1
9 1/4	19.7	21.6	23.6	25.6	27.5	29.5	31.5
9 1/2	20.2	22.2	24.2	26.2	28.3	30.3	32.3
9 3/4	20.7	22.8	24.9	26.9	29.0	31.1	33.2
10	21.3	23.4	25.5	27.6	29.8	31.9	34.0
10 1/4	21.8	24.0	26.1	28.3	30.5	32.7	34.9
10 1/2	22.3	24.5	26.8	29.0	31.2	33.5	35.7
10 3/4	22.8	25.1	27.4	29.7	32.0	34.3	36.6
11	23.4	25.7	28.1	30.4	32.7	35.1	37.4
11 1/4	23.9	26.3	28.7	31.1	33.5	35.9	38.3
11 1/2	24.4	26.9	29.3	31.8	34.2	36.7	39.1
11 3/4	25.0	27.5	30.0	32.5	35.0	37.5	40.0
12	25.5	28.1	30.6	33.2	35.7	38.3	40.8
12 1/2	26.6	29.2	31.9	34.5	37.2	39.8	42.5
13	27.6	30.4	33.2	35.9	38.7	41.4	44.2
13 1/2	28.7	31.6	34.4	37.3	40.2	43.0	45.9
14	29.8	32.7	35.7	38.7	41.7	44.6	47.6
14 1/2	30.8	33.9	37.0	40.1	43.1	46.2	49.3
15	31.9	35.1	38.3	41.4	44.6	47.8	51.0
15 1/2	32.9	36.2	39.5	42.8	46.1	49.4	52.7
16	34.0	37.4	40.8	44.2	47.6	51.0	54.4
16 1/2	35.1	38.6	42.1	45.6	49.1	52.6	56.1
17	36.1	39.7	43.4	47.0	50.6	54.2	57.8
17 1/2	37.2	40.9	44.6	48.3	52.1	55.8	59.5
18	38.3	42.1	45.9	49.7	53.6	57.4	61.2
18 1/2	39.3	43.2	47.2	51.1	55.0	59.0	62.9
19	40.4	44.4	48.5	52.5	56.5	60.6	64.6
19 1/2	41.4	45.6	49.7	53.9	58.0	62.2	66.3
20	42.5	46.8	51.0	55.3	59.5	63.8	68.0
20 1/2	43.6	47.9	52.3	56.6	61.0	65.3	69.7
21	44.6	49.1	53.6	58.0	62.5	66.9	71.4
21 1/2	45.7	50.3	54.8	59.4	64.0	68.5	73.1
22	46.8	51.4	56.1	60.8	65.5	70.1	74.8
22 1/2	47.8	52.6	57.4	62.2	66.9	71.7	76.5
23	48.9	53.8	58.7	63.5	68.4	73.3	78.2
23 1/2	49.9	54.9	59.9	64.9	69.9	74.9	79.9
24	51.0	56.1	61.2	66.3	71.4	76.5	81.6

WEIGHT OF RECTANGULAR SECTIONS

POUNDS PER LINEAR FOOT

Width Inches	THICKNESS, INCHES						
	3/16	1/4	5/16	3/8	7/16	1/2	9/16
25	15.9	21.3	26.6	31.9	37.2	42.5	47.8
26	16.6	22.1	27.6	33.2	38.7	44.2	49.7
27	17.2	23.0	28.7	34.4	40.2	45.9	51.6
28	17.9	23.8	29.8	35.7	41.7	47.6	53.6
29	18.5	24.7	30.8	37.0	43.1	49.3	55.5
30	19.1	25.5	31.9	38.3	44.6	51.0	57.4
31	19.8	26.4	32.9	39.5	46.1	52.7	59.3
32	20.4	27.2	34.0	40.8	47.6	54.4	61.2
33	21.0	28.1	35.1	42.1	49.1	56.1	63.1
34	21.7	28.9	36.1	43.4	50.6	57.8	65.0
35	22.3	29.8	37.2	44.6	52.1	59.5	66.9
36	23.0	30.6	38.3	45.9	53.6	61.2	68.9
37	23.6	31.5	39.3	47.2	55.0	62.9	70.8
38	24.2	32.3	40.4	48.5	56.5	64.6	72.7
39	24.9	33.2	41.4	49.7	58.0	66.3	74.6
40	25.5	34.0	42.5	51.0	59.5	68.0	76.5
41	26.1	34.9	43.6	52.3	61.0	69.7	78.4
42	26.8	35.7	44.6	53.6	62.5	71.4	80.3
43	27.4	36.6	45.7	54.8	64.0	73.1	82.2
44	28.1	37.4	46.8	56.1	65.5	74.8	84.2
45	28.7	38.3	47.8	57.4	66.9	76.5	86.1
46	29.3	39.1	48.9	58.7	68.4	78.2	88.0
47	30.0	40.0	49.9	59.9	69.9	79.9	89.9
48	30.6	40.8	51.0	61.2	71.4	81.6	91.8
49	31.2	41.7	52.1	62.5	72.9	83.3	93.7
50	31.9	42.5	53.1	63.8	74.4	85.0	95.6
51	32.5	43.4	54.2	65.0	75.9	86.7	97.5
52	33.2	44.2	55.3	66.3	77.4	88.4	99.5
53	33.8	45.1	56.3	67.6	78.8	90.1	101
54	34.4	45.9	57.4	68.9	80.3	91.8	103
55	35.1	46.8	58.4	70.1	81.8	93.5	105
56	35.7	47.6	59.5	71.4	83.3	95.2	107
57	36.3	48.5	60.6	72.7	84.8	96.9	109
58	37.0	49.3	61.6	74.0	86.3	98.6	111
59	37.6	50.2	62.7	75.2	87.8	100	113
60	38.3	51.0	63.8	76.5	89.3	102	115

WEIGHT OF RECTANGULAR SECTIONS

POUNDS PER LINEAR FOOT

Width Inches	THICKNESS, INCHES						
	5/8	11/16	3/4	13/16	7/8	15/16	1
25	53.1	58.4	63.8	69.1	74.4	79.7	85.0
26	55.3	60.8	66.3	71.8	77.4	82.9	88.4
27	57.4	63.1	68.9	74.6	80.3	86.1	91.8
28	59.5	65.5	71.4	77.4	83.3	89.3	95.2
29	61.6	67.8	74.0	80.1	86.3	92.4	98.6
30	63.8	70.1	76.5	82.9	89.3	95.6	102
31	65.9	72.5	79.1	85.6	92.2	98.8	105
32	68.0	74.8	81.6	88.4	95.2	102	109
33	70.1	77.1	84.2	91.2	98.2	105	112
34	72.3	79.5	86.7	93.9	101	108	116
35	74.4	81.8	89.3	96.1	104	112	119
36	76.5	84.2	91.8	99.5	107	115	122
37	78.6	86.5	94.4	102	110	118	126
38	80.8	88.8	96.9	105	113	121	129
39	82.9	91.2	99.5	108	116	124	133
40	85.0	93.5	102	111	119	128	136
41	87.1	95.8	105	113	122	131	139
42	89.3	98.2	107	116	125	134	143
43	91.4	101	110	119	128	137	146
44	93.5	103	112	122	131	140	150
45	95.6	105	115	124	134	143	153
46	97.8	108	117	127	137	147	156
47	99.9	110	120	130	140	150	160
48	102	112	122	133	143	153	163
49	104	115	125	135	146	156	167
50	106	117	128	138	149	159	170
51	108	119	130	141	152	163	173
52	111	122	133	144	155	166	177
53	113	124	135	146	158	169	180
54	115	126	138	149	161	172	184
55	117	129	140	152	164	175	187
56	119	131	143	155	167	179	190
57	121	133	145	158	170	182	194
58	123	136	148	160	173	185	197
59	125	138	151	163	176	188	201
60	128	140	153	166	179	191	204

WEIGHT OF RECTANGULAR SECTIONS

POUNDS PER LINEAR FOOT

Width Inches	THICKNESS, INCHES						
	3/16	1/4	5/16	3/8	7/16	1/2	9/16
61	38.9	51.9	64.8	77.8	90.7	104	117
62	39.5	52.7	65.9	79.1	92.2	105	119
63	40.2	53.6	66.9	80.3	93.7	107	121
64	40.8	54.4	68.0	81.6	95.2	109	122
65	41.4	55.3	69.1	82.9	96.7	111	124
66	42.1	56.1	70.1	84.2	98.2	112	126
67	42.7	57.0	71.2	85.4	99.7	114	128
68	43.4	57.8	72.3	86.7	101	116	130
69	44.0	58.7	73.3	88.0	103	117	132
70	44.6	59.5	74.4	89.3	104	119	134
71	45.3	60.4	75.4	90.5	106	121	136
72	45.9	61.2	76.5	91.8	107	122	138
73	46.5	62.1	77.6	93.1	109	124	140
74	47.2	62.9	78.6	94.4	110	126	142
75	47.8	63.8	79.7	95.6	112	128	143
76	48.5	64.6	80.8	96.9	113	129	145
77	49.1	65.5	81.8	98.2	115	131	147
78	49.7	66.3	82.9	99.5	116	133	149
79	50.4	67.2	83.9	101	118	134	151
80	51.0	68.0	85.0	102	119	136	153
81	51.6	68.9	86.1	103	121	138	155
82	52.3	69.7	87.1	105	122	139	157
83	52.9	70.6	88.2	106	124	141	159
84	53.6	71.4	89.3	107	125	143	161
85	54.2	72.3	90.3	108	126	145	163
86	54.8	73.1	91.4	110	128	146	165
87	55.5	74.0	92.4	111	129	148	166
88	56.1	74.8	93.5	112	131	150	168
89	56.7	75.7	94.6	114	132	151	170
90	57.4	76.5	95.6	115	134	153	172
91	....	77.4	96.7	116	135	155	174
92	....	78.2	97.8	117	137	156	176
93	....	79.1	98.8	119	138	158	178
94	....	79.9	99.9	120	140	160	180
95	....	80.8	101	121	141	162	182
96	....	81.6	102	122	143	163	184

WEIGHT OF RECTANGULAR SECTIONS

POUNDS PER LINEAR FOOT

Width Inches	THICKNESS, INCHES						
	5/8	11/16	3/4	13/16	7/8	15/16	1
61	130	143	156	169	182	194	207
62	132	145	158	171	185	198	211
63	134	147	161	174	187	201	214
64	136	150	163	177	190	204	218
65	138	152	166	180	193	207	221
66	140	154	168	182	196	210	224
67	142	157	171	185	199	214	228
68	145	159	173	188	202	217	231
69	147	161	176	191	205	220	235
70	149	164	179	193	208	223	238
71	151	166	181	196	211	226	241
72	153	168	184	199	214	230	245
73	155	171	186	202	217	233	248
74	157	173	189	204	220	236	252
75	159	175	191	207	223	239	255
76	162	178	194	210	226	242	258
77	164	180	196	213	229	245	262
78	166	182	199	216	232	249	265
79	168	185	202	218	235	252	269
80	170	187	204	221	238	255	272
81	172	189	207	224	241	258	275
82	174	192	209	227	244	261	279
83	176	194	212	229	247	265	282
84	179	196	214	232	250	268	286
85	181	199	217	235	253	271	289
86	183	201	219	238	256	274	292
87	185	203	222	240	259	277	296
88	187	206	224	243	262	281	299
89	189	208	227	246	265	284	303
90	191	210	230	249	268	287	306
91	193	213	232	251	271	290	309
92	196	215	235	254	274	293	313
93	198	217	237	257	277	296	316
94	200	220	240	260	280	300	320
95	202	222	242	262	283	303	323
96	204	224	245	265	286	306	326

WEIGHT OF RECTANGULAR SECTIONS

POUNDS PER LINEAR FOOT

Width Inches	THICKNESS, INCHES						
	3/16	1/4	5/16	3/8	7/16	1/2	9/16
98	....	83.3	104	125	146	167	187
100	....	85.0	106	128	149	170	191
102	....	86.7	108	130	152	173	195
104	....	88.4	111	133	155	177	199
106	....	90.1	113	135	158	180	203
108	....	91.8	115	138	161	184	207
110	....	93.5	117	140	164	187	210
112	....	95.2	119	143	167	190	214
114	....	96.9	121	145	170	194	218
116	....	98.6	123	148	173	197	222
118	....	100	125	151	176	201	226
120	....	102	128	153	179	204	230
122	....	104	130	156	182	207	233
124	....	105	132	158	185	211	237
126	....	107	134	161	187	214	241
128	....	109	136	163	190	218	245

WEIGHT OF RECTANGULAR SECTIONS

POUNDS PER LINEAR FOOT

Width Inches	THICKNESS, INCHES						
	5/8	11/16	3/4	13/16	7/8	15/16	1
98	208	229	250	271	292	312	333
100	213	234	255	276	298	319	340
102	217	238	260	282	304	325	347
104	221	243	265	287	309	332	354
106	225	248	270	293	315	338	360
108	230	253	275	298	321	344	367
110	234	257	281	304	327	351	374
112	238	262	286	309	333	357	381
114	242	267	291	315	339	363	388
116	247	271	296	321	345	370	394
118	251	276	301	326	351	376	401
120	255	281	306	332	357	383	408
122	259	285	311	337	363	389	415
124	264	290	316	343	369	395	422
126	268	295	321	348	375	402	428
128	272	299	326	354	381	408	435

EXPLANATION OF SHEET METAL GAGES

The thicknesses of sheet metals and the diameters of wires are produced to various systems of gages. These gages are indicated by numbers and the accompanying tables give the decimal thickness or diameter equivalents of the different gage numbers. Much confusion has resulted from the use of gage numbers in ordering materials and for that reason the engineers will generally give the exact dimensions in decimal fractions of an inch.

Some of the important gages in use in the United States are—

- The United States Standard Gage for Sheet and Plate Iron and Steel
- The Manufacturers' Standard Gage for Steel Sheets
- The American Wire Gage (Brown & Sharpe Wire Gage) for Copper, Aluminum, Brass, and other non-ferrous alloys
- The Birmingham Wire Gage (Stubs Iron Wire Gage)
- The Birmingham Standard Sheet and Hoop Gage used in England and Canada
- British Imperial Standard Wire Gage

Variations of these gages are used for galvanized sheets, tin plates, stainless sheets, etc.

UNITED STATES STANDARD GAGE FOR SHEET AND PLATE IRON AND STEEL

In 1893, Congress passed an Act establishing a standard gage for sheet and plate iron and steel, this Act being for the purpose of securing uniformity, particularly in connection with determining import duties levied by the government on sheets and plates. The basis of each gage number is the weight per square foot in ounces; consequently, the U. S. Standard Gage is a weight gage. This gage system designates that a section of iron or steel one foot square and one inch thick should weigh 640 ounces. On this basis, each U. S. Gage Number represents a certain number of ounces in weight and a corresponding multiple of 640ths of an inch in approximate thickness. Approximate thicknesses are derived from the weights per square foot, based on the weight of wrought iron, which is two per cent lighter than steel. Therefore, these approximate thicknesses in the U. S. Standard Gage Table are not correct for steel. In that table, the density of wrought iron is taken at 480 pounds per cubic foot.

MANUFACTURERS' STANDARD GAGE FOR STEEL SHEETS

Due to the inconsistencies encountered in the U. S. Standard Gage Table in converting from weight to thickness, steel producers have adopted a gage table, known as the Manufacturers' Standard Gage for Steel Sheets, having a definite thickness equivalent for each gage number. In that standard gage, the density of steel is taken as 489.6 pounds per cubic foot, 0.2833 pounds per cubic inch, or 40.80 pounds per square foot per inch thick. However, since sheet weights are calculated on the basis of the specified width and length, with all shearing tolerances on the over side, and also since sheets are somewhat thicker at the center than they are at the edges, a further adjustment must be made in order to obtain a closer approximation for interchangeability between weight and thickness. Over a long period of time, this value for sheets has been found to be close to 2.5 per cent heavier than 40.80 pounds per square foot per inch thick, or 41.820 pounds per square foot per inch thick. This figure of 41.820 pounds per square foot per inch thick is the one commonly used to express the relationship between weight and thickness.

AMERICAN WIRE GAGE

The American Wire Gage, A.W.G. (B. & S. Gage), specifies thicknesses without regard to weight. It is fundamentally a wire gage.

BIRMINGHAM WIRE GAGE

This gage is used in the United States in designating the size of iron or steel wire, and for strip steel, steel bands, etc., and for sheet copper. It is used to a limited extent in Great Britain. It is a thickness gage, and the equivalent weights per square foot of the thickness are arrived at by multiplying the thicknesses by 41.82.

BIRMINGHAM STANDARD SHEET AND HOOP GAGE

This gage was legalized in Great Britain in 1914 and is used mainly for iron and steel sheets and hoops. It differs from the older Birmingham or Stubs iron wire gage.

BRITISH IMPERIAL STANDARD WIRE GAGE

This gage is used in England for aluminum and other non-ferrous sheets.

GALVANIZED SHEETS

Galvanized sheets are produced to weights per unit of area of coated sheet. The Galvanized Sheet Gage, established by custom, is based on the United States Standard Gage, the weight corresponding to each Galvanized Sheet Gage Number being 2.5 oz. per square foot heavier than the weight corresponding to the same United States Standard Gage Number, regardless of coating weights.

Since galvanized sheets are produced to weight rather than thickness, it is impossible to give the exact decimal thicknesses for the various gage numbers, because different methods of galvanizing will give different densities of coating, therefore different thicknesses.

WIRE AND SHEET METAL GAGES

In Decimals of an Inch

Name of Gage	United States Standard Gage U. S. Std.		Manufacturer's Std. Gage	Birmingham (or Stubs Iron) Wire Gage B.W.G.	New Birmingham Standard Sheet and Hoop Gage B.G.	American or Browne & Sharpe Wire Gage B. & S.	British Imperial or English Legal Standard Wire Gage S.W.G.
Principal Use	Uncoated Steel Sheets and Light Plates		Steel Sheets	Strips, Bands, Hoops and Wire	Iron and Steel Sheets and Hoops	Non-Ferrous Sheets and Wire	Wire
Gage No.	Weight (lbs. sq. ft.)	Thickness (inches)	Thickness or Diameter (inches)	(inches)	(inches)	(inches)	(inches)
7/0s	20.00	0.4902	....	....	0.6666	....	0.500
6/0s	18.75	0.4596	....	....	0.6250	0.580000	0.464
5/0s	17.50	0.4289	....	0.500	0.5883	0.516500	0.432
4/0s	16.25	0.3983	....	0.454	0.5416	0.460000	0.400
3/0s	15.00	0.3676	....	0.425	0.5000	0.409642	0.372
2/0s	13.75	0.3370	....	0.380	0.4452	0.364796	0.348
1/0	12.50	0.3064	....	0.340	0.3964	0.324861	0.324
1	11.25	0.2757	....	0.300	0.3532	0.289297	0.300
2	10.625	0.2604	....	0.284	0.3147	0.257627	0.276
3	10.00	0.2451	0.2391	0.259	0.2804	0.229423	0.252
4	9.375	0.2298	0.2242	0.238	0.2500	0.204307	0.232
5	8.750	0.2145	0.2092	0.220	0.2225	0.181940	0.212
6	8.125	0.1991	0.1943	0.203	0.1981	0.162023	0.192
7	7.500	0.1838	0.1793	0.180	0.1764	0.144285	0.176
8	6.875	0.1685	0.1644	0.165	0.1570	0.128490	0.160
9	6.250	0.1532	0.1495	0.148	0.1398	0.114423	0.144
10	5.625	0.1379	0.1345	0.134	0.1250	0.101897	0.128
11	5.000	0.1225	0.1196	0.120	0.1113	0.090742	0.116
12	4.375	0.1072	0.1046	0.109	0.0991	0.080808	0.104
13	3.750	0.0919	0.0897	0.095	0.0882	0.071962	0.092
14	3.125	0.0766	0.0747	0.083	0.0785	0.064084	0.080
15	2.8125	0.0689	0.0673	0.072	0.0699	0.057068	0.072
16	2.500	0.0613	0.0598	0.065	0.0625	0.050821	0.064
17	2.250	0.0551	0.0538	0.058	0.0556	0.045257	0.056

WIRE AND SHEET METAL GAGES

In Decimals of an Inch

Name of Gage	United States Standard Gage U. S. Std.		Manufacturer's Std. Gage	Birmingham (or Stubs Iron) Wire Gage B.W.G.	New Birmingham Standard Sheet and Hoop Gage B.G.	American or Browne & Sharpe Wire Gage B. & S.	British Imperial or English Legal Standard Wire Gage S.W.G.
Principal Use	Uncoated Steel Sheets and Light Plates		Steel Sheets	Strips, Bands, Hoops and Wire	Iron and Steel Sheets and Hoops	Non-Ferrous Sheets and Wire	Wire
Gage No.	Weight (lbs. sq. ft.)	Thickness (inches)	Thickness or Diameter (inches)	(inches)	(inches)	(inches)	(inches)
18	2.000	0.0490	0.0478	0.049	0.0495	0.040303	0.048
19	1.750	0.0429	0.0418	0.042	0.0440	0.035890	0.040
20	1.500	0.0368	0.0359	0.035	0.0392	0.031961	0.036
21	1.375	0.0337	0.0329	0.032	0.0349	0.028462	0.032
22	1.250	0.0306	0.0299	0.028	0.03125	0.025346	0.028
23	1.125	0.0276	0.0269	0.025	0.02782	0.022572	0.024
24	1.000	0.0245	0.0239	0.022	0.02476	0.020101	0.022
25	0.875	0.0214	0.0209	0.020	0.02204	0.017900	0.020
26	0.750	0.0184	0.0179	0.018	0.01961	0.015941	0.018
27	0.6875	0.0169	0.0164	0.016	0.01745	0.014195	0.0164
28	0.625	0.0153	0.0149	0.014	0.015625	0.012641	0.0148
29	0.5625	0.0138	0.0135	0.013	0.0139	0.011257	0.0136
30	0.5000	0.0123	0.0120	0.012	0.0123	0.010025	0.0124
31	0.4375	0.0107	0.0105	0.010	0.0110	0.008928	0.0116
32	0.4062	0.0100	0.0097	0.009	0.0098	0.007950	0.0108
33	0.3750	0.0092	0.0090	0.008	0.0087	0.007080	0.0100
34	0.3438	0.0084	0.0082	0.007	0.0077	0.006305	0.0092
35	0.3125	0.0077	0.0075	0.005	0.0069	0.005615	0.0084
36	0.2812	0.0069	0.0067	0.004	0.0061	0.005000	0.0076
37	0.2656	0.0065	0.0064	....	0.0054	0.004453	0.0068
38	0.2500	0.0061	0.0060	....	0.0048	0.003965	0.0060
39	0.2344	0.0057	....	....	0.0043	0.003531	0.0052
40	0.2188	0.0054	....	....	0.00386	0.003144	0.0048

MANUFACTURERS' STANDARD GAGE FOR STEEL SHEETS

Thickness equivalents are based on 0.0014945 in. per oz. per sq. ft.; 0.023912 in. per lb. per sq. ft. (reciprocal of 41.820 lb. per sq. ft. per in. thick); 3.443329 in. per lb. per sq. in.

Manufacturers' Standard Gage No.	Ounces per Square Foot	Pounds per Square Inch	Pounds per Square Foot	Inch Equivalent for Steel Sheet Thickness	Manufacturers' Standard Gage No.
3	160	0.069444	10.0000	0.2391	3
4	150	.065104	9.3750	.2242	4
5	140	.060764	8.7500	.2092	5
6	130	.056424	8.1250	.1943	6
7	120	.052083	7.5000	.1793	7
8	110	.047743	6.8750	.1644	8
9	100	.043403	6.2500	.1495	9
10	90	.039062	5.6250	.1345	10
11	80	.034722	5.0000	.1196	11
12	70	.030382	4.3750	.1046	12
13	60	.026042	3.7500	.0897	13
14	50	.021701	3.1250	.0747	14
15	45	.019531	2.8125	.0673	15
16	40	.017361	2.5000	.0598	16
17	36	.015625	2.2500	.0538	17
18	32	.013889	2.0000	.0478	18
19	28	.012153	1.7500	.0418	19
20	24	.010417	1.5000	.0359	20
21	22	.0095486	1.3750	.0329	21
22	20	.0086806	1.2500	.0299	22
23	18	.0078125	1.1250	.0269	23
24	16	.0069444	1.0000	.0239	24
25	14	.0060764	0.87500	.0209	25
26	12	.0052083	.75000	.0179	26
27	11	.0047743	.68750	.0164	27
28	10	.0043403	.62500	.0149	28
29	9	.0039062	.56250	.0135	29
30	8	.0034722	.50000	.0120	30
31	7	.0030382	.43750	.0105	31
32	6.5	.0028212	.40625	.0097	32
33	6	.0026042	.37500	.0090	33
34	5.5	.0023872	.34375	.0082	34
35	5	.0021701	.31250	.0075	35
36	4.5	.0019531	.28125	.0067	36
37	4.25	.0018446	.26562	.0064	37
38	4	.0017361	.25000	.0060	38

THICKNESS AND WEIGHT EQUIVALENTS FOR STEEL SHEETS

Weight equivalents are based on 41.820 lb. per sq. ft. per inch thick; 0.2904167 lb. per sq. in. per inch thick.

Thickness Inches	WEIGHT		Thickness Inches	WEIGHT	
	Lb. per Sq. In.	Lb. per Sq. Ft.		Lb. per Sq. In.	Lb. per Sq. Ft.
0.2490	0.072314	10.413	0.2080	0.060407	8.6986
.2480	.072023	10.371	.2070	.060116	8.6567
.2470	.071733	10.330	.2060	.059826	8.6149
			.2050	.059535	8.5731
.2460	.071443	10.288	.2040	.059245	8.5313
.2450	.071152	10.246	.2030	.058955	8.4895
.2440	.070862	10.204	.2020	.058664	8.4476
.2430	.070571	10.162			
.2420	.070281	10.120	.2010	.058374	8.4058
.2410	.069990	10.079	.2000	.058083	8.3640
.2400	.069700	10.037	.1990	.057793	8.3222
.2390	.069410	9.9950	.1980	.057503	8.2804
.2380	.069119	9.9532	.1970	.057212	8.2385
.2370	.068829	9.9113	.1960	.056922	8.1967
.2360	.068538	9.8695	.1950	.056631	8.1549
.2350	.068248	9.8277	.1940	.056341	8.1131
.2340	.067958	9.7859	.1930	.056050	8.0713
.2330	.067667	9.7441	.1920	.055760	8.0294
.2320	.067377	9.7022	.1910	.055470	7.9876
			.1900	.055179	7.9458
.2310	.067086	9.6604	.1890	.054889	7.9040
.2300	.066796	9.6186	.1880	.054598	7.8622
.2290	.066505	9.5768	.1870	.054308	7.8203
.2280	.066215	9.5350			
.2270	.065925	9.4931	.1860	.054018	7.7785
.2260	.065634	9.4513	.1850	.053727	7.7367
.2250	.065344	9.4095	.1840	.053437	7.6949
.2240	.065053	9.3677	.1830	.053146	7.6531
.2230	.064763	9.3259	.1820	.052856	7.6112
.2220	.064473	9.2840	.1810	.052565	7.5694
.2210	.064182	9.2422	.1800	.052275	7.5276
.2200	.063892	9.2004	.1790	.051985	7.4858
.2190	.063601	9.1586	.1780	.051694	7.4440
.2180	.063311	9.1168	.1770	.051404	7.4021
.2170	.063020	9.0749	.1760	.051113	7.3603
			.1750	.050823	7.3185
.2160	.062730	9.0331	.1740	.050533	7.2767
.2150	.062440	8.9913	.1730	.050242	7.2349
.2140	.062149	8.9495	.1720	.049952	7.1930
.2130	.061859	8.9077			
.2120	.061568	8.8658	.1710	.049661	7.1512
.2110	.061278	8.8240	.1700	.049371	7.1094
.2100	.060988	8.7822	.1690	.049080	7.0676
.2090	.060697	8.7404	.1680	.048790	7.0258

THICKNESS AND WEIGHT EQUIVALENTS FOR STEEL SHEETS

Thickness Inches	WEIGHT		Thickness Inches	WEIGHT	
	Lb. per Sq. In.	Lb. per Sq. Ft.		Lb. per Sq. In.	Lb. per Sq. Ft.
0.1670	0.048500	6.9839	0.1250	0.036302	5.2275
.1660	.048209	6.9421	.1240	.036012	5.1857
.1650	.047919	6.9003	.1230	.035721	5.1439
.1640	.047628	6.8585			
.1630	.047338	6.8167	.1220	.035431	5.1020
.1620	.047048	6.7748	.1210	.035140	5.0602
.1610	.046757	6.7330	.1200	.034850	5.0184
.1600	.046467	6.6912	.1190	.034560	4.9766
.1590	.046176	6.6494	.1180	.034269	4.9348
.1580	.045886	6.6076	.1170	.033979	4.8929
.1570	.045595	6.5657	.1160	.033688	4.8511
.1560	.045305	6.5239	.1150	.033398	4.8093
.1550	.045015	6.4821	.1140	.033108	4.7675
.1540	.044724	6.4403	.1130	.032817	4.7257
.1530	.044434	6.3985	.1120	.032527	4.6838
			.1110	.032236	4.6420
.1520	.044143	6.3566	.1100	.031946	4.6002
.1510	.043853	6.3148	.1090	.031655	4.5584
.1500	.043563	6.2730	.1080	.031365	4.5166
.1490	.043272	6.2312			
.1480	.042982	6.1894	.1070	.031075	4.4747
.1470	.042691	6.1475	.1060	.030784	4.4329
.1460	.042401	6.1057	.1050	.030494	4.3911
.1450	.042110	6.0639	.1040	.030203	4.3493
.1440	.041820	6.0221	.1030	.029913	4.3075
.1430	.041530	5.9803	.1020	.029623	4.2656
.1420	.041239	5.9384	.1010	.029332	4.2238
.1410	.040949	5.8966	.1000	.029042	4.1820
.1400	.040658	5.8548	.0990	.028751	4.1402
.1390	.040368	5.8130	.0980	.028461	4.0984
.1380	.040078	5.7712	.0970	.028170	4.0565
			.0960	.027880	4.0147
.1370	.039787	5.7293	.0950	.027590	3.9729
.1360	.039497	5.6875	.0940	.027299	3.9311
.1350	.039206	5.6457	.0930	.027009	3.8893
.1340	.038916	5.6039			
.1330	.038625	5.5621	.0920	.026718	3.8474
.1320	.038335	5.5202	.0910	.026428	3.8056
.1310	.038045	5.4784	.0900	.026138	3.7638
.1300	.037754	5.4366	.0890	.025847	3.7220
.1290	.037464	5.3948	.0880	.025557	3.6802
.1280	.037173	5.3530	.0870	.025266	3.6383
.1270	.036883	5.3111	.0860	.024976	3.5965
.1260	.036593	5.2693	.0850	.024685	3.5547

THICKNESS AND WEIGHT EQUIVALENTS FOR STEEL SHEETS

Thickness Inches	WEIGHT Lb. per Sq. In.	WEIGHT Lb. per Sq. Ft.
0.0840	0.024395	3.5129
.0830	.024105	3.4711
.0820	.023814	3.4292
.0810	.023524	3.3874
.0800	.023233	3.3456
.0790	.022943	3.3038
.0780	.022653	3.2620
.0770	.022362	3.2201
.0760	.022072	3.1783
.0750	.021781	3.1365
.0740	.021491	3.0947
.0730	.021200	3.0529
.0720	.020910	3.0110
.0710	.020620	2.9692
.0700	.020329	2.9274
.0690	.020039	2.8856
.0680	.019748	2.8438
.0670	.019458	2.8019
.0660	.019168	2.7601
.0650	.018877	2.7183
.0640	.018587	2.6765
.0630	.018296	2.6347
.0620	.018006	2.5928
.0610	.017715	2.5510
.0600	.017425	2.5092
.0590	.017135	2.4674
.0580	.016844	2.4256
.0570	.016554	2.3837
.0560	.016263	2.3419
.0550	.015973	2.3001
.0540	.015683	2.2583
.0530	.015392	2.2165
.0520	.015102	2.1746
.0510	.014811	2.1328
.0500	.014521	2.0910
.0490	.014230	2.0492
.0480	.013940	2.0074
.0470	.013650	1.9655
.0460	.013359	1.9237
.0450	.013069	1.8819
.0440	.012778	1.8401
0.0430	0.012488	1.7983
.0420	.012198	1.7564
.0410	.011907	1.7146
.0400	.011617	1.6728
.0395	.011471	1.6519
.0390	.011326	1.6310
.0385	.011181	1.6101
.0380	.011036	1.5892
.0375	.010891	1.5682
.0370	.010745	1.5473
.0365	.010600	1.5264
.0360	.010455	1.5055
.0355	.010310	1.4846
.0350	.010165	1.4637
.0345	.010019	1.4428
.0340	.0098742	1.4219
.0335	.0097290	1.4010
.0330	.0095838	1.3801
.0325	.0094385	1.3592
.0320	.0092933	1.3382
.0315	.0091481	1.3173
.0310	.0090029	1.2964
.0305	.0088577	1.2755
.0300	.0087125	1.2546
.0295	.0085673	1.2337
.0290	.0084221	1.2128
.0285	.0082769	1.1919
.0280	.0081317	1.1710
.0275	.0079865	1.1500
.0270	.0078413	1.1291
.0265	.0076960	1.1082
.0260	.0075508	1.0873
.0255	.0074056	1.0664
.0250	.0072604	1.0455

To determine the weight equivalent of any thinner sheet, multiply its thickness by ten; find this amount in the table; then divide its corresponding weight by ten.

WEIGHT AND THICKNESS RANGES FOR THE RESPECTIVE GAGES FOR STEEL SHEETS

Manufacturers' Standard Gage No.	Pounds per Square Foot	Thickness Inch
3	10.312–9.688	0.2465–.2317
4	9.687–9.063	.2316–.2168
5	9.062–8.438	.2167–.2018
6	8.437–7.813	.2017–.1869
7	7.812–7.188	.1868–.1719
8	7.187–6.563	.1718–.1570
9	6.562–5.938	.1569–.1420
10	5.937–5.313	.1419–.1271
11	5.312–4.688	.1270–.1121
12	4.687–4.063	.1120–.0972
13	4.062–3.438	.0971–.0822
14	3.437–2.969	.0821–.0710
15	2.968–2.657	.0709–.0636
16	2.656–2.375	.0635–.0568
17	2.374–2.125	.0567–.0509
18	2.124–1.875	.0508–.0449
19	1.874–1.625	.0448–.0389
20	1.624–1.438	.0388–.0344
21	1.437–1.313	.0343–.0314
22	1.312–1.188	.0313–.0284
23	1.187–1.063	.0283–.0255
24	1.062–0.938	.0254–.0225
25	.937– .813	.0224–.0195
26	.812– .719	.0194–.0172
27	.718– .657	.0171–.0157
28	.656– .594	.0156–.0142
29	.593– .532	.0141–.0128
30	.531– .469	.0127–.0113
31	.468– .422	.0112–.0101
32	.421– .391	.0100–.0094
33	.390– .360	.0093–.0086
34	.359– .329	.0085–.0079
35	.328– .297	.0078–.0071
36	.296– .274	.0070–.0066
37	.273– .258	.0065–.0062
38	.257– .243	.0061–.0058

The foregoing table shows the upper and lower limits for unit weight and thickness for each number of the Manufacturers' Standard Gage table. These ranges should not be used as tolerances.

Sheets specified to a Manufacturers' Standard Gage number are produced to the inch equivalent for that gage number. Sheets specified to unit weight are produced to the corresponding thickness.

ELEMENTS OF STRUCTURAL SECTIONS

In the computation of the values of structural shapes for the various conditions under which they are subjected to stress, certain mathematical expressions are used.

NEUTRAL AXIS. The line, in the cross section of a beam or column in a state of flexure, on which there is neither tension nor compression; the neutral axis passes through the center of gravity of the section when unit stresses do not exceed the elastic limit of the material. In the usual position of structural sections there are two neutral axes, perpendicular to each other, their normal distance from extreme fiber of the section being designated by x and y.

MOMENT OF INERTIA—I. The sum of the products obtained by multiplying each of the elementary areas of which the section is composed, by the square of its normal distance from a neutral axis of the section or from any axis of moments assumed for purposes of calculation.

SECTION MODULUS—S. The moment of inertia divided by the normal distance from the axis to which it refers to extreme fiber of the section. For the two moments of inertia, corresponding to the two principal axes of a section, there are also two section moduli.

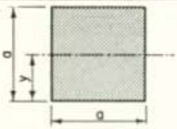
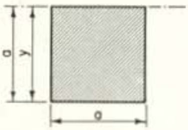
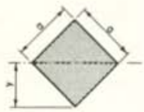
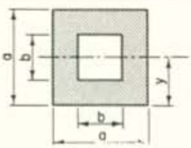
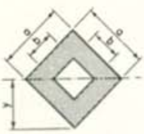
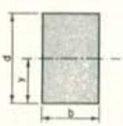
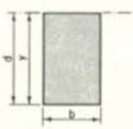
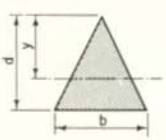
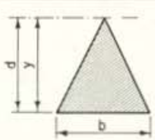
The section modulus is used to determine the stress in the extreme fiber of a section, subjected to bending stresses, by dividing the bending moment by the section modulus referred to neutral axis normal to line of force, both values being expressed in like units of measure; the section modulus of a section, is obtained by dividing the bending stress by the allowable fiber stress, both values also in like units of measure.

RADIUS OF GYRATION—r. The normal distance from a neutral axis to the center of gyration, the point where the entire area is considered to be concentrated and have the same moment of inertia as the actual area. The radius of gyration of a section referred to a neutral axis, or any axis of moments, is equal to the square root of (moment of inertia, referred to that axis, divided by the area).

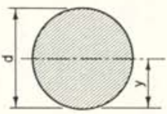
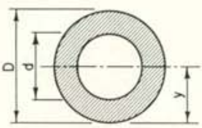
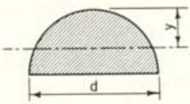
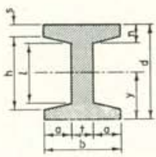
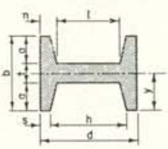
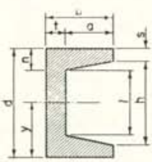
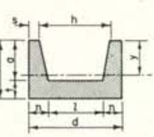
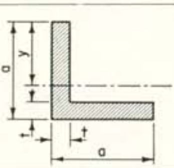
The radius of gyration of a section is used to ascertain the safe load this section will sustain when used in compression, as a strut or column. The unbraced length of the section divided by the least radius of gyration is called the Ratio of Slenderness.

ENGINEERING PROPERTIES OF SECTIONS

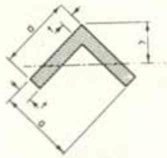
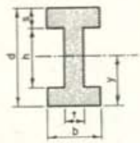
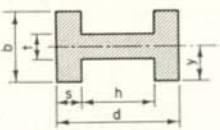
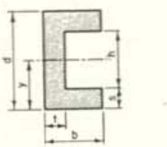
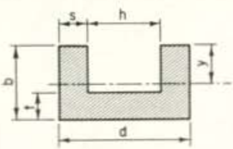
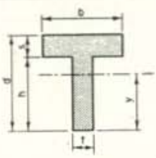
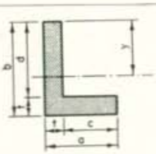
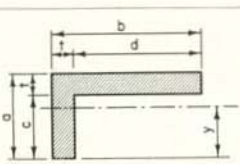
The engineering properties of different cross sections frequently encountered in using steel in structural designs are shown on the following pages.

Section	Area of Section, A	Distance from Neutral Axis to Extreme Fiber, y
	a^2	$\frac{1}{2}a$
	a^2	a
	a^2	$\frac{a}{\sqrt{2}} = 0.707\,a$
	$a^2 - b^2$	$\frac{1}{2}a$
	$a^2 - b^2$	$\frac{a}{\sqrt{2}} = 0.707\,a$
	bd	$\frac{1}{2}d$
	bd	d
	$\frac{1}{2}bd$	$\frac{2}{3}d$
	$\frac{1}{2}bd$	d

Moment of Inertia I	Section Modulus $Z = \frac{I}{y}$	Radius of Gyration $r = \sqrt{\frac{I}{A}}$
$\frac{a^4}{12}$	$\frac{a^3}{6}$	$\frac{a}{\sqrt{12}} = 0.289\,a$
$\frac{a^4}{3}$	$\frac{a^3}{3}$	$\frac{a}{\sqrt{3}} = 0.577\,a$
$\frac{a^4}{12}$	$\frac{a^3}{6\sqrt{2}} = 0.118\,a^3$	$\frac{a}{\sqrt{12}} = 0.289\,a$
$\frac{a^4 - b^4}{12}$	$\frac{a^4 - b^4}{6\,a}$	$\sqrt{\frac{a^2 + b^2}{12}}$ $= 0.289\sqrt{a^2 + b^2}$
$\frac{a^4 - b^4}{12}$	$\frac{\sqrt{2}(a^4 - b^4)}{12\,a}$ $= 0.118\,\frac{a^4 - b^4}{a}$	$\sqrt{\frac{a^2 + b^2}{12}}$ $= 0.289\sqrt{a^2 + b^2}$
$\frac{bd^3}{12}$	$\frac{bd^2}{6}$	$\frac{d}{\sqrt{12}} = 0.289\,d$
$\frac{bd^3}{3}$	$\frac{bd^2}{3}$	$\frac{d}{\sqrt{3}} = 0.577\,d$
$\frac{bd^3}{36}$	$\frac{bd^2}{24}$	$\frac{d}{\sqrt{18}} = 0.236\,d$
$\frac{bd^3}{12}$	$\frac{bd^2}{12}$	$\frac{d}{\sqrt{6}} = 0.408\,d$

Section	Area of Section, A	Distance from Neutral Axis to Extreme Fiber, y
	$\frac{\pi d^2}{4} = 0.7854\, d^2$	$\frac{d}{2}$
	$\frac{\pi(D^2 - d^2)}{4} = 0.7854\,(D^2 - d^2)$	$\frac{D}{2}$
	$\frac{\pi d^2}{8} = 0.393\, d^2$	$\frac{(3\pi - 4)\,d}{6\pi} = 0.288\, d$
	$dt + 2\,a\,(s + n)$	$\frac{d}{2}$
	$dt + 2\,a\,(s + n)$	$\frac{b}{2}$
	$dt + a\,(s + n)$	$\frac{d}{2}$
	$dt + a\,(s + n)$	$b - \left[b^2 s + \frac{ht^2}{2} + \frac{g}{3}(b - t)^2 \times (b + 2\,t)\right] \div A$ in which g = slope of flange $= \frac{h - l}{2\,(b - t)}$
	$t\,(2\,a - t)$	$a - \frac{a^2 + at - t^2}{2\,(2\,a - t)}$

Moment of Inertia, I	Section Modulus, $Z=\frac{I}{y}$	Radius of Gyration, $r=\sqrt{\frac{I}{A}}$
$\frac{\pi d^4}{64}=0.049\ d^4$	$\frac{\pi d^3}{32}=0.098\ d^3$	$\frac{d}{4}$
$\frac{\pi(D^4-d^4)}{64}$ $=0.049(D^4-d^4)$	$\frac{\pi(D^4-d^4)}{32\ D}$ $=0.098\frac{D^4-d^4}{D}$	$\frac{\sqrt{D^2+d^2}}{4}$
$\frac{(9\pi^2-64)\ d^4}{1152\ \pi}$ $=0.007\ d^4$	$\frac{(9\pi^2-64)\ d^3}{192\ (3\pi-4)}$ $=0.024\ d^3$	$\frac{\sqrt{(9\pi^2-64)\ d^2}}{12\ \pi}$ $=0.132\ d$
$\frac{1}{12}\left[bd^3-\frac{1}{4\ g}(h^4-l^4)\right]$ in which g = slope of flange $=\frac{h-l}{b-t}=\frac{1}{6}$ for standard I-beams	$\frac{1}{6\ d}\left[bd^3-\frac{1}{4\ g}(h^4-l^4)\right]$	$\sqrt{\frac{\frac{1}{12}\left[bd^3-\frac{1}{4\ g}(h^4-l^4)\right]}{dt+2\ a\ (s+n)}}$
$\frac{1}{12}\left[b^3(d-h)+lt^3+\frac{g}{4}(b^4-t^4)\right]$ in which g = slope of flange (see above)	$\frac{1}{6\ b}\left[b^3(d-h)+lt^3+\frac{g}{4}(b^4-t^4)\right]$	$\sqrt{\frac{I}{A}}$
$\frac{1}{12}\left[bd^3-\frac{1}{8\ g}(h^4-l^4)\right]$ in which g = slope of flange $=\frac{h-l}{2\ (b-t)}=\frac{1}{6}$ for standard channels	$\frac{1}{6\ d}\left[bd^3-\frac{1}{8\ g}(h^4-l^4)\right]$	$\sqrt{\frac{\frac{1}{12}\left[bd^3-\frac{1}{8\ g}(h^4-l^4)\right]}{dt+a\ (s+n)}}$
$\frac{1}{3}\left[2\ sb^3+lt^3+\frac{g}{2}(b^4-t^4)\right]$ $-A\ (b-y)^2$ in which g = slope of flange (see above)	$\frac{I}{y}$	$\sqrt{\frac{I}{A}}$
$1/3\ [ty^3+a\ (a-y)^3$ $-(a-t)\ (a-y-t)^3]$	$\frac{I}{y}$	$\sqrt{\frac{I}{A}}$

Section	Area of Section, A	Distance from Neutral Axis to Extreme Fiber, y
	$t(2a - t)$	$\dfrac{a^2 + at - t^2}{2(2a - t)\cos 45^\circ}$
	$bd - h(b - t)$	$\dfrac{d}{2}$
	$bd - h(b - t)$	$\dfrac{b}{2}$
	$bd - h(b - t)$	$\dfrac{d}{2}$
	$bd - h(b - t)$	$b - \dfrac{2b^2s + ht^2}{2bd - 2h(b - t)}$
	$bs + ht$	$d - \dfrac{d^2t + s^2(b - t)}{2(bs + ht)}$
	$t(a + b - t)$	$b - \dfrac{t(2d + a) + d^2}{2(d + a)}$
	$t(a + b - t)$	$a - \dfrac{t(2c + b) + c^2}{2(c + b)}$

Moment of Inertia, I	Section Modulus, $Z = \frac{I}{y}$	Radius of Gyration, $r = \sqrt{\frac{I}{A}}$
$\frac{1}{3}[2x^4 - 2(x-t)^4 + t[a - (2x - \frac{1}{2}t)]^3]$ in which $x = \frac{a^2 + at - t^2}{2(2a - t)}$	$\frac{I}{y}$	$\sqrt{\frac{I}{A}}$
$\frac{bd^3 - h^3(b-t)}{12}$	$\frac{bd^3 - h^3(b-t)}{6d}$	$\sqrt{\frac{bd^3 - h^3(b-t)}{12[bd - h(b-t)]}}$
$\frac{2sb^3 + ht^3}{12}$	$\frac{2sb^3 + ht^3}{6b}$	$\sqrt{\frac{2sb^3 + ht^3}{12[bd - h(b-t)]}}$
$\frac{bd^3 - h^3(b-t)}{12}$	$\frac{bd^3 - h^3(b-t)}{6d}$	$\sqrt{\frac{bd^3 - h^3(b-t)}{12[bd - h(b-t)]}}$
$\frac{2sb^3 + ht^3}{3} - A(b-y)^2$	$\frac{I}{y}$	$\sqrt{\frac{I}{A}}$
$\frac{1}{3}[ty^3 + b(d-y)^3 - (b-t)(d-y-s)^3]$	$\frac{I}{y}$	$\sqrt{\frac{1}{3(bs+ht)}[ty^3 + b(d-y)^3 - (b-t)(d-y-s)^3]}$
$\frac{1}{3}[ty^3 + a(b-y)^3 - (a-t)(b-y-t)^3]$	$\frac{I}{y}$	$\sqrt{\frac{1}{3t(a+b-t)}[ty^3 + a(b-y)^3 - (a-t)(b-y-t)^3]}$
$\frac{1}{3}[ty^3 + b(a-y)^3 - (b-t)(a-y-t)^3]$	$\frac{I}{y}$	$\sqrt{\frac{1}{3t(a+b-t)}[ty^3 + b(a-y)^3 - (b-t)(a-y-t)^3]}$

GLOSSARY OF COMMON STEEL TERMS

ACID BRITTLENESS—The brittleness induced in steel, especially wire or sheet, when pickled in dilute acid for the purpose of removing scale or upon electroplating. This brittleness is commonly attributed to the absorption of hydrogen.

ACID STEEL—Steel melted in a furnace with an acid (siliceous) bottom and lining and under a slag which is dominantly siliceous.

AGING—A change in a metal or alloy by which its structure recovers from an unstable or metastable condition produced by quenching or by cold working. Aging takes place slowly at room temperature but may be accelerated by a slight increase in temperature.

ALLOY—A mixture with metallic properties composed of two or more elements of which at least one is a metal.

ALLOY ELEMENTS—Chemical elements comprising an alloy; in steels usually limited to the metallic elements added to steel to modify its properties.

ANNEALING—A term used to describe the heating and cooling cycle of steel in the solid state. Annealing usually implies slow cooling. The purpose of annealing is to remove stresses, to induce softness, to alter ductility, to change the crystalline structure and to alter the electric, magnetic or other physical and mechanical properties.

BASIC STEEL—Steel melted in a furnace with a basic bottom and lining and under a slag which is dominantly basic.

BESSEMER PROCESS—A process for making steel by blowing air through molten pig iron contained in a suitable vessel. The process is one of rapid oxidation mainly of silicon and carbon.

BLAST FURNACE—A furnace for the production of pig iron in which the iron ore, coke and limestone are placed and the ore reduced by the burning of the coke and hot gases introduced by the blast.

BLISTER—A defect in metal produced by gas bubbles either on the surface or formed beneath the surface. Very fine blisters are called pinhead or pepper blisters.

BLOOM—(slab, billet, sheet bar)—Semifinished products of rectangular cross-section with rounded corners, hot rolled from ingots.

BLOWHOLE—A hole produced during the solidification of metal by evolved gas which, in failing to escape, is held in pockets.

BLUE ANNEALING—A process of annealing sheets after rolling. The sheets, if fairly heavy, are allowed to cool slowly after the hot rolling; if of lighter gage, as is usually the case, they are passed singly through an open furnace for heating to the proper annealing temperature. As the name indicates, the sheets have a bluish-black appearance.

BLUE BRITTLENESS—Brittleness occurring in steel when in temperature range of 400° to 700° F., or when cold after being worked within this temperature range.

BOX ANNEALING—Softening steel by heating, usually at a subcritical temperature, in a suitable closed metal box or pot to protect it from oxidation, employing a slow heating and cooling cycle; also called close annealing or pot annealing.

BRIGHT ANNEALING—A process of annealing, usually with reducing gases, such that surface oxidation is reduced to a minimum, thereby yielding a relatively bright surface.

Brinell Hardness—A hardness number determined by applying a known load to the surface of the material to be tested through a hardened steel ball of known diameter. The diameter of the resulting permanent impression is measured.

Burning—The heating of a metal to temperatures sufficiently close to the melting point to cause permanent injury. Such injury may be caused by the melting of the more fusible constituents, by the penetration of gases such as oxygen into the metal with consequent reactions, or perhaps by the segregation of elements already present in the metal.

Carbon Steel—Steel which owes its properties chiefly to various percentages of carbon without substantial amounts of other alloying elements; also known as ordinary steel or straight carbon or plain carbon steel.

Carburizing—Adding carbon to the surface of steel by heating the metal below its melting point in contact with carbonaceous solids, liquids or gases.

Case Hardening—A process of surface hardening involving a change in the composition of the outer layer of an iron-base alloy by inward diffusion from a gas or liquid followed by appropriate heat treatment.

Cast Iron—An alloy of iron containing so much carbon that, as cast, it is not appreciably malleable at any temperature.

Cold Working—Plastic deformation of a metal at a temperature low enough to insure strain hardening.

Controlled Cooling—A process by which steel is cooled from a high temperature in a predetermined manner to avoid hardening, cracking or internal damage.

Critical Range—The structural changes which occur in steel take place at different temperatures known as critical points, depending upon whether the steel is being heated or cooled. The range between critical points on heating and on cooling is known as the critical range.

Cup Fracture—The form of fracture of a tension test specimen when the exterior portion is extended and the interior relatively depressed, so that it looks like a cup, as the name implies.

Cyaniding—Surface hardening by carbon and nitrogen absorption of an iron base alloy article or portion of it by heating at a suitable temperature in contact with a cyanide salt, followed by quenching.

Decarburization—The loss of carbon at the surface of steel which is subjected to high temperatures such as hot rolling, forging or heat treating.

Deoxidizing—The removal of oxygen from molten metal or the reducing of scale (oxide of iron) on the surface.

Ductility—The property of a metal which allows it to be permanently deformed in tension before final rupture.

Elastic Limit—The greatest unit stress to which a material may be subjected without a permanent deformation remaining upon complete release of the stress.

Elongation—The amount of permanent extension in a ruptured tensile-test specimen, usually expressed as a percentage of the original gage length. It may also refer to the amount of extension at any stage in any process which continuously elongates a body, as in rolling.

ENDURANCE LIMIT—A limiting stress, below which metal will withstand without fracture an indefinitely large number of cycles of stress.

FATIGUE—A phenomenon of the progressive fracture of a metal by means of a crack which spreads under repeated cycles of stress.

FIBER—A characteristic of wrought metal manifested by a fibrous or woody appearance of fractures and indicating directional properties. Fiber is caused chiefly by the extension in the direction of working of the constituents of the metal, both metallic and nonmetallic.

FIBER STRESS—Local unit stress at a point or line on a section over which stress is not uniform, such as the cross section of a beam under a bending load.

FLAKES—Flakes are internal fissures in steel forgings or rolled products. In a fractured or etched surface or test piece they appear as sizable areas of silvery brightness and coarser grain size than their surroundings.

FLAME HARDENING—A process of hardening steel by heating the surface above the transformation temperature range by means of a high temperature flame, followed by rapid cooling.

FRACTURE—The irregular surface produced when a piece of metal is ruptured or broken.

FRACTURE TEST—Breaking a piece of metal for the purpose of examining the fractured surface to determine the structure or carbon content of the metal or the presence of internal defects.

FULL ANNEALING—A softening process in which metal is heated to a temperature above the transformation range and after being held for a proper time at this temperature is cooled slowly to a temperature below the transformation range.

GRAY CAST IRON—A cast iron which, as cast, has combined or cementitic carbon not in excess of a eutectoid percentage, the balance of the carbon occurring as graphite flakes. The term "gray iron" is derived from the characteristic gray fracture.

HARDENABILITY—The ability of a steel to reach a desired hardness, usually measured by the depth to which the steel will harden under defined conditions of heating and cooling.

HARDENING—A process of increasing the hardness of metal by suitable treatment usually involving heating and cooling.

HEAT TREATMENT—A combination of operations involving the heating and cooling of a metal or an alloy in the solid state for the purpose of obtaining certain desirable conditions or properties.

HOT TOP (sinkhead)—A heat insulated reservoir for excess metal on top of an ingot mold or casting mold which feeds the shrinkage of the ingot or the casting.

IMPACT TEST—A test in which one or more blows are given to a specimen. The results are usually expressed in terms of energy absorbed or number of blows of a given intensity required to break the specimen.

JOMINY TEST—The Jominy test is used to determine end-quench hardenability. It involves water quenching under closely controlled conditions, one end of a one inch diameter specimen of the steel under test and measuring the degree of hardness at regular distances from the quenched end along the side.

KILLED STEEL—Steel which has been deoxidized with silicon and aluminum to such a degree that there is no gas evolution upon solidification resulting in a compact steel free of blowholes.

LAP—A surface defect appearing as a seam caused from folding over hot metal fins or sharp corners and then rolling or forging, but not welding, them into the surface.

MECHANICAL PROPERTIES—Those properties that reveal the reaction, elastic and inelastic, of a material to an applied force, or that involve the relationship between stress and strain; for example, modulus of elasticity, tensile strength, fatigue limit.

MECHANICAL WORKING—Subjecting metal to pressure exerted by rolls, presses, or hammers to change its form, or to affect the structure and therefore the mechanical and physical properties.

MODULUS OF ELASTICITY—The ratio within the limit of elasticity, of the stress to the corresponding strain. The stress in pounds per square inch is divided by the elongation in fractions of an inch for each inch of the original gage length of the specimen.

NITRIDING—Adding nitrogen to iron-base alloys by heating the metal in contact with ammonia gas, or other suitable nitrogenous material.

NORMALIZING—Heating iron-base alloys to approximately 100° F. above the critical temperature range followed by cooling to below that range in still air at ordinary temperature.

OPEN HEARTH—A furnace for the manufacture of steel using gaseous fuel and preheated air. The process is one of oxidation of impurities by the combustion gases. Steel is made by the open hearth method.

PATENTING—Heating iron-base alloys above the critical temperature range followed by cooling below that range in air, or in molten lead or a molten mixture of nitrates or nitrites maintained at a temperature usually between 800-1050° F., depending on the carbon content of the steel and the properties required of the finished product.

PERMANENT SET—Permanent deformation.

PHYSICAL PROPERTIES—Those properties familiarly discussed in physics, exclusive of those described under mechanical properties; for example, density, electrical conductivity, coefficient of thermal expansion.

PHYSICAL TESTING—Testing methods by which mechanical and physical properties are determined.

PICKLING—Removal of foreign substances, notably iron oxides, from the surface of steel by bathing in acid solutions.

PIERCING—Producing a hole in metal by forcing an instrument through it. Usually refers to making steel tubes from solid steel bars.

PIG IRON—The product of the blast furnace which is made by the reduction of iron ore.

PIPE—A cavity formed in metal (especially ingots) formed during the solidification of the last portion of liquid metal. Contraction of the metal causes this cavity or pipe.

PIT—A sharp depression in the surface of metal.

Quenching and Tempering—The procedure of heating a specimen to the proper austenitizing temperature, holding it at that temperature for a period long enough to effect the desired change in crystalline structure and then quenching it in a suitable medium such as water, oil or air. After quenching, the specimen is reheated to a predetermined temperature below the critical range and then cooled under suitable conditions.

Reduction of Area—The difference between the original cross-sectional area and the least cross-sectional area after rupture, expressed as a percentage of the original area.

Rimmed Steel—Incompletely deoxidized steel normally containing less than 0.25% carbon. During solidification, evolution of gas occurs which maintains a liquid top until a side and bottom "rim" of considerable thickness has formed.

Rockwell Hardness Test—The measure of the hardness of a substance by determining the depth of penetration of a penetrator into the specimen under certain arbitrary fixed conditions. The penetrator may be a steel ball or a diamond spherocone.

Scarfing—One method for removing seams and other surface defects with chisel or gouge, so that the defects will not be worked into the finished product. If the defects are removed by means of gas cutting the term "scarfing" is used. Scarfing is often employed simply to remove metal apart from defects.

Scleroscope—A machine which gives a comparative hardness value of a material by measuring the rebound of a diamond tipped hammer which falls freely from a set height.

Secondary Hardening—Hardness developed by tempering high alloy steels.

Semi-Killed Steel—A steel less completely deoxidized than killed steel but developing sufficient gas evolution internally in solidifying to replace the central pipe with a substantially equivalent volume of deep-seated blowholes.

Shortness—Brittleness in metal.

Spalling—The cracking and flaking of small particles of metal from the surface.

Spheroidizing—Prolonged heating of iron-base alloys at a temperature in the neighborhood of, but generally slightly below the critical temperature range, usually followed by relatively slow cooling.

Steel—Malleable alloy of iron and carbon, usually containing substantial quantities of manganese.

Stress Relieving—A process of reducing internal residual stresses in a metal by heating to a suitable temperature and holding for a proper time at that temperature. This treatment is used to relieve stresses induced by welding, casting, quenching, normalizing or cold working.

Temper Colors—The colors which appear on the surface of steel when heated at a low temperature in an oxidizing atmosphere.

Tempering—Reheating hardened steel to some temperature below the lower critical temperature, followed by any desired rate of cooling.

Tensile Strength—The maximum load per unit of original cross-sectional area sustained by a material during a tension test.

Tension Test—A test in which a specimen is broken by applying an increasing load to the two ends.

WELD—A localized coalescence of metal wherein coalescence is produced by heating to suitable temperatures, with or without the application of pressure, and with or without the use of filler metal.

WELDABILITY—The capacity of a metal to be welded under the fabrication conditions imposed into a specific, suitably designed structure and to perform satisfactorily in the intended service.

WELD BEAD—A weld deposit resulting from the introduction of filler metal.

WELD METAL—That portion of a weld which has been melted during welding.

WHITE CAST IRON—Contains carbon in the combined form. The presence of iron carbide (Fe_3C), cementite, makes this metal hard and brittle, and the absence of graphite gives the fracture a white color.

WORK HARDNESS—Hardness developed in metal resulting from cold working.

WROUGHT IRON—A ferrous material aggregated from a solidifying mass of pasty particles of highly refined metallic iron with which is incorporated, without subsequent fusion, a minutely and uniformly distributed quantity of slag.

YIELD POINT—The load per unit area at which a marked increase in deformation of the specimen occurs without increase of load. It is the stress at which a marked increase in strain occurs without an increase in stress.

YIELD STRENGTH—Stress corresponding to some fixed permanent deformation.

TIN PLATE BASE WEIGHT TABLE

Weight, Lb. Per Base Box	Equivalent Weight, Lb. Per Sq. Ft.	Approximate Thickness, In.	Old Symbol	Nearest Mfrs. Std. Gage for Steel Sheets
55	0.2526	0.0061	. . .	38
60	0.2755	0.0066	. . .	37
65	0.2985	0.0072	. . .	35
70	0.3214	0.0077	. . .	35
75	0.3444	0.0083	. . .	34
80	0.3673	0.0088	. . .	33
85	0.3903	0.0094	. . .	32
90	0.4133	0.0099	. . .	32
95	0.4362	0.0105	. . .	31
100	0.4592	0.0110	ICL	30½
107	0.4913	0.0118	IC	30
112	0.5143	0.0123	. . .	30
118	0.5418	0.0130	. . .	29
128	0.5878	0.0141	IXL	28½
135	0.6199	0.0149	IX	28
139	0.6383	0.0153	DC	28
148	0.6796	0.0163	2XL	27
155	0.7117	0.0171	2X	26½
168	0.7714	0.0185	3XL	26
175	0.8036	0.0193	3X	25½
180	0.8265	0.0198	DX	25½
188	0.8633	0.0207	4XL	25
195	0.8954	0.0215	4X	25
208	0.9551	0.0229	5XL	24½
210	0.9643	0.0231	D2X	24½
215	0.9872	0.0237	5X	24
228	1.0469	0.0251	6XL	23½
235	1.0791	0.0259	6X	23
240	1.1020	0.0264	D3X	23
248	1.1388	0.0273	7XL	23
255	1.1709	0.0281	7X	22½
268	1.2306	0.0295	8XL	22
270	1.2398	0.0297	D4X	22
275	1.2628	0.0303	8X	22

GLOSSARY OF TIN MILL TERMS

BASE BOX—Originally 112 sheets, measuring 14″x20″. Now a unit of tin plate having 31,360 square inches of surface (217.78 square feet), therefore, a fraction of a package.

BASIS WEIGHT—Weight of one base box.

BLACK PLATE—Cold reduced steel sheet in tin plate gages, without tin coating.

BUNDLES—are the actual unit of packaging and consist usually of 10, 12, or 15 packages, normally on a solid skid.

COBBLES—A grade designation below Waste Waste, having similar imperfections to a greater degree.

COKE TIN PLATE—Tin plate produced by the hot dip method.

COLD REDUCTION—The rolling and elongation of steel in the cold plastic state.

CROWN—Refers to convexity in cross section of sheet brought about by the practice of turning the rolls slightly concave, resulting in the rolled section increasing in thickness across the width from the edges to the center. This has been found to be better practice than to risk the distortion of sheet surface which occurs when the rolls through temperature fluctuation are permitted to change from a true cylindrical form and take on a barrel shape.

DRIP EDGE (LIST EDGE)—pertains to the trailing edge of hot dip tin plate which has a slightly heavier tin coating than the leading edge. For this reason it is termed the drip edge and may be specified in ordering hot dip plate or on electrolytic orders where menders are acceptable.

FLUTING—Creases developing from lack of temper when curving tin plate into a cylinder, as in the manufacture of a can body.

GRAIN (ROLLING DIRECTION)—Rolled steel develops its greatest strength in the direction of the grain, i.e., the direction of rolling. For this reason, the grain or rolling direction may be specified in ordering.

HOT ROLLED—The rolling and elongation of steel sections while red hot.

MARKER—Any device inserted in a package or loose pile of material for the purpose of maintaining count or quantity.

MENDERS—Electrolytic tin plate which is rejected due to coating imperfections is mended by hot dipping to prime plate, providing the base steel is satisfactory.

MILL ACCUMULATION—Prime plate which cannot be applied to its original order and is held in the mill warehouse as stock. Material may be classified as mill accumulation because it is excess production, off gage, out of dimension, or unapplicable menders.

PACKAGE—A unit consisting of 56, 112, or 224 sheets, depending on the net weight of the product. The quantity contained in a package is traditional and was originally set to permit manual handling of packages conveniently and individually. Modern practice, in which mechanical handling equipment is used, permits the assembly of several packages into a single unit, the most common of which is the conventional multiple package unit consisting usually of 10, 12, or 15 packages.

PICKLING—Treating with acid, usually hot sulphuric—to remove surface scale or annealing border oxide.

PRIMES—Tin plate free from defects readily detected by the unaided eye.

RATIO—The relation of the surface area of a package to a base box, i.e., area of package divided by 31,360 square inches.

REJECTS—This term applies to secondary black plate which has a certain amount of prime area, but not enough to be so classified. Rejects of one bundle are of like gage, width, and length. Like the other secondary products, rejects are measured in pounds.

ROCKWELL—A measure of surface hardness.

SECONDS—Tin plate having slight imperfections in coating of steel. Customarily tin plate is ordered including seconds, i.e., "unassorted" or "primes and seconds." (P and S.)

STRIP—The product of continuous rolling, both hot and cold.

STRIPS—Tin plate or black plate strips sheared from cut down plate. Will vary from 2″ to 10″ or more in width, and 18″ to 32″ in length.

TEMPER—is designated by numbers such as T1, T2, T3, T4, etc. In general, the higher tempers have higher hardness value, but other considerations than hardness are also involved in having the proper temper of tin plate. The proper temper is produced by combination of steel analysis, annealing, and temper rolling, and is used as an aim for mill controls.

TERNE PLATE—A tin mill product coated with a lead-tin alloy and used as sheet metal in construction.

TIN PLATE REJECTS—A secondary tin product having imperfections in the base steel. It is the same as waste waste, except packages contain uniform gages and sizes.

UNASSORTED—Mixed primes and seconds, frequently designated as "P and S"

WASTE WASTE—This applies to coated material, both electrolytic and hot dip, which cannot be classified as prime due to an imperfection in the base steel, not in the coating which could be corrected by mending to hot dipped plate. Waste waste is packaged non-uniformly, but is classified into basis weight ranges as follows:

79 lbs. and lighter
80 lbs. to 107 lbs. inclusive
108 lbs. and heavier

Waste waste is measured in pounds.

WASTE WASTERS—This is the second category of black plate secondaries. Waste wasters have less prime area than rejects and may be packaged with non-uniform gages and dimensions. They are measured in pounds.

SIMPLE RULES FOR PRACTICAL PIPE CALCULATIONS

The following list of simple rules will be found useful for many practical calculations in the use of pipe:

To find the area of a pipe, square the diameter and multiply by .7854.

Doubling the diameter of a pipe increases its capacity four times.

Friction of liquids in pipes increases as the square of the velocity.

To reduce pounds pressure to feet head, multiply by 2.3.

To reduce heads in feet to pressure in pounds, multiply by .433.

A cubic foot of water weighs 62½ pounds and contains 1728 cubic inches or 7½ U.S. gallons. One cubic inch weighs .0361 pounds.

Approximately every foot elevation of a column of water produces a pressure of ½ pound per square inch (actual .433).

A "miner's inch" of water is approximately equal to a supply of 12 gallons per minute. In California, 9 gallons.

The gallons per minute which a pipe will deliver equals .0408 times the square of the diameter, multiplied by the velocity in feet per minute.

To find the capacity of a pipe or cylinder in gallons, multiply the square of the diameter in inches by the length in inches and by .0034.

The weight of water in any length of pipe is obtained by multiplying the length in feet by the square of the diameter in inches, and by .34.

To find the discharge from any pipe in cubic feet per minute, square the diameter and multiply by the velocity in feet per minute and by .00545.

One U.S. gallon of water weighs 8⅓ pounds and contains 231 cubic inches. An imperial gallon weighs 10 pounds and contains 277 cubic inches.

Petroleum weighs 6½ lbs. per U.S. gallon. There are 42 gallons to the barrel.

To find the diameter of pipe in inches, divide the gallons per minute by the velocity in feet per minute, and multiply the square root of the quotient by 4.95.

To find the capacity of a given tank or cistern in U.S. gallons, square the diameter (in feet), and multiply by .7854, multiply by the height in feet, and by 7.48.

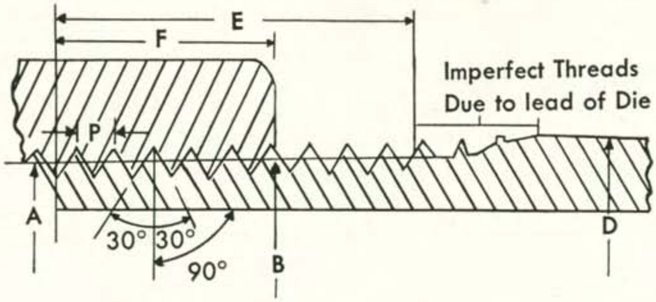
To find the discharge in U.S. gallons per minute from any pipe, square the diameter in inches, multiply by the velocity in feet per second and by 2.448.

The discharge from a pipe in cubic feet per second is equal to the mean velocity in feet per second multiplied by the area of cross section of pipe in square feet.

Sharp angles or sudden bends in pipes cause great increase in friction, consequently increased power is necessary to maintain the rate of flow. Where a change of direction is desired, the friction is minimized by the use of long, easy curves.

The resistance of friction in the flow of water through pipes of uniform diameters is independent of the pressure and increases directly as the length and square of the velocity of the flow, and inversely as the diameter of the pipe. With wooden pipes the friction is 2.75 times greater than in metallic.

AMERICAN STANDARD TAPER PIPE THREADS



Dimensions, in Inches

Nominal Pipe Size	A Pitch Diameter at End of Male Thread	B Pitch Diameter at End of Female Thread	D Outside Diameter of Pipe	E Length of Effective Thread	F Normal Engagement by hand between Male and Female Thread	P Pitch of Thread	Depth of Thread	No. Thrds. per Inch
1/2	0.75843	0.77843	0.840	0.5337	0.320	0.07143	0.05714	14
3/4	0.96768	0.98887	1.050	0.5457	0.339	0.07143	0.05714	14
1	1.21363	1.23863	1.315	0.6828	0.400	0.08696	0.06957	11 1/2
1 1/4	1.55713	1.58338	1.660	0.7068	0.420	0.08696	0.06957	11 1/2
1 1/2	1.79609	1.82234	1.900	0.7235	0.420	0.08696	0.06957	11 1/2
2	2.26902	2.29627	2.375	0.7565	0.436	0.08696	0.06957	11 1/2
2 1/2	2.71953	2.76216	2.875	1.1375	0.682	0.12500	0.10000	8
3	3.34063	3.38850	3.500	1.2000	0.766	0.12500	0.10000	8
3 1/2	3.83750	3.88881	4.000	1.2500	0.821	0.12500	0.10000	8
4	4.33438	4.38713	4.500	1.3000	0.844	0.12500	0.10000	8
5	5.39073	5.44929	5.563	1.4063	0.937	0.12500	0.10000	8
6	6.44609	6.50597	6.625	1.5125	0.958	0.12500	0.10000	8
8	8.43359	8.50003	8.625	1.7125	1.063	0.12500	0.10000	8
10	10.54531	10.62094	10.750	1.9250	1.210	0.12500	0.10000	8
12	12.53281	12.61781	12.750	2.1250	1.360	0.12500	0.10000	8

LENGTH OF PIPE IN BENDS

Radius of Bends	Length of Pipe, Inches				
	90° Bends	180° Bends	270° Bends	360° Bends	540° Bends
1 In.	1½	3	4¾	6¼	9½
2 In.	3	6¼	9½	12½	18¾
3 In.	4¾	9½	14¼	18¾	28¼
4 In.	6¼	12½	18¾	25¼	37¾
5 In.	7¾	15¾	23½	31½	47¼
6 In.	9½	18¾	28¼	37¾	56½
7 In.	11	22	33	44	66
8 In.	12½	25¼	37¾	50¼	75½
9 In.	14¼	28¼	42½	56½	84¾
10 In.	15¾	31½	47¼	62¾	94¼
11 In.	17¼	34½	51¾	69	103¾
1 Ft.	18¾	37¾	56½	75½	113
2 Ft.	37¾	75½	113	150¾	226¼
3 Ft.	56½	113	169½	226¼	339¼
4 Ft.	75½	150¾	226¼	301½	452½
5 Ft.	94¼	188½	282¾	377	565½
6 Ft.	113	226¼	339¼	452½	678½
7 Ft.	132	263¾	395¾	527¾	791½
8 Ft.	150¾	301½	452½	603	904¾
9 Ft.	169½	339¼	509	678½	1017¾
10 Ft.	188½	377	565½	754	1131
11 Ft.	207¼	414¾	622	829½	1244
12 Ft.	226¼	452½	678½	904¾	1357¼
13 Ft.	245	490	735¼	980¼	1470¼
14 Ft.	263¾	527¾	791½	1055½	1583½
15 Ft.	282¾	565½	848¼	1131	1696½
16 Ft.	301½	603	904¾	1206¼	1809½
17 Ft.	320½	640¾	961¼	1281¾	1922½
18 Ft.	339¼	678½	1017¾	1357¼	2035¾
19 Ft.	358	716¼	1074½	1432½	2148¾
20 Ft.	377	754	1131	1508	2262

EXPANSION IN STEEL PIPE LINES

Inches of Linear Expansion per 100 Feet

The expansion for any length of pipe may be found by the following method: From the table below, obtain the difference in increased length at the minimum and maximum temperatures, divide this result by 100 to obtain the increase in length per foot, and multiply by the length of the line in feet.

Temperature Degrees F.	Linear Expansion per 100 Feet, Inches	Temperature Degrees F.	Linear Expansion per 100 Feet, Inches
20	.150	520	4.390
40	.300	540	4.590
60	.455	560	4.780
80	.610	580	4.975
100	.770	600	5.170
120	.915	620	5.365
140	1.075	640	5.565
160	1.235	660	5.765
180	1.400	680	5.965
200	1.570	700	6.170
220	1.730	720	6.375
240	1.890	740	6.580
260	2.065	760	6.790
280	2.230	780	6.990
300	2.410	800	7.210
320	2.590	820	7.415
340	2.760	840	7.630
360	2.935	860	7.840
380	3.110	880	8.055
400	3.290	900	8.280
420	3.465	920	8.495
440	3.650	940	8.720
460	3.835	960	8.945
480	4.020	980	9.170
500	4.210	1000	9.400

SIMPLE HYDRAULIC INFORMATION

Water is practically an incompressible liquid, weighing, at the average temperature of 62° F., 62.355 lb. to the cu. ft. and 8.335 lb. to the gallon. These figures change slightly with changes in temperature and atmospheric pressure. 62.4 lb. per cu. ft. is the weight of water used for ordinary computations.

Pressure of Water. The pressure of still water in pounds per square inch against the sides of any pipe or vessel of any shape whatever is due alone to the head, or height of the surface of the water above the point considered pressed upon, and is equal to 0.433 lb. per sq. in. for every foot of head at 62° F. The fluid-pressure per square inch is equal in all directions. To find the total pressure of quiet water against and perpendicular to any surface, whether vertical, horizontal, or inclined at any angle, whether it be flat or curved, multiply together the area in square feet of the surface pressed, the vertical depth of its center of gravity below the surface of the water, and the constant 62.4. The product will be the required pressure in pounds. This may be expressed by formula as follows:

$$P = 62.4\,AD$$

in which P = the pressure in pounds of quiescent water on the surface considered;
A = the area pressed upon in square feet; and
D = the vertical depth in feet of center of gravity of surface considered.

Pressure in Pounds per Square Inch for Different Heads of Water in Feet.

Head, Ft.	0	1	2	3	4	5	6	7	8	9
0	....	0.433	0.866	1.299	1.732	2.165	2.598	3.031	3.464	3.897
10	4.330	4.763	5.196	5.629	6.062	6.495	6.928	7.361	7.794	8.227
20	8.660	9.093	9.526	9.959	10.392	10.825	11.258	11.691	12.124	12.557
30	12.990	13.423	13.856	14.289	14.722	15.155	15.588	16.021	16.454	16.887
40	17.320	17.753	18.186	18.619	19.052	19.485	19.918	20.351	20.784	21.217
50	21.650	22.083	22.516	22.949	23.382	23.815	24.248	24.681	25.114	25.547
60	25.980	26.413	26.846	27.279	27.712	28.145	28.578	29.011	29.444	29.877
70	30.310	30.743	31.176	31.609	32.042	32.475	32.908	33.341	33.774	34.207
80	34.640	35.073	35.506	35.939	36.372	36.805	37.238	37.671	38.104	38.537
90	38.970	39.403	39.836	40.269	40.702	41.135	41.568	42.001	42.436	42.867

The above figures are correct for water at 62° F. and for atmospheric pressure at 14.7 lbs. per sq. in.

Flow of Water in Pipes. Owing to the many practical and variable conditions which affect the flow of water in pipes, such as the smoothness of the pipe, the number and character of the joints, bends and valves in the pipe, as well as the size and length of the pipe, all formulas for the velocity and discharge of water in and through pipes can only be considered as approximate. The quantity of water passing through a given pipe is governed by the sectional area of the pipe or outlet and the mean velocity. The velocity depends primarily upon the pressure or head, and is greatly affected by friction, which again varies with the smoothness of the bore, the diameter and length of the pipe, and whatever obstructions there may be in the pipe. The head is the vertical distance from the surface of the water in the reservoir to the center of gravity of the lower end of the pipe when the discharge is into the air, or to the level surface of the lower reservoir when the discharge is under water. When the pressure is produced by mechanical means, the head of water in feet may be readily determined by the following table:

***For Converting Pressure in Pounds per Square Inch into Head of Water in Feet.**

Pressure	0	1	2	3	4	5	6	7	8	9
0	....	2.309	4.619	6.928	9.238	11.547	13.857	16.166	18.476	20.785
10	23.0947	25.404	27.714	30.023	32.333	34.642	36.952	39.261	41.570	43.880
20	46.1894	48.499	50.808	53.118	55.427	57.737	60.046	62.356	64.665	66.975
30	69.2841	71.594	73.903	76.213	78.522	80.831	83.141	85.450	87.760	90.069
40	92.3788	94.688	96.998	99.307	101.62	103.93	106.24	108.55	110.85	113.16
50	115.4735	117.78	120.09	122.40	124.71	127.00	129.33	131.64	133.95	136.26
60	138.5682	140.88	143.19	145.50	147.81	150.12	152.42	154.73	157.04	159.35
70	161.6629	163.97	166.28	168.59	170.90	173.21	175.52	177.83	180.14	182.45
80	184.7576	187.07	189.38	191.69	194.00	196.31	198.61	200.92	203.23	205.54
90	207.8523	210.16	212.47	214.78	217.09	219.40	221.71	224.02	226.33	228.64

*The above figures are correct for water at 62° F. and for atmospheric pressure at 14.7 lbs. per sq. in.

To find the velocity of water discharged from a pipe-line longer than four times its diameter, knowing the head, length and inside diameter, use the following formula:

$$v = m\sqrt{\frac{hd}{L + 54d}}$$

in which v = approximate mean velocity in feet per second;

m = coefficient from the table below:

d = diameter of pipe in feet;

h = total head in feet;

L = total length of line in feet.

The following coefficients are averages deduced from experiments. In most cases of pipes carefully laid and in fair condition, they should give results varying not more than from 5 to 10%.

Values of Coefficient m

$\sqrt{\frac{hd}{L + 54d}}$	Diameter of Pipe in feet							
	0.05	0.10	0.50	1	1.5	2	3	4
	m	m	m	m	m	m	m	m
0.005	29	31	33	35	37	40	44	47
0.01	34	35	37	39	42	45	49	53
0.02	39	40	42	45	49	52	56	59
0.03	41	43	47	50	54	57	60	63
0.05	44	47	52	54	56	60	64	67
0.10	47	50	54	56	58	62	66	70
0.20	48	51	55	58	60	64	67	70

FRICTION OF WATER IN PIPES

Loss of Head in Feet Due to Friction, per 100 Feet of Ordinary Pipe

Gal. per Min.	Size Pipe, Inches											
	½		¾		1		1¼		1½		2	
	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.
1	1.05	2.1	......	......	......	......	......	......	......	......	......	......
2	2.10	7.4	1.20	1.9	......	......	......	......	......	......	......	......
3	3.16	15.8	1.80	4.1	1.12	1.26	......	......	......	......	......	......
4	4.21	27.0	2.41	7.0	1.49	2.14	0.86	0.57	0.63	0.26	......	......
5	5.26	41.0	3.01	10.5	1.86	3.25	1.07	0.84	0.79	0.39	......	......
10	10.52	147.0	6.02	38.0	3.72	11.7	2.14	3.05	1.57	1.43	1.02	0.50
15	......	......	9.02	80.0	5.60	25.0	3.2	6.50	2.36	3.0	1.53	1.0
20	......	......	12.03	136.0	7.44	42.0	4.29	11.1	3.15	5.2	2.04	1.82
25	......	......	......	......	9.30	64.0	5.36	16.6	3.94	7.8	2.55	2.73
30	......	......	......	......	11.15	89.0	6.43	23.5	4.72	11.0	3.06	3.84
35	......	......	......	......	13.02	119.0	7.51	31.2	5.51	14.7	3.57	5.1
40	......	......	......	......	14.88	152.0	8.58	40.0	6.3	18.8	4.08	6.6
45	......	......	......	......	......	......	9.65	50.	7.08	23.2	4.60	8.2
50	......	......	......	......	......	......	10.72	60.	7.87	28.4	5.11	9.9
70	......	......	......	......	......	......	15.01	113.	11.02	53.0	7.15	18.4
90	......	......	......	......	......	......	......	......	14.17	84.0	9.19	29.4
100	......	......	......	......	......	......	......	......	15.74	102.0	10.21	35.8
120	......	......	......	......	......	......	......	......	18.89	143.0	12.25	50.0
140	......	......	......	......	......	......	......	......	22.04	190.0	14.30	67.0
160	......	......	......	......	......	......	......	......	......	......	16.34	86.0
180	......	......	......	......	......	......	......	......	......	......	18.38	107.0
200	......	......	......	......	......	......	......	......	......	......	20.42	129.0
220	......	......	......	......	......	......	......	......	......	......	22.47	154.0
240	......	......	......	......	......	......	......	......	......	......	24.51	182.0
260	......	......	......	......	......	......	......	......	......	......	26.55	211.0

Vel.—velocity feet per second.

Fric.—friction head in feet.

FRICTION OF WATER IN PIPES

Loss of Head in Feet Due to Friction, per 100 Feet of Ordinary Pipe

Gal. per Min.	Size Pipe, Inches											
	2½		3		4		5		6		8	
	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.
10	0.65	0.17	0.45	0.07	......	......	......	......	......	......	......	......
15	0.98	0.36	0.68	0.15	......	......	......	......	......	......	......	......
20	1.31	0.61	0.91	0.25	......	......	......	......	......	......	......	......
25	1.63	0.92	1.13	0.38	......	......	......	......	......	......	......	......
30	1.96	1.29	1.36	0.54	......	......	......	......	......	......	......	......
35	2.29	1.72	1.59	0.71	......	......	......	......	......	......	......	......
40	2.61	2.20	1.82	0.91	1.02	0.22	......	......	......	......	......	......
45	2.94	2.80	2.05	1.15	1.17	0.28	......	......	......	......	......	......
50	3.27	3.32	2.27	1.38	1.28	0.34	......	......	......	......	......	......
70	4.58	6.2	3.18	2.57	1.79	0.63	1.14	0.21	......	......	......	......
75	......	......	......	......	1.92	0.73	1.22	0.24	......	......	......	......
90	5.88	9.8	4.09	4.08	......	......	......	......	......	......	......	......
100	6.54	12.0	4.54	4.96	2.55	1.23	1.63	0.39	1.14	0.14	......	......
120	7.84	16.8	5.45	7.0	3.06	1.71	1.96	0.57	1.42	0.25	......	......
125	......	......	......	......	3.19	1.86	2.04	0.64	1.48	0.28	......	......
140	9.15	22.3	6.35	9.2	......	......	......	......	......	......	......	......
150	......	......	......	......	3.84	2.55	2.45	0.88	1.71	0.32	......	......
160	10.46	29.0	7.26	11.8	......	......	......	......	......	......	......	......
175	......	......	......	......	4.45	3.36	2.86	1.18	2.00	0.48	......	......
180	11.76	35.7	8.17	14.8	......	......	......	......	......	......	......	......
200	13.07	43.1	9.08	17.8	5.11	4.37	3.27	1.48	2.28	0.62	......	......
220	14.38	52.0	9.99	21.3	......	......	......	......	......	......	......	......
225	......	......	......	......	6.32	6.61	3.67	1.86	2.57	0.74	......	......
240	15.69	61.0	10.89	25.1	......	......	......	......	......	......	......	......
250	......	......	......	......	6.40	6.72	4.08	2.24	2.80	0.92	1.60	0.22
260	16.99	70.0	11.80	29.1	......	......	......	......	......	......	......	......
270	......	......	......	......	6.90	7.70	4.42	2.60	3.03	1.13	1.70	0.25
275	......	......	......	......	7.03	7.99	4.50	2.72	3.06	1.15	1.73	0.27
280	18.30	81.0	12.71	33.4	......	......	......	......	......	......	......	......
300	19.61	92.0	13.62	38.0	7.66	9.38	4.90	3.15	3.40	1.29	1.90	0.36
350	......	......	......	......	8.90	12.32	5.72	4.19	3.98	1.69	2.20	0.41
400	......	......	......	......	10.20	15.82	6.54	5.33	4.54	2.21	2.60	0.56
450	......	......	......	......	11.50	19.74	7.35	6.65	5.12	2.74	2.92	0.64
470	......	......	......	......	12.16	22.40	7.78	7.42	5.49	3.12	3.07	0.77
475	......	......	......	......	12.30	22.96	7.88	7.22	5.55	3.21	3.10	0.79
500	......	......	......	......	12.77	24.08	8.17	8.12	5.60	3.26	3.20	0.81
550	......	......	......	......	......	......	8.99	9.66	6.16	3.93	3.52	0.98
600	......	......	......	......	......	......	9.80	11.34	6.72	4.70	3.84	1.16
650	......	......	......	......	......	......	10.62	13.16	7.28	5.50	4.16	1.34
700	......	......	......	......	......	......	11.44	15.12	7.84	6.38	4.46	1.54
750	......	......	......	......	......	......	12.26	17.22	8.50	7.00	4.80	1.74
800	......	......	......	......	......	......	......	......	9.08	7.90	5.12	1.97
850	......	......	......	......	......	......	......	......	9.58	8.75	5.48	2.28
900	......	......	......	......	......	......	......	......	10.30	10.11	5.75	2.46
950	......	......	......	......	......	......	......	......	10.72	10.71	6.06	2.87
1000	......	......	......	......	......	......	......	......	11.32	12.04	6.40	3.02
1050	......	......	......	......	......	......	......	......	11.90	13.30	6.70	3.21
1100	......	......	......	......	......	......	......	......	12.50	14.31	7.03	3.51
1150	......	......	......	......	......	......	......	......	12.95	15.34	7.35	3.84
1200	......	......	......	......	......	......	......	......	13.52	16.69	7.67	4.26
1250	......	......	......	......	......	......	......	......	14.10	18.20	8.00	4.45
1500	......	......	......	......	......	......	......	......	......	......	9.60	6.27
2000	......	......	......	......	......	......	......	......	......	......	12.70	10.71

FRICTION OF WATER IN PIPES

Loss of Head in Feet Due to Friction, per 100 Feet of Ordinary Pipe

Gal. per Min.	Size Pipe, Inches											
	10		12		14		15		16		20	
	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.
450	1.80	0.21	....	....	....	....	....	....	....	....	....	....
470	1.92	0.24	....	....	....	....	....	....	....	....	....	....
475	1.94	0.25	....	....	....	....	....	....	....	....	....	....
500	2.04	0.28	1.42	0.11	....	....	....	....	....	....	....	....
550	2.25	0.33	1.57	0.14	....	....	....	....	....	....	....	....
600	2.46	0.39	1.71	0.15	....	....	....	....	....	....	....	....
650	2.66	0.46	1.85	0.19	1.37	.09	....	....	....	....	....	....
700	2.86	0.52	2.00	0.22	1.47	.10	....	....	....	....	....	....
750	3.06	0.59	2.13	0.24	1.58	.11	....	....	....	....	....	....
800	3.28	0.67	2.27	0.27	1.68	.13	....	....	....	....	....	....
850	3.48	0.75	2.41	0.31	1.79	.14	....	....	....	....	....	....
900	3.68	0.83	2.56	0.34	1.89	.16	....	....	....	....	....	....
950	3.88	0.91	2.70	0.35	2.00	.16	1.73	.12	....	....	....	....
1000	4.08	1.01	2.84	0.41	2.10	.19	1.82	.14	....	....	....	....
1050	4.29	1.09	2.98	0.48	2.20	.22	1.91	.16	....	....	....	....
1100	4.50	1.20	3.13	0.49	2.31	.23	2.00	.16	....	....	....	....
1150	4.71	1.34	3.27	0.53	2.42	.25	2.09	.17	....	....	....	....
1200	4.91	1.46	3.41	0.57	2.52	.26	2.18	.19	....	....	....	....
1250	5.11	1.51	3.55	0.62	2.63	.29	2.28	.20	1.99	.15	....	....
1500	6.10	2.09	4.20	0.85	3.15	.39	2.73	.28	2.39	.24	....	....
2000	8.10	3.50	5.60	1.43	4.20	.66	3.64	.47	3.19	.39	....	....
2500	10.10	5.33	7.00	2.18	5.25	1.01	4.55	.72	3.99	.56	....	....
3000	12.10	7.42	8.40	3.39	6.30	1.57	5.46	1.12	4.79	.80	3.08	.27
3500	14.10	10.08	9.80	3.92	7.35	1.82	6.37	1.29	5.59	1.04	3.59	.35
4000	....	....	11.35	5.32	8.40	2.47	7.28	1.76	6.38	1.34	4.10	.45
4200	....	....	11.93	6.30	8.82	2.92	7.64	2.08	6.72	1.45	4.32	.50
4500	....	....	12.78	6.75	9.45	3.13	8.19	2.23	7.20	1.65	4.62	.56
5000	....	....	14.20	8.15	10.50	3.78	9.10	2.69	7.96	2.02	5.13	.68
5500	....	....	....	....	11.55	4.50	10.01	3.16	8.78	2.39	5.64	.82
6000	....	....	....	....	12.60	5.40	10.92	3.79	9.56	2.84	6.15	.96
6500	....	....	....	....	13.65	6.14	11.83	4.30	10.36	3.32	6.66	1.01
7000	....	....	....	....	14.70	6.65	12.74	4.66	11.12	3.68	7.18	1.28
7200	....	....	....	....	....	....	13.10	4.95	11.50	3.96	7.38	1.35
7500	....	....	....	....	....	....	13.65	5.60	11.95	4.28	7.66	1.45
8000	....	....	....	....	....	....	....	....	....	....	8.17	1.63
8500	....	....	....	....	....	....	....	....	....	....	8.68	1.83
9000	....	....	....	....	....	....	....	....	....	....	9.20	2.04
9500	....	....	....	....	....	....	....	....	....	....	9.70	2.23
10000	....	....	....	....	....	....	....	....	....	....	10.40	2.53

FRICTION OF WATER IN PIPES

Loss of Head in Feet Due to Friction, per 100 Feet of Ordinary Pipe

Gallons per Minute	Size Pipe, Inches			
	24		30	
	Velocity	Friction	Velocity	Friction
2000	1.42	.05	....	......
2500	1.77	.07	....	......
3000	2.13	.10	....	......
3500	2.49	.14	1.56	.04
4000	2.85	.18	1.81	.06
4200	....	......	....	......
4500	3.20	.22	2.04	.08
5000	3.54	.27	2.26	.09
5500	3.90	.33	2.50	.11
6000	4.25	.39	2.72	.13
6500	4.61	.45	2.95	.15
7000	4.97	.52	3.18	.17
7200	....	......	....	......
7500	5.32	.59	3.42	.20
8000	5.68	.66	3.63	.22
8500	6.03	.74	3.86	.25
9000	6.35	.81	4.08	.27
9500	6.74	.91	4.31	.30
10000	7.07	.98	4.54	.33
10500	7.45	1.10	4.76	.37
11000	7.80	1.20	5.00	.40
11500	8.16	1.29	5.21	.43
12000	8.50	1.40	5.44	.47
12500	8.86	1.52	5.67	.51
13000	9.22	1.63	5.91	.54
13500	9.60	1.75	6.13	.58
14000	9.95	1.87	6.36	.63
14500	10.3	2.00	6.61	.68
15000	10.63	2.12	6.81	.72
16000	11.38	2.40	7.36	.83
17000	12.09	2.70	7.73	.91
18000	12.76	2.97	8.18	1.00
19000	13.50	3.26	8.66	1.11
20000	14.20	3.60	9.09	1.22
21000	14.90	3.96	9.54	1.34
22000	....	......	10.0	1.47
23000	....	......	10.45	1.59
24000	....	......	10.90	1.71
25000	....	......	11.35	1.85
26000	....	......	11.80	1.97
27000	....	......	12.26	2.12
28000	....	......	12.73	2.28

IRRIGATION TABLE

Discharge Inches	Gallons per Minute	Cubic Feet per Second	Number of Acres Irrigated in 12 Hours' Pumping			
			1 Inch Deep	2 Inches Deep	3 Inches Deep	4 Inches Deep
1	20	.045	.529	.2645	.1765	.1324
1½	50	.11	1.328	.664	.4425	.332
2	100	.22	2.65	1.325	.883	.6625
2½	150	.33	3.98	1.991	1.328	.995
3	225	.50	5.97	2.985	1.99	1.492
4	300	.67	7.96	3.98	2.655	1.99
4	400	.89	10.61	5.305	3.535	2.652
5	700	1.56	18.58	9.28	6.18	4.64
6	900	2.01	23.85	11.95	7.96	5.97
8	1200	2.68	31.82	15.92	10.61	7.95
8	1600	3.57	42.35	21.20	14.15	10.61
10	3000	6.68	79.50	39.75	26.50	19.88
12	4500	10.03	119.30	59.70	39.75	20.85
16	6000	13.36	159.10	79.60	53.00	39.75
16	7000	15.61	185.70	92.80	61.90	46.45
16	8500	18.95	225.50	112.80	75.20	56.35
20	10000	22.25	265.00	132.50	88.30	66.25
20	14000	31.15	371.00	185.50	123.70	92.75

Discharge Inches	Gallons per Minute	Cubic Feet per Second	Number of Acres Irrigated in 12 Hours' Pumping			
			6 Inches Deep	8 Inches Deep	10 Inches Deep	12 Inches Deep
1	20	.045	.0883	.0663	.0529	.0442
1½	50	.11	.221	.166	.1328	.1105
2	100	.22	.442	.3313	.265	.221
2½	150	.33	.664	.4975	.398	.332
3	225	.50	.994	.747	.597	.4975
4	300	.67	1.327	.995	.796	.663
4	400	.89	1.770	1.328	1.061	.884
5	700	1.56	3.095	2.32	1.858	1.548
6	900	2.01	3.98	2.975	2.385	1.99
8	1200	2.68	5.305	3.975	3.182	2.65
8	1600	3.57	7.075	5.305	4.235	3.535
10	3000	6.68	13.25	9.94	7.95	6.625
12	4500	10.03	19.90	14.93	11.93	9.95
16	6000	13.36	26.52	19.89	15.91	13.26
16	7000	15.61	30.95	23.20	18.57	15.47
16	8500	18.95	37.60	28.19	22.55	18.79
20	10000	22.25	44.20	33.15	26.50	22.10
20	14000	31.15	61.80	46.35	37.10	30.95

PROPERTIES OF HYDROCARBONS FOUND IN NATURAL GAS AND CASING-HEAD GAS

	Methane	Ethane	Propane	Butane	Pentane	Hexane	Heptane	Octane
Formula	CH_4	C_2H_6	C_3H_8	C_4H_{10}	C_5H_{12}	C_6H_{14}	C_7H_{16}	C_8H_{18}
Molecular weight	16.03	30.05	44.07	58.08	72.10	86.12	100.13	114.15
Specific gravity of liquid	.....	0.432= 194°Bé	0.515= 142°Bé	0.585= 109°Bé	0.630= 92.2°Bé	0.670= 78.9°Bé	0.697= 70.9°Bé	0.718= 65.0°Bé
Specific gravity of gas	0.555	1.049	1.526	2.008	2.496	2.982	3.467	3.952
Boiling point at atmospheric pressure	–165 C –265 F	–93 C –135 F	–45 C –49 F	+1 C 34 F	36.3 C 97 F	69 C 156 F	98.4 C 200 F	125.5°C 258 F
Pressure to liquefy at 60 F, psi	.....	475	105	35	6.5	1.8	0.5	0.15
Vapor pressure 70 F in percentage of atmosphere	100+	100+	100+	100+	55	10	2.7	0.7
Gallons per 1,000 cu. ft. at B.P. reduced to 60 F	.....	22.13	27.01	31.28	36.13	40.56	45.34	50.11
Weight 1,000 cu. ft. vapor at B.P. reduced to 60 F, lb.	42	79.7	116	152.6	189.7	226.6	263.5	300
Shrinkage in volume by 1 gal. liquid removed per 1,000 cu. ft.	.....	.....	.....	.....	2.8%	2.5%	2.2%	2.0%
Maximum possible removal gal. per 1,000 cu. ft. at 70 F gal.	.....	.....	.....	.....	19.87	4.06	1.22	0.35
High heat value, Btu per cu. ft.	1,065	1,861	2,685	3,447	4,250	5,012	5,780	6,542
Btu per lb.	25,360	23,350	23,150	22,590	22,400	22,120	21,935	21,807
Cubic feet air to burn 1 cu. ft. gas	9.57	16.72	23.92	31.10	38.28	46.46	53.6	60.8
Carbon percentage	75.0	80.0	21.8	82.8	83.3	83.7	84.0	84.2
Explosive mixture percentage in air, Maximum	14.5	5.0	3.5	3.0	2.5	2.2	1.9	1.6
Minimum	5.6	3.0	2.1	1.6	1.3			

TYPICAL COMPOSITIONS AND PROPERTIES OF FUEL AND ILLUMINATING GASES

	Percentage Composition by Volume										Density, lb. per cu. ft.	Specific gravity (air = 1)	Specific Heat at constant pressure		High-Heat value[2]	
	Hydrogen, H_2	Methane, CH_4	Ethane, C_2H_6	Illuminants[1], C_nH_{2n}	Propane, C_3H_8	Butane, C_4H_{10}	Carbon monoxide, CO	Carbon dioxide, CO_2	Nitrogen, N_2	Oxygen, O_2			Btu per lb. per F	Btu per cu. ft. per F	Btu per lb.	Btu per cu. ft.
Specific heat in Btu per lb. per degree F at constant pressure	3.42	0.593	0.400	0.400	0.390	0.390	0.243	0.210	0.247	0.217						
Oil gas	32.0	48.0	....	16.5	....	....	....	....	3.0	0.5	0.03666	0.48	0.63	0.023	23,077	846
Refinery gas:																
Dubbs	5.0	33.0	15.0	33.0	14.0	....	....	....	....	....	0.07332	0.96	0.44	0.040	20,458	1,500
Houdrie	....	28.6	17.5	0.6	33.4	19.9	....	....	....	....	0.11533	1.51	0.41	0.047	17,342	2,000
Natural gas		87.0	9.6	....	....	....	....	0.4	3.0	....	0.04659	0.61	0.54	0.025	23,932	1,115
Natural gas		74.0	14.5	....	....	....	....	0.1	11.2	0.2	0.05230	0.685	0.38	0.020	19,311	1,010
Natural gas		....	79.4	....	20.0	....	....	....	0.6	....	0.08604	1.13	0.40	0.034	21,513	1,851
Pintsch gas	12.6	45.4	....	35.7	....	....	0.6	0.7	3.0	2.0	0.06416	0.84	0.47	0.031	23,379	1,500
Blast-furnace gas	2.0	2.0	....	....	....	....	26.0	12.0	58.0	....	0.07638	1.00	0.25	0.019	1,309	100
Producer gas, coal	12.0	2.6	....	0.4	....	....	29.0	4.0	52.0	....	0.06645	0.87	0.28	0.019	2,453	163
Coke-oven gas	50.0	36.0	....	4.0	....	....	6.0	1.5	2.0	0.5	0.02902	0.38	0.73	0.021	20,779	603
Coal-retort gas,	52.5	31.4	....	2.2	....	....	8.6	1.5	3.5	0.3	0.03208	0.42	0.70	0.021	17,924	575
Blue water gas	51.3	....	....	....	....	....	43.4	3.5	1.3	0.5	0.04048	0.53	0.46	0.018	7,411	300
Carbureted water gas	35.6	16.5	....	14.6	....	....	28.0	3.8	1.0	0.5	0.04888	0.64	0.46	0.023	11,457	560

1. Includes ethylene C_2H_4, prophlene C_3H_6, etc.

2. Owing to the varying hydrogen content of different types of gas the low-heat value will vary considerably, depending also on the flue gas temperature. Correction for loss due to water vapor can be made by the following formula (see ASME Power Test Code for Stationary Steam Generating Units, and "Computation of Heat in Moisture," by C. H. Berry, Power, Vol. 61, Mar. 17, 1925, p. 410):

Heat loss in Btu per fuel unit $= 9H_2\ (1{,}066 + 0.5tg - ta)$, when tg is more than 550 F

$= 9H_2\ (1{,}089 + 0.46tg - ta)$, when tg is less than 550 F

where H_2 = weight of hydrogen in the fuel unit (lb. H_2 per lb. of gas, or lb. H_2 per cu. ft. of gas as the case may be).

tg = temperature of the flue gas, degrees F.

ta = temperature of the atmosphere, degrees F.

GLOSSARY OF PIPE FITTING TERMS

BACKING RING—A strip of metal used to prevent weld splatter from entering a pipe when making a butt-welded joint and to ensure complete penetration of the weld to the inside of the pipe wall.

BACK-PRESSURE VALVE—A valve similar to a low-pressure safety valve which is set to maintain a certain back pressure on feed heaters, oiling systems, or other devices requiring a constant operating pressure irrespective of pressure variations of the supply. The back-pressure valve is arranged to relieve any excess supply to atmosphere or elsewhere, and it opens and closes automatically as required to produce this result.

BELL AND SPIGOT JOINT—The usual term for the joint in cast-iron pipe. Each piece is made with an enlarged diameter or bell at one end into which the plain or spigot end of another piece is inserted when laying. The joint is then made tight by cement, oakum, lead, rubber or other suitable substance, which is driven in or calked into the bell and around the spigot.

BLANK FLANGE—A flange that is not drilled but is otherwise complete. Compare Blind Flange.

BLEEDER—A small cock or valve to draw off water of condensation from a run of piping. A small connection to obtain circulation in warming up a line.

BLIND FLANGE—A flange used to close the end of a pipe. It produces a blind end which s also known as a dead end. Compare with Blank Flange.

BONNET—A cover used to guide and enclose the tail end of a valve spindle.

BRANCH ELL—Used to designate an elbow having a back outlet in line with one of the outlets of the "run." It is also called a heel outlet elbow.

BRANCH PIPE—A very general term used to signify a pipe that is equipped with one or more branches. Such pipes are used so frequently that they have acquired common names such as tees, crosses, side or back outlet elbows, manifolds, double-branch elbows, etc. The term branch pipe is generally restricted to such as do not conform to usual dimensions.

BRANCH TEE (HEADER)—A tee having many side branches. (See Manifold.)

BULL HEAD TEE—A tee the branch of which is larger than the run.

BUSHING—A pipe fitting for the purpose of connecting a pipe with a fitting of larger size, being a hollow plug with internal and external threads to suit the different diameters.

BUTT WELD—Welded along a seam that is butted edge to edge and not scarfed or lapped. A term used to designate pipe made by this process. Also applied to circumferential pipe joints made by the fusion-welding process.

BY-PASS—A small passage around a large valve for warming up a line. An emergency connection around a reducing valve, trap, etc., to use in case they are out of commission.

CLOSE NIPPLE—One the length of which is about twice the length of a standard pipe thread and is without any shoulder.

COMPANION FLANGE—A pipe flange suited to connect with another companion flange or with a flanged valve or fitting. A loose flange which is attached to a pipe by threading, Van Stoning, welding, or similar method as distinguished from a flange which is cast integral with a fitting or pipe.

COUPLING—A threaded sleeve used to connect two pipes. Commercial couplings are threaded inside to suit the exterior thread of the pipe. The term coupling is occasionally used to mean any jointing device and may be applied to either straight or reducing sizes.

CROSS—A pipe fitting with four branches arranged in pairs, each pair on one axis, and the axes at right angles. When the outlets are otherwise arranged the fittings are branch pipes or specials.

CROSS-OVER—A small fitting with a double offset, or shaped like the letter U with the ends turned out. It is only made in small sizes and used to pass the flow of one pipe past another when the pipes are in the same plane.

CROSS-OVER TEE—A fitting made along lines similar to the cross-over, but having at one end two openings in a tee-head the plane of which is at right angles to the plane of the cross-over bend.

CROSS VALVE—A valve fitted on a transverse pipe so as to open communication at will between two parallel lines of piping. It is used in connection with oil and water pumping arrangements, especially on ship board.

CROTCH—A fitting that has the general shape of the letter Y. Caution should be exercised not to confuse the crotch and wye.

DISCHARGE HEAD—The vertical distance from the center of the pump to the center of the discharge outlet where the water is delivered, to which must be added the loss due to friction of the water in the discharge pipe.

DOUBLE BRANCH ELBOW—A fitting that, in a manner, looks like a tee, or as if two elbows had been shaved and then placed together, forming a shape something like the letter Y or a crotch.

DOUBLE SWEEP TEE—A tee made with easy curves between body and branch, i.e., the center of the curve between run and branch lies outside the body.

ELBOW (ELL)—A fitting that makes an angle between adjacent pipes. The angle is always 90 degrees, unless another angle is stated. (See Branch, Service, and Union Ell.)

ELECTRIC FUSION WELD PIPE—Pipe in which the longitudinal weld is made by the submerged arc welding method, with the addition of extraneous metal.

ELECTRIC RESISTANCE WELD PIPE—Pipe in which the formed skelp or plate is welded longitudinally by passing an electric current between the edges. The electric resistance setup heats the edges to welding temperature and a solid weld is made without the addition of extraneous metal.

EXTRA HEAVY—When applied to pipe, means pipe thicker than standard pipe; when applied to valves and fittings, indicates construction suitable for a working pressure of 250 pounds per square inch.

FUSION WELD—The union of metals by fusion, using an oxy-acetylene torch, the electric arc, or thermit reaction. With the first two methods, the edges to be joined usually are chamfered or beveled to give an included angle of 45 to 90 degrees which is filled in with fused metal from a welding rod. This is also known as an "autogenous weld."

GALVANIZING—A process by which the surface of iron or steel is covered with a layer of zinc.

Header—A large pipe into which one set of boilers, heaters or tanks is connected by suitable nozzles or tees, or similar large pipes from which a number of smaller ones lead to consuming points.

Hydraulically Expanded Pipe—Pipe which is given its final size by internal hydraulic pressure. Cold working the steel in this manner also increases its yield strength.

Hydrostatic Joint—Used in large water mains, in which sheet lead is forced tightly into the bell of a pipe by means of the hydrostatic pressure of a liquid.

Lapped Joint—A type of pipe joint made by using loose flanges on lengths of pipe whose ends are lapped over to give a bearing surface for a gasket or metal-to-metal joint.

Lap Weld—Welded along a scarfed longitudinal seam in which one part is overlapped by the other. A term used to designate pipe made by this process.

Lead Joint—Generally used to signify the connection between pipes which is made by pouring molten lead into the annular space between a bell and spigot, and then making the lead tight by calking.

Lead Wool—A material used in place of molten lead for making pipe joints. It is lead fiber, about as coarse as fine excelsior, and when made in a strand, it can be calked into the joints, making them very solid.

Line Pipe—Special brand of pipe that employs recessed and taper thread couplings, and usually a greater length of thread than the American Standard. The pipe is also subjected to higher test.

Malleable Iron—Cast iron which has been heat-treated in a malleableizing oven to relieve its brittleness. The process somewhat improves the tensile strength and enables the material to stretch to a limited extent without breaking.

Manifold—(1) A fitting with numerous branches used to convey fluids between a large pipe and several smaller pipes. (See Branch Tee.) (2) A header for a coil.

Matheson Joint—A wrought pipe joint made by enlarging one end of the pipe to form a suitable lead recess, similar to the bell end of a cast-iron pipe, and which receives the male or spigot end of the next length. Practically the same style of a joint as used for cast-iron pipe.

Mill Length—Also known as "random length." The usual run-of-mill pipe is 16 to 20 ft. in length. Line pipe and pipe for power-plant use are sometimes made in double lengths of 30 to 35 ft.

Nipple—A tubular pipe fitting usually threaded on both ends and under 12 inches in length. (See Close, Short, Shoulder and Space Nipple.)

Nonreturn Valve—A stop valve whose disk can move independently of the stem so that the valve can act as a check. Such valves are largely used between boilers and headers to prevent steam from the header entering the boiler in case of tube failure or other trouble necessitating shutdown. The name "stop and check valve" is often applied to this type.

Nozzle—As applied to piping, this term refers to a flanged connection on a boiler, tank, or manifold consisting of a pipe flange, a short neck, and a riveted or welded attatchment to the boiler or other vessel.

Pipe—The name "pipe" is applied to tubular products of dimensions and materials commonly used for pipe lines and connections, formerly designated as "iron pipe size" (IPS). The outside diameter of all weights and kinds of IPS pipe is of necessity the same for a given pipe size on account of threading.

REDUCER—A fitting having a larger size at one end than at the other. They are always threaded inside, unless specified flanged or for some special joint.

RELIEF VALVE—A valve arranged to provide an automatic relief in case of excess pressure. It may be either spring loaded or of the dead-weight type.

RESISTANCE WELD—Method of manufacturing pipe by bending a plate into circular form and passing electric current through the material to obtain a welding heat.

RUN—(1) A length of pipe that is made of more than one piece of pipe. (2) The portion of any fitting having its ends "in line" or nearly so, in contradistinction to the branch or side opening, as of a tee. The two main openings of an ell also indicate its run.

RUST JOINT—Employed to secure rigid connection. The joint is made by packing an intervening space tightly with a stiff paste which oxidizes the iron, the whole rusting together and hardening into a solid mass. It generally cannot be separated except by destroying some of the pieces.

SADDLE FLANGE—Also known as "tank flange" or "boiler flange." A curved flange shaped to fit a boiler, tank, or other vessel, and receive a threaded pipe. A saddle flange is usually riveted or welded to the vessel.

SAFETY VALVE—A relief valve for expansive fluids provided with a huddling ring and chamber to control the amount of blow-back before the valve reseats.

SEAMLESS—Pipe formed by piercing and rolling a solid billet or cupping from a plate is termed "seamless."

SEMI-STEEL—A high grade of cast iron made by the addition of steel scrap to pig iron in the cupola or electric furnace. More correctly described as "high-strength gray iron." It is used to some extent for valve bodies and fittings.

SERVICE ELL—An elbow having an outside thread on one end. Also known as a street ell.

SERVICE PIPE—A pipe connecting mains with a dwelling.

SERVICE TEE—A tee having an inside thread on one end and on the branch, but an outside thread on the other end of the run. It is also known as a street tee.

SHORT NIPPLE—One whose length is a little greater than that of two threaded lengths or somewhat longer than a close nipple. It always has some unthreaded portion between the two threads.

SHOULDER NIPPLE—A nipple of any length, which has a portion of pipe between two pipe threads. As generally used, however, it is a nipple about halfway between the length of a close nipple and a short nipple.

SKELP—A piece of plate prepared by forming and bending, ready for welding into pipe. Flat plates when used for butt-welded pipe are called "skelp."

SOURCE NIPPLE—A short length of heavy-walled pipe between steam lines and the first valve of by-pass drain or instrument connections.

SPACE NIPPLE—A nipple with a portion of pipe or shoulder between the two threads. It may be of any length long enough to allow a shoulder.

SPIRAL RIVETED—A method of manufacturing pipe by coiling a plate into a helix and riveting together the overlapped edges.

SPIRAL WELDED—A method of manufacturing pipe by coiling a plate into a helix and fusion-welding the overlapped or abutted edges.

STOP AND CHECK VALVE— See Nonreturn Valve.

STOP VALVE—A valve of the gate or globe type used to shut off a line.

STRESS RELIEVING—A term applied to the process of heating welded assemblies and pipe joints to a temperature of 1100 to 1300° F to permit locked-in stresses to relieve themselves through creep.

SUCTION LIFT—The vertical distance from the level of the water supply to the center of the pump, to which must be added the loss due to friction of the water in the suction pipe.

TEE—A fitting, either cast or wrought, that has one side outlet at right angles to the run. A single outlet branch pipe. (See Branch, Bull Head, Cross-over, Double Sweep and Service.)

TOTAL HEAD—The sum of the suction lift, discharge head, and all friction loss in both suction and discharge pipes.

UNION—The usual trade term for a device used to connect pipes. It commonly consists of three pieces which are, first, the thread end fitted with exterior and interior threads; second, the bottom end fitted with interior threads and a small exterior shoulder; and third, the ring which has an inside flange at one end while the other end has an inside thread like that on the exterior of the thread end. A gasket is placed between the thread and bottom ends, which are drawn together by the ring. Unions are very extensively used, because they permit of connections with little disturbance of the pipe positions.

UNION JOINT—A pipe coupling, usually threaded, which permits disconnection without disturbing other sections.

WELDING FITTINGS—Wrought- or forged- steel elbows, tees, reducers, heads, saddles, and the like, beveled for butt welding to pipe. Fittings with hubs or with ends counterbored for fillet welding to pipe are used to some extent for small pipe sizes.

WELDING-END VALVES—Valves without end flanges and with ends tapered and beveled for butt welding to pipe. Small valves may be counterbored to provide sockets for fillet welding to pipe.

WIPED JOINT—A lead joint in which the molten solder is poured upon the desired place, after scraping and fitting the parts together. The joint is wiped up by hand with a moleskin or cloth pad while the metal is in a plastic condition.

WROUGHT PIPE—The term "wrought pipe" refers to both wrought steel and wrought iron. Wrought in this sense means "worked" as in the process of forming furnace-welded pipe from skelp, or seamless pipe from plates or billets. The expression "wrought pipe" is thus used as a distinction from cast pipe. Wrought pipe in this sense should not be confused with "wrought-iron pipe" which is only one variety of wrought pipe. When "wrought-iron pipe" is referred to, it should be designated by its complete name.

WYE (Y)—A fitting that has one side outlet at any angle other than 90 degrees. The angle is usually 45 degrees, unless another angle is specified. The fitting is usually indicated by the letter Y.

DECIMAL EQUIVALENTS

Decimals of an inch for each 64th of an Inch.
With Millimeter Equivalents

Fraction	1/64ths	Decimal	Millimeters	Fraction	1/64ths	Decimal	Millimeters
..	1	.01563	0.397	..	33	.51563	13.097
1/32	2	.03125	0.794	17/32	34	.53125	13.494
..	3	.04688	1.191	..	35	.54688	13.891
1/16	4	.0625	1.588	9/16	36	.5625	14.288
..	5	.07813	1.984	..	37	.57813	14.684
3/32	6	.09375	2.381	19/32	38	.59375	15.081
..	7	.10938	2.778	..	39	.60938	15.478
1/8	8	.125	3.175	5/8	40	.625	15.875
..	9	.14063	3.572	..	41	.64063	16.272
5/32	10	.15625	3.969	21/32	42	.65625	16.669
..	11	.17188	4.366	..	43	.67188	17.066
3/16	12	.1875	4.763	11/16	44	.6875	17.463
..	13	.20313	5.159	..	45	.70313	17.859
7/32	14	.21875	5.556	23/32	46	.71875	18.256
..	15	.23438	5.953	..	47	.73438	18.653
1/4	16	.250	6.350	3/4	48	.750	19.050
..	17	.26563	6.747	..	49	.76563	19.447
9/32	18	.28125	7.144	25/32	50	.78125	19.844
..	19	.29688	7.541	..	51	.79688	20.241
5/16	20	.3125	7.938	13/16	52	.8125	20.638
..	21	.32813	8.334	..	53	.82813	21.034
11/32	22	.34375	8.731	27/32	54	.84375	21.431
..	23	.35938	9.128	..	55	.85938	21.828
3/8	24	.375	9.525	7/8	56	.875	22.225
..	25	.39063	9.922	..	57	.89063	22.622
13/32	26	.40625	10.319	29/32	58	.90625	23.019
..	27	.42188	10.716	..	59	.92188	23.416
7/16	28	.4375	11.113	15/16	60	.9375	23.813
..	29	.45313	11.509	..	61	.95313	24.209
15/32	30	.46875	11.906	31/32	62	.96875	24.606
..	31	.48438	12.303	..	63	.98438	25.003
1/2	32	.500	12.700	1	64	1.000	25.400

WEIGHTS AND MEASURES

English and Metric Equivalents

1 pound (lb.)	= 453.6 grams.
100 lb.	= 45.36 kilos.
112 lb.	= 50.80 kilos.
1 net ton (2000 lb.)	= 907.2 kilos.
1 gross ton (2240 lb.)	= 1016 kilos.
1 kilo	= 2.2046 lb.
100 kilos	= 220.46 lb.
1 metric ton (1000 kilos)	= 2204.6 lbs. = 0.9842 gross ton = 1.1023 net tons.
1 inch	= 25.40 millimeters.
1 foot (12 inches)	= 30.48 centimeters.
1 yard (3 feet)	= 91.44 centimeters.
1 mile (1760 yards)	= 1609.35 meters.
1 millimeter	= 0.03937 inch.
1 centimeter	= 0.3937 inch.
1 meter	= 39.37 inches = 3.2808 feet.
1 kilometer	= 0.62137 mile = 1093.6 yards.
1 square inch	= 6.4516 square centimeters. = 645.16 square millimeters.
1 square foot	= 0.0929 square meter.
1 square yard	= 0.8361 square meter.
1 square millimeter	= 0.00155 square inch.
1 square centimeter	= 0.155 square inch.
1 square meter	= 10.7639 square feet. = 1.196 square yards.
1 pound per foot	= 1.4882 kilos per meter.
1 pound per yard	= 0.4961 kilo per meter.
1 pound per square inch	= 0.0703 kilo per square centimeter.
1 pound per square foot	= 4.8825 kilos per square meter.
1 kilo per meter	= 0.6720 pound per foot.
1 kilo per square millimeter	= 1422.32 pounds per square inch.
1 kilo per square centimeter	= 14.2232 pounds per square inch.
1 kilo per square meter	= 0.2048 pound per square foot. = 1.8433 pounds per square yard.

METRIC CONVERSION

Millimeters into Inches

Milli-meters	Inches	Milli-meters	Inches	Milli-meters	Inches
1	0.0394	38	1.4961	75	2.9527
2	0.0787	39	1.5354	76	2.9921
3	0.1181	40	1.5748	77	3.0315
4	0.1575	41	1.6142	78	3.0709
5	0.1968	42	1.6535	79	3.1102
6	0.2362	43	1.6929	80	3.1496
7	0.2756	44	1.7323	81	3.1890
8	0.3150	45	1.7716	82	3.2283
9	0.3543	46	1.8110	83	3.2677
10	0.3937	47	1.8504	84	3.3071
11	0.4331	48	1.8898	85	3.3464
12	0.4724	49	1.9291	86	3.3858
13	0.5118	50	1.9685	87	3.4252
14	0.5512	51	2.0079	88	3.4646
15	0.5905	52	2.0472	89	3.5039
16	0.6299	53	2.0866	90	3.5433
17	0.6693	54	2.1260	91	3.5827
18	0.7087	55	2.1653	92	3.6220
19	0.7480	56	2.2047	93	3.6614
20	0.7874	57	2.2441	94	3.7008
21	0.8268	58	2.2835	95	3.7401
22	0.8661	59	2.3228	96	3.7795
23	0.9055	60	2.3622	97	3.8189
24	0.9449	61	2.4016	98	3.8583
25	0.9842	62	2.4409	99	3.8976
26	1.0236	63	2.4803	100	3.9370
27	1.0630	64	2.5197	200	7.8740
28	1.1024	65	2.5590	300	11.8110
29	1.1417	66	2.5984	400	15.7480
30	1.1811	67	2.6378	500	19.6850
31	1.2205	68	2.6772	600	23.6220
32	1.2598	69	2.7165	700	27.5590
33	1.2992	70	2.7559	800	31.4960
34	1.3386	71	2.7953	900	35.4330
35	1.3779	72	2.8346	1000	39.3700
36	1.4173	73	2.8740		
37	1.4567	74	2.9134		

ENGINEERING CONVERSION FACTORS

Multiply	By	To Obtain
ATMOSPHERES	76.0	Cms. of mercury
Atmospheres	29.92	Inches of mercury
Atmospheres	33.90	Feet of water
Atmospheres	1.0333	Kgs./sq. cm.
Atmospheres	14.70	Lbs./sq. inch
Atmospheres	1.058	Tons/sq. ft.
BARRELS-OIL	42	Gallons-Oil
BRITISH THERMAL UNITS	0.2520	Kilogram-calories
British Thermal Units	777.5	Foot-lbs.
British Thermal Units	3.927×10^{-4}	Horsepower-hrs.
British Thermal Units	107.5	Kilogram-meters
British Thermal Units	2.928×10^{-4}	Kilowatt-hrs.
B.T.U./MIN	12.96	Foot-lbs./sec.
B.T.U./min	0.02356	Horsepower
B.T.U./min	0.01757	Kilowatts
B.T.U./min	17.57	Watts
CENTIGRAMS	0.01	Grams
CENTILITERS	0.01	Liters
CENTIMETERS	0.3937	Inches
Centimeters	0.01	Meters
Centimeters	10	Millimeters
CENTIMETERS OF MERCURY	0.01316	Atmospheres
Centimeters of mercury	0.4461	Feet of water
Centimeters of mercury	136.0	Kgs./sq. meter
Centimeters of mercury	27.85	Lbs./sq. ft.
Centimeters of mercury	0.1934	Lbs./sq. inch
CENTIMETERS/SECOND	1.969	Feet/min.
Centimeters/second	0.03281	Feet/sec.
Centimeters/second	0.036	Kilometers/hr.
Centimeters/second	0.6	Meters/min.
Centimeters/second	0.02237	Miles/hr.
Centimeters/second	3.728×10^{-4}	Miles/min.
CMS./SEC./SEC.	0.03281	Feet/sec./sec.
CUBIC CENTIMETERS	3.531×10^{-5}	Cubic feet
Cubic centimeters	6.102×10^{-2}	Cubic inches
Cubic centimeters	10^{-6}	Cubic meters
Cubic centimeters	1.308×10^{-6}	Cubic yards
Cubic centimeters	2.642×10^{-4}	Gallons
Cubic centimeters	10^{-3}	Liters
Cubic centimeters	2.113×10^{-3}	Pints (liq.)
Cubic centimeters	1.057×10^{-3}	Quarts (liq.)
CUBIC FEET	2.832×10^{4}	Cubic cms.
Cubic feet	1728	Cubic inches
Cubic feet	0.02832	Cubic meters

ENGINEERING CONVERSION FACTORS—(Continued)

Multiply	By	To Obtain
Cubic feet	0.03704	Cubic yards
Cubic feet	7.48052	Gallons
Cubic feet	28.32	Liters
Cubic feet	59.84	Pints (liq.)
Cubic feet	29.92	Quarts (liq.)
CUBIC FEET/MINUTE	472.0	Cubic cms./sec.
Cubic feet/minute	0.1247	Gallons/sec.
Cubic feet/minute	0.4720	Liters/sec.
Cubic feet/minute	62.43	Pounds of water/min.
CUBIC FEET/SECOND	0.646317	Million gals./day
Cubic feet/second	448.831	Gallons/min.
CUBIC INCHES	16.39	Cubic centimeters
Cubic inches	5.787×10^{-4}	Cubic feet
Cubic inches	1.639×10^{-5}	Cubic meters
Cubic inches	2.143×10^{-5}	Cubic yards
Cubic inches	4.329×10^{-3}	Gallons
Cubic inches	1.639×10^{-2}	Liters
Cubic inches	0.03463	Pints (liq.)
Cubic inches	0.01732	Quarts (liq.)
CUBIC METERS	10^{6}	Cubic centimeters
Cubic meters	35.31	Cubic feet
Cubic meters	61,023	Cubic inches
Cubic meters	1.308	Cubic yards
Cubic meters	264.2	Gallons
Cubic meters	10^{3}	Liters
Cubic meters	2113	Pints (liq.)
Cubic meters	1057	Quarts (liq.)
CUBIC YARDS	7.646×10^{5}	Cubic centimeters
Cubic yards	27	Cubic feet
Cubic yards	46,656	Cubic inches
Cubic yards	0.7646	Cubic meters
Cubic yards	202.0	Gallons
Cubic yards	764.6	Liters
Cubic yards	1616	Pints (liq.)
Cubic yards	807.9	Quarts (liq.)
CUBIC YARDS/MIN.	0.45	Cubic feet/sec.
Cubic yards/min.	3.367	Gallons/sec.
Cubic yards/min.	12.74	Liters/sec.
DECIGRAMS	0.1	Grams
DECILITERS	0.1	Liters
DECIMETERS	0.1	Meters
DEGREES (ANGLE)	60	Minutes
Degrees (angle)	0.01745	Radians
Degrees (angle)	3600	Seconds

ENGINEERING CONVERSION FACTORS—(Continued)

Multiply	By	To Obtain
DEGREES/SEC.	0.01745	Radians/sec.
Degrees/sec.	0.1667	Revolutions/min.
Degrees/sec.	0.002778	Revolutions/sec.
DEKAGRAMS	10	Grams
DEKALITERS	10	Liters
DEKAMETERS	10	Meters
DRAMS	27.34375	Grains
Drams	0.0625	Ounces
Drams	1.771845	Grams
FATHOMS	6	Feet
FEET	30.48	Centimeters
Feet	12	Inches
Feet	0.3048	Meters
Feet	1/3	Yards
FEET OF WATER	0.02950	Atmospheres
Feet of water	0.8826	Inches of mercury
Feet of water	0.03048	Kgs./sq. cm.
Feet of water	62.43	Lbs./sq. ft.
Feet of water	0.4335	Lbs./sq. inch
FEET/MIN.	0.5080	Centimeters/sec.
Feet/min.	0.01667	Feet/sec.
Feet/min.	0.01829	Kilometers/hr.
Feet/min.	0.3048	Meters/min.
Feet/min.	0.01136	Miles/hr.
FEET/SEC./SEC.	30.48	Cms./sec./sec.
Feet/sec./sec.	0.3048	Meters/sec./sec.
FOOT-POUNDS	1.286×10^{-3}	British Thermal Units
Foot-pounds	5.050×10^{-7}	Horsepower-hrs.
Foot-pounds	3.241×10^{-4}	Kilogram-calories
Foot-pounds	0.1383	Kilogram-meters
Foot-pounds	3.766×10^{-7}	Kilowatt-hrs.
FOOT-POUNDS/MIN.	1.286×10^{-3}	B. T. Units/min.
Foot-pounds/min.	0.01667	Foot-pounds/sec.
Foot-pounds/min.	3.030×10^{-5}	Horsepower
Foot-pounds/min.	3.241×10^{-4}	Kg.-calories/min.
Foot-pounds/min.	2.260×10^{-5}	Kilowatts
FOOT-POUNDS/SEC.	7.717×10^{-2}	B. T. Units/min.
Foot-pounds/sec.	1.818×10^{-3}	Horsepower
Foot-pounds/sec.	1.945×10^{-2}	Kg.-calories/min.
Foot-pounds/sec.	1.356×10^{-3}	Kilowatts
GALLONS	3785	Cubic centimeters
Gallons	0.1337	Cubic feet
Gallons	231	Cubic inches

ENGINEERING CONVERSION FACTORS—(Continued)

Multiply	By	To Obtain
Gallons	3.785×10^{-3}	Cubic meters
Gallons	4.951×10^{-3}	Cubic yards
Gallons	3.785	Liters
Gallons	8	Pints (liq.)
Gallons	4	Quarts (liq.)
Gallons, Imperial	1.20095	U. S. Gallons
Gallons, U. S.	0.83267	Imperial gallons
Gallons water	8.3453	Pounds of water
Gallons/min.	2.228×10^{-3}	Cubic feet/sec.
Gallons/min.	0.06308	Liters/sec.
Gallons/min.	8.0208	Cu. ft./hr.
Gallons water/min.	6.0086	Tons water/24 hrs.
Grains (troy)	1	Grains (avoir.)
Grains (troy)	0.06480	Grams
Grains (troy)	0.04167	Pennyweights (troy)
Grains (troy)	2.0833×10^{-3}	Ounces (troy)
Grains/U. S. gal.	17.118	Parts/million
Grains/U. S. gal.	142.86	Lbs./million gal.
Grains/Imp. gal.	14.286	Parts/million
Grams	980.7	Dynes
Grams	15.43	Grains
Grams	10^{-3}	Kilograms
Grams	10^{3}	Milligrams
Grams	0.03527	Ounces
Grams	0.03215	Ounces (troy)
Grams	2.205×10^{-3}	Pounds
Grams/cm.	5.600×10^{-3}	Pounds/inch
Grams/cu. cm.	62.43	Pounds/cubic foot
Grams/cu. cm.	0.03613	Pounds/cubic inch
Grams/liter	58.417	Grains/gal.
Grams/liter	8.345	Pounds/1000 gals.
Grams/liter	0.062427	Pounds/cubic foot
Grams/liter	1000	Parts/million
Hectograms	100	Grams
Hectoliters	100	Liters
Hectometers	100	Meters
Hectowatts	100	Watts
Horsepower	42.44	B. T. Units/min.
Horsepower	33,000	Foot-lbs./min.
Horsepower	550	Foot-lbs./sec.
Horsepower	1.014	Horsepower (Metric)

ENGINEERING CONVERSION FACTORS—(Continued)

Multiply	By	To Obtain
Horsepower	10.70	Kg.-calories/min.
Horsepower	0.7457	Kilowatts
Horsepower	745.7	Watts
HORSEPOWER (BOILER)	33,479	B. T. U./hr.
Horsepower (boiler)	9.803	Kilowatts
HORSEPOWER-HOURS	2547	British Thermal Units
Horsepower-hours	1.98×10^6	Foot-lbs.
Horsepower-hours	641.7	Kilogram-calories
Horsepower-hours	2.737×10^5	Kilogram-meters
Horsepower-hours	0.7457	Kilowatt-hours
INCHES	2.540	Centimeters
INCHES OF MERCURY	0.03342	Atmospheres
Inches of mercury	1.133	Feet of water
Inches of mercury	0.03453	Kgs./sq. cm.
Inches of mercury	70.73	Lbs./sq. ft.
Inches of mercury	0.4912	Lbs./sq. inch
INCHES OF WATER	0.002458	Atmospheres
Inches of water	0.07355	Inches of mercury
Inches of water	0.002540	Kgs./sq. cm.
Inches of water	0.5781	Ounces/sq. inch
Inches of water	5.202	Lbs./sq. foot
Inches of water	0.03613	Lbs./sq. inch
KILOGRAMS	980,665	Dynes
Kilograms	2.205	Lbs.
Kilograms	1.102×10^{-3}	Tons (short)
Kilograms	10^3	Grams
KGS./METER	0.6720	Lbs./foot
KGS./SQ. CM.	0.9678	Atmospheres
Kgs./sq. cm.	32.81	Feet of water
Kgs./sq. cm.	28.96	Inches of mercury
Kgs./sq. cm.	2048	Lbs./sq. foot
Kgs./sq. cm.	14.22	Lbs./sq. inch
KGS./SQ. MILLIMETER	10^6	Kgs./sq. meter
KILOLITERS	10^3	Liters
KILOMETERS	10^5	Centimeters
Kilometers	3281	Feet
Kilometers	10^3	Meters
Kilometers	0.6214	Miles
Kilometers	1094	Yards
KILOMETERS/HR.	27.78	Centimeters/sec.
Kilometers/hr.	54.68	Feet/min.
Kilometers/hr.	0.9113	Feet/sec.
Kilometers/hr.	0.5396	Knots
Kilometers/hr.	16.67	Meters/min.

ENGINEERING CONVERSION FACTORS—(Continued)

Multiply	By	To Obtain
Kilometers/hr.	0.6214	Miles/hr.
Kms./hr./sec.	27.78	Cms./sec./sec.
Kms./hr./sec.	0.9113	Ft./sec./sec.
Kms./hr./sec.	0.2778	Meters/sec./sec.
Kilowatts	56.92	B. T. Units/min.
Kilowatts	4.425×10^4	Foot-lbs./min.
Kilowatts	737.6	Foot-lbs./sec.
Kilowatts	1.341	Horsepower
Kilowatts	14.34	Kg.-calories/min.
Kilowatts	10^3	Watts
Kilowatt-hours	3415	British Thermal Units
Kilowatt-hours	2.655×10^6	Foot-lbs.
Kilowatt-hours	1.341	Horsepower-hrs.
Kilowatt-hours	860.5	Kilogram-calories
Kilowatt-hours	3.671×10^5	Kilogram-meters
Liters	10^3	Cubic centimeters
Liters	0.03531	Cubic feet
Liters	61.02	Cubic inches
Liters	10^{-3}	Cubic meters
Liters	1.308×10^{-3}	Cubic yards
Liters	0.2642	Gallons
Liters	2.113	Pints (liq.)
Liters	1.057	Quarts (liq.)
Liters/min.	5.886×10^{-4}	Cubic ft./sec.
Liters/min.	4.403×10^{-3}	Gals./sec.
$\frac{\text{Lumber Width (in.)} \times \text{Thickness (in.)}}{12}$	Length (ft.)	Board feet
Meters	100	Centimeters
Meters	3.281	Feet
Meters	39.37	Inches
Meters	10^{-3}	Kilometers
Meters	10^3	Millimeters
Meters	1.094	Yards
Meters/min.	1.667	Centimeters/sec.
Meters/min.	3.281	Feet/min.
Meters/min.	0.05468	Feet/sec.
Meters/min.	0.06	Kilometers/hr.
Meters/min.	0.03728	Miles/hr.
Meters/sec.	196.8	Feet/min.
Meters/sec.	3.281	Feet/sec.
Meters/sec.	3.6	Kilometers/hr.
Meters/sec.	0.06	Kilometers/min.
Meters/sec.	2.237	Miles/hr.
Meters/sec.	0.03728	Miles/min.

ENGINEERING CONVERSION FACTORS—(Continued)

Multiply	By	To Obtain
MILES	1.609×10^5	Centimeters
Miles	5280	Feet
Miles	1.609	Kilometers
Miles	1760	Yards
MILES/HR.	44.70	Centimeters/sec.
Miles/hr.	88	Feet/min.
Miles/hr.	1.467	Feet/sec.
Miles/hr.	1.609	Kilometers/hr.
Miles/hr.	0.8684	Knots
Miles/hr.	26.82	Meters/min.
MILES/MIN.	2682	Centimeters/sec.
Miles/min.	88	Feet/sec.
Miles/min.	1.609	Kilometers/min.
Miles/min.	60	Miles/hr.
MILLIGRAMS	10^{-3}	Grams
MILLILITERS	10^{-3}	Liters
MILLIMETERS	0.1	Centimeters
Millimeters	0.03937	Inches
MILLIGRAMS/LITER	1	Parts/million
MILLION GALS./DAY	1.54723	Cubic ft./sec.
MINER'S INCHES	1.5	Cubic ft./min.
MINUTES (ANGLE)	2.909×10^{-4}	Radians
OUNCES	16	Drams
Ounces	437.5	Grains
Ounces	0.0625	Pounds
Ounces	28.349527	Grams
Ounces	0.9115	Ounces (troy)
Ounces	2.790×10^{-5}	Tons (long)
Ounces	2.835×10^{-5}	Tons (metric)
OUNCES, TROY	480	Grains
Ounces, troy	20	Pennyweights (troy)
Ounces, troy	0.08333	Pounds (troy)
Ounces, troy	31.103481	Grams
Ounces, troy	1.09714	Ounces (avoir.)
OUNCES (FLUID)	1.805	Cubic inches
Ounces (fluid)	0.02957	Liters
OUNCES/SQ. INCH	0.0625	Lbs./sq. inch
PARTS/MILLION	0.0584	Grains/U. S. gal.
Parts/million	0.07016	Grains/Imp. gal.
Parts/million	8.345	Lbs./million gal.
PENNYWEIGHTS (TROY)	24	Grains
Pennyweights (troy)	1.55517	Grams

ENGINEERING CONVERSION FACTORS—(Continued)

Multiply	By	To Obtain
Pennyweights (troy)	0.05	Ounces (troy)
Pennyweights (troy)	4.1667×10^{-3}	Pounds (troy)
Pounds	16	Ounces
Pounds	256	Drams
Pounds	7000	Grains
Pounds	0.0005	Tons (short)
Pounds	453.5924	Grams
Pounds	1.21528	Pounds (troy)
Pounds	14.5833	Ounces (troy)
Pounds (troy)	5760	Grains
Pounds (troy)	240	Pennyweights (troy)
Pounds (troy)	12	Ounces (troy)
Pounds (troy)	373.24177	Grams
Pounds (troy)	0.822857	Pounds (avoir.)
Pounds (troy)	13.1657	Ounces (avoir.)
Pounds (troy)	3.6735×10^{-4}	Tons (long)
Pounds (troy)	4.1143×10^{-4}	Tons (short)
Pounds (troy)	3.7324×10^{-4}	Tons (metric)
Pounds of water	0.01602	Cubic feet
Pounds of water	27.68	Cubic inches
Pounds of water	0.1198	Gallons
Pounds of water/min.	2.670×10^{-4}	Cubic ft./sec.
Pounds/cubic foot	0.01602	Grams/cubic cm.
Pounds/cubic foot	16.02	Kgs./cubic meter
Pounds/cubic foot	5.787×10^{-4}	Lbs./cubic inch
Pounds/cubic inch	27.68	Grams/cubic cm.
Pounds/cubic inch	2.768×10^{4}	Kgs./cubic meter
Pounds/cubic inch	1728	Lbs./cubic foot
Pounds/foot	1.488	Kgs./meter
Pounds/inch	178.6	Grams/cm.
Pounds/sq. foot	0.01602	Feet of water
Pounds/sq. foot	4.883×10^{-4}	Kgs./sq. cm.
Pounds/sq. foot	6.945×10^{-3}	Pounds/sq. inch
Pounds/sq. inch	0.06804	Atmospheres
Pounds/sq. inch	2.307	Feet of water
Pounds/sq. inch	2.036	Inches of mercury
Pounds/sq. inch	0.07031	Kgs./sq. cm.
Quarts (dry)	67.20	Cubic inches
Quarts (liq.)	57.75	Cubic inches
Quintal, Argentine	101.28	Pounds
Quintal, Brazil	129.54	Pounds
Quintal, Castile, Peru	101.43	Pounds
Quintal, Chile	101.41	Pounds

ENGINEERING CONVERSION FACTORS — (Continued)

Multiply	By	To Obtain
Quintal, Mexico	101.47	Pounds
Quintal, Metric	220.46	Pounds
TEMP. (°C.)+273	1	Abs. temp. (°C.)
Temp. (°C.)+17.78	1.8	Temp. (°F.)
Temp. (°F.)+460	1	Abs. temp. (°F.)
Temp. (°F.)—32	5/9	Temp. (°C.)
TONS (LONG)	1016	Kilograms
Tons (long)	2240	Pounds
Tons (long)	1.12000	Tons (short)
TONS (METRIC)	10^3	Kilograms
Tons (metric)	2205	Pounds
TONS (SHORT)	2000	Pounds
Tons (short)	32000	Ounces
Tons (short)	907.18486	Kilograms
Tons (short)	2430.56	Pounds (troy)
Tons (short)	0.89287	Tons (long)
Tons (short)	29166.66	Ounces (troy)
Tons (short)	0.90718	Tons (metric)
TONS OF WATER/24 HRS.	83.333	Pounds water/hour
Tons of water/24 hrs.	0.16643	Gallons/min.
Tons of water/24 hrs.	1.3349	Cu. ft./hr.
WATTS	0.05692	B. T. Units/min.
Watts	44.26	Foot-pounds/min.
Watts	0.7376	Foot-pounds/sec.
Watts	1.341×10^{-3}	Horsepower
Watts	0.01434	Kg.-calories/min.
Watts	10^{-3}	Kilowatts
WATT-HOURS	3.415	British Thermal Units
Watt-hours	2655	Foot-pounds
Watt-hours	1.341×10^{-3}	Horsepower-hours
Watt-hours	0.8605	Kilogram-calories
Watt-hours	367.1	Kilogram-meters
Watt-hours	10^{-3}	Kilowatt-hours

INTERCONVERSION TABLE FOR UNITS OF ENERGY

Multiply by

To Convert from	To B.t.u.	To Cal.	To Ft.-Lb.	To Ft. Tons	To Kg-m.	To Hp-hr.	To Kw-hr.	To Joules (abs.)	To Lb. C.	To Lb. H_2O
B.t.u. (mean)	1.00	0.252	778.000	0.389001	107.563	$0.0_{3}3929$	$0.0_{3}2931$	1054.8	0.046876	0.001031
Calories (mean)	3.968	1.000	3091.36	1.544	426.84	0.001559	0.001163	4185	$0.0_{3}2729$	0.004089
Ft.-lb.	0.001285	$0.0_{3}3239$	1.000	0.000500	0.1383	$0.0_{6}5050$	$0.0_{6}3767$	1.355	$0.0_{7}8840$	$0.0_{5}1325$
Ft. Tons	2.571	0.6478	2000.00	1.000	276.511	0.001010	$0.0_{3}7535$	2712.59	$0.0_{3}1768$	0.002649
Kg-m.	0.009297	0.002343	7.23301	0.003617	1.000	$0.0_{5}3653$	$0.0_{5}2725$	9.806	$0.0_{6}6394$	$0.0_{5}9580$
Hp-hr.	2544.99	641.327	1980000	990.004	273747	1.000	0.746000	2685600	0.1750	2.62261
Kw-hr.	3411.57	859.702	2654200	1327.10	366959	1.34041	1.000	3600000	0.2346	3.51562
Joules (absolute)	$0.0_{3}9477$	$0.0_{3}2389$	0.737356	$0.0_{3}3687$	0.101937	$0.0_{6}3725$	$0.0_{6}2778$	1.000	$0.0_{7}6518$	$0.0_{6}9766$
Lbs. C.	14544	3665	113150_{3}	5658	1564396	5.714	4.263	153470_{3}	1.000	14.98
Lbs. H_2O	970.40	244.537	754971	377.487	104379	0.381270	0.284424	1023966	0.06674	1.000

NOTE: The small subnumeral following a zero indicates that the zero is to be taken that number of times, thus, $0.0_{3}1428$ is equivalent to 0.0001428.

The ton used is 2000 lb. "Lb. C" refers to pounds of carbon oxidized, 100% efficiency equivalent to the corresponding number of heat units. "Lb. H_2O" refers to pounds of water evaporated at 100° C. (212° F.) at 100% efficiency.

TEMPERATURE CONVERSION TABLE

Degrees Centigrade and Fahrenheit

C	F	C	F	C	F
0	32	580	1076	980	1796
100	212	590	1094	990	1814
200	392	600	1112	1000	1832
210	410	610	1130	1010	1850
220	428	620	1148	1020	1868
230	446	630	1166	1030	1886
240	464	640	1184	1040	1904
250	482	650	1202	1050	1922
260	500	660	1220	1060	1940
270	518	670	1238	1070	1958
280	536	680	1256	1080	1976
290	554	690	1274	1090	1994
300	572	700	1292	1100	2012
310	590	710	1310	1110	2030
320	608	720	1328	1120	2048
330	626	730	1346	1130	2066
340	644	740	1364	1140	2084
350	662	750	1382	1150	2102
360	680	760	1400	1160	2120
370	698	770	1418	1170	2138
380	716	780	1436	1180	2156
390	734	790	1454	1190	2174
400	752	800	1472	1200	2192
410	770	810	1490	1210	2210
420	788	820	1508	1220	2228
430	806	830	1526	1230	2246
440	824	840	1544	1240	2264
450	842	850	1562	1250	2282
460	860	860	1580	1260	2300
470	878	870	1598	1270	2318
480	896	880	1616	1280	2336
490	914	890	1634	1290	2354
500	932	900	1652	1300	2372
510	950	910	1670	1310	2390
520	968	920	1688	1320	2408
530	986	930	1706	1330	2426
540	1004	940	1724	1340	2444
550	1022	950	1742	1350	2462
560	1040	960	1760	1360	2480
570	1058	970	1778	1370	2498

TEMPERATURE CONVERSION TABLE — (Continued)

C	F	C	F	C	F
1380	2516	1480	2696	1580	2876
1390	2534	1490	2714	1590	2894
1400	2552	1500	2732	1600	2912
1410	2570	1510	2750	1610	2930
1420	2588	1520	2768	1620	2948
1430	2606	1530	2786	1630	2966
1440	2624	1540	2804	1640	2984
1450	2642	1550	2822	1650	3002
1460	2660	1560	2840	1660	3020
1470	2678	1570	2858	1670	3038

FORMULAS

To convert Fahrenheit to Centigrade:
Subtract 32 from Fahrenheit temperature and multiply by .55556.

To convert Centigrade to Fahrenheit:
Multiply Centigrade temperature by 1.8 and add 32.

CHEMICAL ELEMENTS

Name	Symbol	Atomic Number	Atomic Weight	Melting Point °F	Melting Point °C
Actinium	Ac	89	227.05	2900	1600
Aluminum	Al	13	26.97	1220.4	660.2
Americium	Am	95	241	....	....
Antimony	Sb	51	121.76	1166.9	630.5
Argon	A	18	39.944	—308.9	—189.4
Arsenic	As	33	74.91	1497	814
Astatine	At	85	211	....	....
Barium	Ba	56	137.36	1300	704
Beryllium	Be	4	9.02	2340	1280
Bismuth	Bi	83	209.00	520.3	271.3
Boron	B	5	10.82	4200	2300
Bromine	Br	35	79.916	+19.0	—7.2
Cadmium	Cd	48	112.41	609.6	320.9
Calcium	Ca	20	40.08	1560	850
Carbon	C	6	12.010	6700	3700
Cerium	Ce	58	140.13	1100	600
Cesium	Cs	55	132.91	82	28
Chlorine	Cl	17	35.457	—150	—101
Chromium	Cr	24	52.01	3430	1890
Cobalt	Co	27	58.94	2723	1495
Columbium	Cb	41	92.91	4380	2415
Copper	Cu	29	63.54	1981.4	1083
Curium	Cm	96	242	....	....
Dysprosium	Dy	66	162.46	....	....
Erbium	Er	68	167.2	....	....
Europium	Eu	63	152.0	....	....
Fluorine	F	9	19.00	—370	—223
Francium	Fa or Fr	87	223	....	....
Gadolinium	Gd	64	156.9	....	....
Gallium	Ga	31	69.72	85.6	29.78
Germanium	Ge	32	72.60	1760	958
Glucinum=Beryllium	....	..	....	....	....
Gold	Au	79	197.2	1945.4	1063
Hafnium	Hf	72	178.6	3100	1700
Helium	He	2	4.003	—456.5	—271.4
Holmium	Ho	67	164.94	....	....
Hydrogen	H	1	1.0080	—434.6	—259.4
Illinium	Il	61	147	....	....
Indium	In	49	114.76	313.5	156.4
Iodine	I	53	126.92	237	114
Iridium	Ir	77	193.1	4449	2454
Iron	Fe	26	55.85	2802	1539
Krypton	Kr	36	83.7	—251	—157
Lanthanum	La	57	138.92	1519	826
Lead	Pb	82	207.21	621.3	327.4
Lithium	Li	3	6.940	367	186
Lutecium	Lu	71	174.99	....	....
Magnesium	Mg	12	24.32	1202	650
Manganese	Mn	25	54.93	2273	1245
Mercury	Hg	80	200.61	—37.97	—38.87

CHEMICAL ELEMENTS

Name	Symbol	Atomic Number	Atomic Weight	Melting Point °F	Melting Point °C
Molybdenum	Mo	42	95.95	4760	2625
Neodymium	Nd	60	144.27	1540	840
Neon	Ne	10	20.183	—415.5	—248.6
Neoytterbium=Ytterbium	....	..	....	....	....
Neptunium	Np	93	237	....	....
Nickel	Ni	28	58.69	2651	1455
Niobium=Columbium	....	..	....	....	....
Niton=Radon	....	..	....	....	....
Nitrogen	N	7	14.008	—346	—210
Osmium	Os	76	190.2	4900	2700
Oxygen	O	8	16.0000	—361.8	—218.8
Palladium	Pd	46	106.7	2829	1554
Phosphorus	P	15	30.98	111.4	44.1
Platinum	Pt	78	195.23	3224.3	1773.5
Plutonium	Pu	94	239	....	....
Polonium	Po	84	210	1100	600
Potassium	K	19	39.096	145	63
Praseodymium	Pr	59	140.92	1700	940
Protoactinium	Pa	91	231	5400	3000
Radium	Ra	88	226.05	1300	700
Radon	Rn	86	222	—96	—71
Rhenium	Re	75	186.31	5740	3170
Rhodium	Rh	45	102.91	3571	1966
Rubidium	Rb	37	85.48	102	39
Ruthenium	Ru	44	101.7	4500	2500
Samarium	Sm	62	150.43	>2370	>1300
Scandium	Sc	21	45.10	2190	1200
Selenium	Se	34	78.96	428	220
Silicon	Si	14	28.06	2605	1430
Silver	Ag	47	107.880	1760.9	960.5
Sodium	Na	11	22.997	207.9	97.7
Strontium	Sr	38	87.63	1420	770
Sulfur	S	16	32.066	246.2	119
Tantalum	Ta	73	180.88	5425	2996
Technetium	Tc	43	99	4900	2700
Tellurium	Te	52	127.61	840	450
Terbium	Tb	65	159.2	621	327
Thallium	Tl	81	204.39	572	300
Thorium	Th	90	232.12	3300	1800
Thulium	Tm	69	169.4	....	....
Tin	Sn	50	118.70	449.4	231.9
Titanium	Ti	22	47.90	3300	1820
Tungsten	W	74	183.92	6170	3410
Uranium	U	92	238.07	2065	1130
Vanadium	V	23	50.95	3150	1735
Xenon	Xe	54	131.3	—170	—112
Ytterbium	Yb	70	173.04	....	....
Yttrium	Y	39	88.92	2700	1490
Zinc	Zn	30	65.38	787.03	419.46
Zirconium	Zr	40	91.22	3200	1750

NOTES

THEORETICAL WEIGHT OF STEEL CIRCLES

DIA.	Thickness, Inches 1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	1
1	.028	.042	.056	.069	.083	.097	.111	.125	.139	.153	.167	.181	.195	.223
2	.111	.166	.222	.278	.333	.389	.444	.502	.557	.612	.668	.724	.779	.892
3	.249	.375	.500	.626	.749	.874	.999	1.13	1.25	1.37	1.50	1.63	1.75	2.01
4	.444	.666	.888	1.11	1.33	1.55	1.78	2.01	2.23	2.45	2.67	2.90	3.12	3.57
5	.693	1.04	1.388	1.74	2.08	2.43	2.78	3.14	3.48	3.89	4.18	4.52	4.87	5.58
6	.998	1.50	2.00	2.51	3.00	3.50	4.00	4.52	5.01	5.51	6.01	6.51	7.01	8.30
7	1.36	2.04	2.72	3.41	4.08	4.76	5.44	6.15	6.82	7.50	8.19	8.87	9.55	10.93
8	1.77	2.66	3.55	4.45	5.33	6.22	7.11	8.03	8.91	9.80	10.69	11.58	12.47	14.28
9	2.25	3.37	4.50	5.69	6.74	7.87	9.00	10.16	11.28	12.41	13.53	14.66	15.78	18.07
10	2.77	4.16	5.55	6.96	8.33	9.72	11.11	12.54	13.93	15.36	16.71	18.10	19.49	22.31
11	3.35	5.04	6.72	8.42	10.07	11.76	13.44	15.18	16.85	18.53	20.21	21.90	23.58	26.99
12	3.99	5.99	8.00	10.02	11.99	13.99	15.99	18.06	20.05	22.05	24.06	26.06	28.06	32.12
13	4.69	7.03	9.38	11.76	14.07	16.42	18.77	21.11	23.53	25.88	28.23	30.58	32.93	37.70
14	5.43	8.16	10.88	13.64	16.32	19.04	21.77	24.58	26.29	30.02	32.74	35.47	38.19	43.72
15	6.24	9.37	12.49	15.66	18.73	21.86	24.99	28.22	31.33	33.46	37.59	40.71	43.84	50.19
16	7	11	15	18	22	25	29	32	35	39	42	46	49	56
17	8	12	16	20	24	28	32	36	40	44	48	52	56	64
18	9	14	18	23	27	32	36	40	45	49	54	58	63	71
19	10	15	20	25	30	35	40	45	50	55	60	65	70	80
20	11	17	23	28	34	39	45	50	55	61	66	72	77	88
21	12	19	25	31	37	43	49	55	61	67	73	79	85	97
22	14	20	27	34	41	47	54	60	67	73	80	87	93	107
23	15	22	30	37	44	52	59	66	73	80	88	95	102	117
24	16	24	32	40	48	56	64	71	79	87	95	103	111	127
25	18	26	35	44	53	61	70	78	86	95	103	112	121	138
26	19	28	38	47	56	66	75	84	93	103	112	121	131	149
27	20	30	41	51	61	71	81	91	101	111	121	131	141	161
28	22	33	44	55	65	76	87	97	108	119	130	141	152	173
29	24	35	47	59	71	82	94	104	116	127	139	151	163	186
30	25	38	50	63	75	88	100	112	124	137	149	162	174	199
31	27	40	54	67	80	94	107	119	133	146	159	173	186	212
32	29	43	57	71	86	100	114	127	141	156	170	184	198	226
33	30	45	61	76	91	106	121	135	150	165	180	196	211	241
34	32	48	65	81	97	113	129	144	160	176	192	208	224	255
35	34	51	68	85	102	119	136	152	169	186	203	220	237	271
36	36	54	72	90	108	126	144	162	180	198	216	234	252	288
37	38	57	76	95	115	134	153	172	191	210	229	248	267	306
38	40	60	80	100	121	141	161	181	201	221	241	261	281	322
39	42	64	85	106	127	148	169	190	212	233	254	275	296	338
40	45	67	89	111	134	156	178	200	223	245	267	289	312	356
41	47	70	94	117	141	164	187	211	234	258	281	304	327	374
42	49	74	98	123	148	172	197	221	246	270	295	319	344	394
43	52	77	103	129	155	180	206	232	258	283	309	335	360	412
44	54	81	108	135	162	188	215	242	269	296	323	350	377	430
45	56	85	113	141	169	197	225	253	282	310	338	366	394	450
46	59	88	118	147	177	206	235	265	294	324	353	383	412	475
47	62	92	123	154	185	215	246	277	308	338	369	399	430	492
48	64	96	128	160	193	225	257	289	321	353	385	417	449	514

THEORETICAL WEIGHT OF STEEL CIRCLES (Continued)

DIA.	Thickness, Inches 1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	1
49	67	100	134	167	201	234	267	301	334	367	401	434	467	534
50	70	105	139	174	209	244	279	313	348	383	418	452	487	558
51	....	109	145	181	217	253	289	325	362	398	434	470	506	578
52	....	113	151	188	226	263	301	339	376	414	452	489	527	602
53	....	117	156	195	235	273	313	352	391	430	469	508	547	626
54	....	122	162	203	244	284	325	365	406	446	487	527	568	650
55	....	126	168	210	253	295	337	379	421	463	505	547	589	674
56	....	131	175	218	262	305	349	393	436	480	524	567	610	698
57	....	136	181	226	272	317	362	407	453	498	543	587	633	724
58	....	141	187	234	281	328	375	421	468	515	562	609	655	750
59	....	145	194	242	291	339	387	436	484	533	581	629	678	774
60	....	150	200	250	301	351	401	451	501	551	601	651	701	802
61	....	155	207	259	311	362	414	466	518	569	621	673	724	828
62	....	161	214	268	321	375	428	482	535	589	642	695	749	856
63	....	166	221	276	332	387	442	497	553	608	663	718	774	884
64	....	171	228	285	342	399	456	513	570	627	684	741	798	912
65	....	177	235	294	353	412	471	529	588	647	706	764	823	942
66	....	182	243	303	364	425	485	546	607	667	728	788	848	970
67	....	188	250	313	375	438	500	563	625	688	750	812	874	1000
68	....	193	257	322	386	450	515	579	643	708	772	836	900	1030
69	....	199	265	331	398	464	530	596	663	729	795	861	927	1060
70	....	205	273	341	409	477	545	613	682	750	818	886	954	1090
71	....	211	281	351	421	491	561	631	702	772	842	912	982	1122
72	....	217	289	361	433	505	577	649	722	794	866	937	1009	1154
73	....	223	297	371	445	519	593	667	742	816	890	964	1038	1186
74	....	226	305	381	458	534	610	686	763	839	915	990	1066	1220
75	....	235	313	391	470	548	626	704	783	861	939	1017	1095	1252
76	....	....	322	402	482	563	643	723	804	884	964	1045	1125	1286
77	....	....	330	413	495	578	660	743	825	908	990	1073	1155	1320
78	....	....	339	423	508	593	678	762	847	932	1016	1101	1186	1356
79	....	....	348	434	521	608	695	782	869	956	1043	1129	1216	1390
80	....	....	356	445	534	623	713	802	891	980	1069	1158	1247	1426
81	....	....	365	457	548	639	731	822	913	1004	1096	1187	1278	1462
82	....	....	374	468	561	655	749	842	936	1029	1123	1217	1310	1498
83	....	....	384	479	575	671	767	863	959	1055	1151	1246	1342	1534
84	....	....	393	491	589	687	786	884	982	1080	1179	1277	1375	1572
85	....	....	402	503	603	704	805	905	1006	1106	1207	1307	1408	1610
86	....	....	412	515	618	721	824	926	1029	1132	1235	1338	1441	1648
87	....	....	422	527	632	738	843	948	1054	1159	1265	1370	1475	1686
88	....	....	431	539	647	755	863	970	1078	1186	1294	1402	1509	1726
89	....	....	441	551	661	771	882	992	1102	1212	1323	1433	1543	1764
90	....	....	451	564	677	789	902	1015	1128	1240	1353	1466	1579	1804
91	....	....	461	576	692	807	922	1037	1153	1268	1383	1495	1614	1844
92	....	....	471	589	707	825	943	1060	1178	1296	1414	1532	1649	1886
93	....	....	482	602	722	843	963	1084	1204	1324	1445	1565	1686	1926
94	....	....	492	615	738	861	984	1107	1230	1353	1476	1599	1722	1968
95	....	....	503	628	754	879	1005	1131	1256	1382	1507	1633	1759	2010
96	....	....	513	641	769	897	1026	1154	1282	1410	1538	1666	1795	....

AREA OF RECTANGULAR SECTIONS

SQUARE INCHES

Width Inches	THICKNESS, INCHES						
	3/16	1/4	5/16	3/8	7/16	1/2	9/16
1/4	.047	.063	.078	.094	.109	.125	.141
1/2	.094	.125	.156	.188	.219	.250	.281
3/4	.141	.188	.234	.281	.328	.375	.422
1	.188	.250	.313	.375	.438	.500	.563
1 1/4	.234	.313	.391	.469	.547	.625	.703
1 1/2	.281	.375	.469	.563	.656	.750	.844
1 3/4	.328	.438	.547	.656	.766	.875	.984
2	.375	.500	.625	.750	.875	1.00	1.13
2 1/4	.422	.563	.703	.844	.984	1.13	1.27
2 1/2	.469	.625	.781	.938	1.09	1.25	1.41
2 3/4	.516	.688	.859	1.03	1.20	1.38	1.55
3	.563	.750	.938	1.13	1.31	1.50	1.69
3 1/4	.609	.813	1.02	1.22	1.42	1.63	1.83
3 1/2	.656	.875	1.09	1.31	1.53	1.75	1.97
3 3/4	.703	.938	1.17	1.41	1.64	1.88	2.11
4	.750	1.00	1.25	1.50	1.75	2.00	2.25
4 1/4	.797	1.06	1.33	1.59	1.86	2.13	2.39
4 1/2	.844	1.13	1.41	1.69	1.97	2.25	2.53
4 3/4	.891	1.19	1.48	1.78	2.09	2.38	2.67
5	.938	1.25	1.56	1.88	2.19	2.50	2.81
5 1/4	.984	1.31	1.64	1.97	2.30	2.63	2.95
5 1/2	1.03	1.38	1.72	2.06	2.41	2.75	3.09
5 3/4	1.08	1.44	1.80	2.16	2.52	2.88	3.23
6	1.13	1.50	1.88	2.25	2.63	3.00	3.38
6 1/4	1.17	1.56	1.95	2.34	2.73	3.13	3.52
6 1/2	1.22	1.63	2.03	2.44	2.84	3.25	3.66
6 3/4	1.27	1.69	2.10	2.53	2.95	3.38	3.80
7	1.31	1.75	2.19	2.63	3.06	3.50	3.94
7 1/4	1.36	1.81	2.27	2.72	3.17	3.63	4.08
7 1/2	1.41	1.88	2.34	2.81	3.28	3.75	4.22
7 3/4	1.45	1.94	2.42	2.91	3.39	3.88	4.36
8	1.50	2.00	2.50	3.00	3.50	4.00	4.50
8 1/4	1.55	2.06	2.58	3.09	3.61	4.13	4.64
8 1/2	1.59	2.13	2.66	3.19	3.72	4.25	4.78
8 3/4	1.64	2.19	2.73	3.28	3.83	4.38	4.92
9	1.69	2.25	2.81	3.38	3.94	4.50	5.06

AREA OF RECTANGULAR SECTIONS

SQUARE INCHES

Width Inches	THICKNESS, INCHES						
	5/8	11/16	3/4	13/16	7/8	15/16	1
1/4	.156	.172	.188	.203	.219	.234	.250
1/2	.313	.344	.375	.406	.438	.469	.500
3/4	.469	.516	.563	.609	.656	.703	.750
1	.625	.688	.750	.813	.875	.938	1.00
1 1/4	.781	.859	.938	1.02	1.09	1.17	1.25
1 1/2	.938	1.03	1.13	1.22	1.31	1.41	1.50
1 3/4	1.09	1.20	1.31	1.42	1.53	1.64	1.75
2	1.25	1.38	1.50	1.63	1.75	1.88	2.00
2 1/4	1.41	1.55	1.69	1.83	1.97	2.11	2.25
2 1/2	1.56	1.72	1.88	2.03	2.19	2.34	2.50
2 3/4	1.72	1.89	2.06	2.23	2.41	2.58	2.75
3	1.88	2.06	2.25	2.44	2.63	2.81	3.00
3 1/4	2.03	2.23	2.44	2.64	2.84	3.05	3.25
3 1/2	2.19	2.41	2.63	2.84	3.06	3.28	3.50
3 3/4	2.34	2.58	2.81	3.05	3.28	3.52	3.75
4	2.50	2.75	3.00	3.25	3.50	3.75	4.00
4 1/4	2.66	2.92	3.19	3.45	3.72	3.98	4.25
4 1/2	2.81	3.09	3.38	3.66	3.94	4.22	4.50
4 3/4	2.97	3.27	3.56	3.86	4.16	4.45	4.75
5	3.13	3.44	3.75	4.06	4.38	4.69	5.00
5 1/4	3.28	3.61	3.94	4.27	4.59	4.92	5.25
5 1/2	3.44	3.78	4.13	4.47	4.81	5.16	5.50
5 3/4	3.59	3.95	4.31	4.67	5.03	5.39	5.75
6	3.75	4.13	4.50	4.88	5.25	5.63	6.00
6 1/4	3.91	4.30	4.69	5.08	5.47	5.86	6.25
6 1/2	4.06	4.47	4.88	5.28	5.69	6.09	6.50
6 3/4	4.22	4.64	5.06	5.48	5.91	6.33	6.75
7	4.38	4.81	5.25	5.69	6.13	6.56	7.00
7 1/4	4.53	4.98	5.44	5.89	6.34	6.80	7.25
7 1/2	4.69	5.16	5.63	6.09	6.56	7.03	7.50
7 3/4	4.84	5.33	5.81	6.30	6.78	7.27	7.75
8	5.00	5.50	6.00	6.50	7.00	7.50	8.00
8 1/4	5.16	5.67	6.19	6.70	7.22	7.73	8.25
8 1/2	5.31	5.84	6.38	6.91	7.44	7.97	8.50
8 3/4	5.47	6.02	6.56	7.11	7.66	8.20	8.75
9	5.63	6.19	6.75	7.31	7.88	8.44	9.00

AREA OF RECTANGULAR SECTIONS

SQUARE INCHES

Width Inches	THICKNESS, INCHES						
	3/16	1/4	5/16	3/8	7/16	1/2	9/16
9 1/4	1.73	2.31	2.89	3.47	4.05	4.63	5.20
9 1/2	1.78	2.38	2.97	3.56	4.16	4.75	5.34
9 3/4	1.83	2.44	3.05	3.66	4.27	4.88	5.48
10	1.88	2.50	3.13	3.75	4.38	5.00	5.63
10 1/4	1.92	2.56	3.20	3.84	4.48	5.13	5.77
10 1/2	1.97	2.63	3.28	3.94	4.59	5.25	5.91
10 3/4	2.02	2.69	3.36	4.03	4.70	5.38	6.05
11	2.06	2.75	3.44	4.13	4.81	5.50	6.19
11 1/4	2.11	2.81	3.52	4.22	4.92	5.63	6.33
11 1/2	2.16	2.88	3.59	4.31	5.03	5.75	6.47
11 3/4	2.20	2.94	3.67	4.41	5.14	5.88	6.61
12	2.25	3.00	3.75	4.50	5.25	6.00	6.75
12 1/2	2.34	3.13	3.91	4.69	5.47	6.25	7.03
13	2.44	3.25	4.06	4.88	5.69	6.50	7.31
13 1/2	2.53	3.38	4.22	5.06	5.91	6.75	7.59
14	2.63	3.50	4.38	5.25	6.13	7.00	7.88
14 1/2	2.72	3.63	4.53	5.44	6.34	7.25	8.16
15	2.81	3.75	4.69	5.63	6.56	7.50	8.44
15 1/2	2.91	3.88	4.84	5.81	6.78	7.75	8.72
16	3.00	4.00	5.00	6.00	7.00	8.00	9.00
16 1/2	3.09	4.13	5.16	6.19	7.22	8.25	9.28
17	3.19	4.25	5.31	6.38	7.44	8.50	9.56
17 1/2	3.28	4.38	5.47	6.56	7.66	8.75	9.84
18	3.38	4.50	5.63	6.75	7.88	9.00	10.13
18 1/2	3.47	4.63	5.78	6.94	8.09	9.25	10.41
19	3.56	4.75	5.94	7.13	8.31	9.50	10.69
19 1/2	3.66	4.88	6.09	7.31	8.53	9.75	10.97
20	3.75	5.00	6.25	7.50	8.75	10.00	11.25
20 1/2	3.84	5.13	6.41	7.69	8.97	10.25	11.53
21	3.94	5.25	6.56	7.88	9.19	10.50	11.81
21 1/2	4.03	5.38	6.72	8.06	9.41	10.75	12.09
22	4.13	5.50	6.88	8.25	9.63	11.00	12.38
22 1/2	4.22	5.63	7.03	8.44	9.84	11.25	12.66
23	4.31	5.75	7.19	8.63	10.06	11.50	12.94
23 1/2	4.41	5.88	7.34	8.81	10.28	11.75	13.22
24	4.50	6.00	7.50	9.00	10.50	12.00	13.50

AREA OF RECTANGULAR SECTIONS

SQUARE INCHES

Width Inches	THICKNESS, INCHES						
	5/8	11/16	3/4	13/16	7/8	15/16	1
9 1/4	5.78	6.36	6.94	7.52	8.09	8.67	9.25
9 1/2	5.94	6.53	7.13	7.72	8.31	8.91	9.50
9 3/4	6.09	6.70	7.31	7.92	8.53	9.14	9.75
10	6.25	6.88	7.50	8.13	8.75	9.38	10.00
10 1/4	6.41	7.05	7.69	8.33	8.97	9.61	10.25
10 1/2	6.56	7.22	7.88	8.53	9.19	9.84	10.50
10 3/4	6.72	7.39	8.06	8.73	9.41	10.08	10.75
11	6.88	7.56	8.25	8.94	9.63	10.31	11.00
11 1/4	7.03	7.73	8.44	9.14	9.84	10.55	11.25
11 1/2	7.19	7.91	8.63	9.34	10.06	10.78	11.50
11 3/4	7.34	8.08	8.81	9.55	10.28	11.02	11.75
12	7.50	8.25	9.00	9.75	10.50	11.25	12.00
12 1/2	7.81	8.59	9.38	10.16	10.94	11.72	12.50
13	8.13	8.94	9.75	10.56	11.38	12.19	13.00
13 1/2	8.44	9.28	10.13	10.97	11.81	12.66	13.50
14	8.75	9.63	10.50	11.38	12.25	13.13	14.00
14 1/2	9.06	9.97	10.88	11.78	12.69	13.59	14.50
15	9.38	10.31	11.25	12.19	13.13	14.06	15.00
15 1/2	9.69	10.66	11.63	12.59	13.56	14.53	15.50
16	10.00	11.00	12.00	13.00	14.00	15.00	16.00
16 1/2	10.31	11.34	12.38	13.41	14.44	15.47	16.50
17	10.63	11.69	12.75	13.81	14.88	15.94	17.00
17 1/2	10.94	12.03	13.13	14.22	15.31	16.41	17.50
18	11.25	12.38	13.50	14.63	15.75	16.88	18.00
18 1/2	11.56	12.72	13.88	15.03	16.19	17.34	18.50
19	11.88	13.06	14.25	15.44	16.63	17.81	19.00
19 1/2	12.19	13.41	14.63	15.84	17.06	18.28	19.50
20	12.50	13.75	15.00	16.25	17.50	18.75	20.00
20 1/2	12.81	14.09	15.38	16.66	17.94	19.22	20.50
21	13.13	14.44	15.75	17.06	18.38	19.69	21.00
21 1/2	13.44	14.78	16.13	17.47	18.81	20.16	21.50
22	13.75	15.13	16.50	17.88	19.25	20.63	22.00
22 1/2	14.06	15.47	16.88	18.28	19.69	21.09	22.50
23	14.38	15.81	17.25	18.69	20.13	21.56	23.00
23 1/2	14.69	16.16	17.63	19.09	20.56	22.03	23.50
24	15.00	16.50	18.00	19.50	21.00	22.50	24.00

AREA OF RECTANGULAR SECTIONS

SQUARE INCHES

Width Inches	THICKNESS, INCHES						
	3/16	1/4	5/16	3/8	7/16	1/2	9/16
25	4.69	6.25	7.81	9.38	10.94	12.50	14.06
26	4.88	6.50	8.13	9.75	11.38	13.00	14.63
27	5.06	6.75	8.44	10.13	11.81	13.50	15.19
28	5.25	7.00	8.75	10.50	12.25	14.00	15.75
29	5.44	7.25	9.06	10.88	12.69	14.50	16.31
30	5.63	7.50	9.38	11.25	13.13	15.00	16.88
31	5.81	7.75	9.69	11.63	13.56	15.50	17.44
32	6.00	8.00	10.00	12.00	14.00	16.00	18.00
33	6.19	8.25	10.31	12.38	14.44	16.50	18.56
34	6.38	8.50	10.63	12.75	14.88	17.00	19.13
35	6.56	8.75	10.94	13.13	15.31	17.50	19.69
36	6.75	9.00	11.25	13.50	15.75	18.00	20.25
37	6.94	9.25	11.56	13.88	16.19	18.50	20.81
38	7.13	9.50	11.88	14.25	16.63	19.00	21.38
39	7.31	9.75	12.19	14.63	17.06	19.50	21.94
40	7.50	10.00	12.50	15.00	17.50	20.00	22.50
41	7.69	10.25	12.81	15.38	17.94	20.50	23.06
42	7.88	10.50	13.13	15.75	18.38	21.00	23.63
43	8.06	10.75	13.44	16.13	18.81	21.50	24.19
44	8.25	11.00	13.75	16.50	19.25	22.00	24.75
45	8.44	11.25	14.06	16.88	19.69	22.50	25.31
46	8.63	11.50	14.38	17.25	20.13	23.00	25.88
47	8.81	11.75	14.69	17.63	20.56	23.50	26.44
48	9.00	12.00	15.00	18.00	21.00	24.00	27.00
49	9.19	12.25	15.31	18.38	21.44	24.50	27.56
50	9.38	12.50	15.63	18.75	21.88	25.00	28.13
51	9.56	12.75	15.94	19.13	22.31	25.50	28.69
52	9.75	13.00	16.25	19.50	22.75	26.00	29.25
53	9.94	13.25	16.56	19.88	23.19	26.50	29.81
54	10.13	13.50	16.88	20.25	23.63	27.00	30.38
55	10.31	13.75	17.19	20.63	24.06	27.50	30.94
56	10.50	14.00	17.50	21.00	24.50	28.00	31.50
57	10.69	14.25	17.81	21.38	24.94	28.50	32.06
58	10.88	14.50	18.13	21.75	25.38	29.00	32.63
59	11.06	14.75	18.44	22.13	25.81	29.50	33.19
60	11.25	15.00	18.75	22.50	26.25	30.00	33.75

AREA OF RECTANGULAR SECTIONS

SQUARE INCHES

Width Inches	THICKNESS, INCHES						
	5/8	11/16	3/4	13/16	7/8	15/16	1
25	15.63	17.19	18.75	20.31	21.88	23.44	25.00
26	16.25	17.88	19.50	21.13	22.75	24.38	26.00
27	16.88	18.56	20.25	21.94	23.63	25.31	27.00
28	17.50	19.25	21.00	22.75	24.50	26.25	28.00
29	18.13	19.94	21.75	23.56	25.38	27.19	29.00
30	18.75	20.63	22.50	24.38	26.25	28.13	30.00
31	19.38	21.31	23.25	25.19	27.13	29.06	31.00
32	20.00	22.00	24.00	26.00	28.00	30.00	32.00
33	20.63	22.69	24.75	26.81	28.88	30.94	33.00
34	21.25	23.38	25.50	27.63	29.75	31.88	34.00
35	21.88	24.06	26.25	28.44	30.63	32.81	35.00
36	22.50	24.75	27.00	29.25	31.50	33.75	36.00
37	23.13	25.44	27.75	30.06	32.38	34.69	37.00
38	23.75	26.13	28.50	30.88	33.25	35.63	38.00
39	24.38	26.81	29.25	31.69	34.13	36.56	39.00
40	25.00	27.50	30.00	32.50	35.00	37.50	40.00
41	25.63	28.19	30.75	33.31	35.88	38.44	41.00
42	26.25	28.88	31.50	34.13	36.75	39.38	42.00
43	26.88	29.56	32.25	34.94	37.63	40.31	43.00
44	27.50	30.25	33.00	35.75	38.50	41.25	44.00
45	28.13	30.94	33.75	36.56	39.38	42.19	45.00
46	28.75	31.63	34.50	37.38	40.25	43.13	46.00
47	29.38	32.31	35.25	38.19	41.13	44.06	47.00
48	30.00	33.00	36.00	39.00	42.00	45.00	48.00
49	30.63	33.69	36.75	39.81	42.88	45.94	49.00
50	31.25	34.38	37.50	40.63	43.75	46.88	50.00
51	31.88	35.06	38.25	41.44	44.63	47.81	51.00
52	32.50	35.75	39.00	42.25	45.50	48.75	52.00
53	33.13	36.44	39.75	43.06	46.38	49.69	53.00
54	33.75	37.13	40.50	43.88	47.25	50.63	54.00
55	34.38	37.81	41.25	44.69	48.13	51.56	55.00
56	35.00	38.50	42.00	45.50	49.00	52.50	56.00
57	35.63	39.19	42.75	46.31	49.88	53.44	57.00
58	36.25	39.88	43.50	47.13	50.75	54.38	58.00
59	36.88	40.56	44.25	47.94	51.63	55.31	59.00
60	37.50	41.25	45.00	48.75	52.50	56.25	60.00

AREA OF RECTANGULAR SECTIONS

SQUARE INCHES

Width Inches	THICKNESS, INCHES						
	3/16	1/4	5/16	3/8	7/16	1/2	9/16
61	11.44	15.25	19.06	22.88	26.69	30.50	34.31
62	11.63	15.50	19.38	23.25	27.13	31.00	34.88
63	11.81	15.75	19.69	23.63	27.56	31.50	35.44
64	12.00	16.00	20.00	24.00	28.00	32.00	36.00
65	12.19	16.25	20.31	24.38	28.44	32.50	36.56
66	12.38	16.50	20.63	24.75	28.88	33.00	37.13
67	12.56	16.75	20.94	25.13	29.31	33.50	37.69
68	12.75	17.00	21.25	25.50	29.75	34.00	38.25
69	12.94	17.25	21.56	25.88	30.19	34.50	38.81
70	13.13	17.50	21.88	26.25	30.63	35.00	39.38
71	13.31	17.75	22.19	26.63	31.06	35.50	39.94
72	13.50	18.00	22.50	27.00	31.50	36.00	40.50
73	13.69	18.25	22.81	27.38	31.94	36.50	41.06
74	13.88	18.50	23.13	27.75	32.38	37.00	41.63
75	14.06	18.75	23.44	28.13	32.81	37.50	42.19
76	14.25	19.00	23.75	28.50	33.25	38.00	42.75
77	14.44	19.25	24.06	28.88	33.69	38.50	43.31
78	14.63	19.50	24.38	29.25	34.13	39.00	43.88
79	14.81	19.75	24.69	29.63	34.56	39.50	44.44
80	15.00	20.00	25.00	30.00	35.00	40.00	45.00
81	15.19	20.25	25.31	30.38	35.44	40.50	45.56
82	15.38	20.50	25.63	30.75	35.88	41.00	46.13
83	15.56	20.75	25.94	31.13	36.31	41.50	46.69
84	15.75	21.00	26.25	31.50	36.75	42.00	47.25
85	15.94	21.25	26.56	31.88	37.19	42.50	47.81
86	16.13	21.50	26.88	32.25	37.63	43.00	48.38
87	16.31	21.75	27.19	32.63	38.06	43.50	48.94
88	16.50	22.00	27.50	33.00	38.50	44.00	49.50
89	16.69	22.25	27.81	33.38	38.94	44.50	50.06
90	16.88	22.50	28.13	33.75	39.38	45.00	50.63
91	....	22.75	28.44	34.13	39.81	45.50	51.19
92	....	23.00	28.75	34.50	40.25	46.00	51.75
93	....	23.25	29.06	34.88	40.69	46.50	52.31
94	....	23.50	29.38	35.25	41.13	47.00	52.88
95	....	23.75	29.69	35.63	41.56	47.50	53.44
96	....	24.00	30.00	36.00	42.00	48.00	54.00

AREA OF RECTANGULAR SECTIONS

SQUARE INCHES

Width Inches	THICKNESS, INCHES						
	5/8	11/16	3/4	13/16	7/8	15/16	1
61	38.13	41.94	45.75	49.56	53.38	57.19	61.00
62	38.75	42.63	46.50	50.38	54.25	58.13	62.00
63	39.38	43.31	47.25	51.19	55.13	59.06	63.00
64	40.00	44.00	48.00	52.00	56.00	60.00	64.00
65	40.63	44.69	48.75	52.81	56.88	60.94	65.00
66	41.25	45.38	49.50	53.63	57.75	61.88	66.00
67	41.88	46.06	50.25	54.44	58.63	62.81	67.00
68	42.50	46.75	51.00	55.25	59.50	63.75	68.00
69	43.13	47.44	51.75	56.06	60.38	64.69	69.00
70	43.75	48.13	52.50	56.88	61.25	65.63	70.00
71	44.38	48.81	53.25	57.69	62.13	66.56	71.00
72	45.00	49.50	54.00	58.50	63.00	67.50	72.00
73	45.63	50.19	54.75	59.31	63.88	68.44	73.00
74	46.25	50.88	55.50	60.13	64.75	69.38	74.00
75	46.88	51.56	56.25	60.94	65.63	70.31	75.00
76	47.50	52.25	57.00	61.75	66.50	71.25	76.00
77	48.13	52.94	57.75	62.56	67.38	72.19	77.00
78	48.75	53.63	58.50	63.38	68. 25	73.13	78.00
79	49.38	54.31	59.25	64.19	69.13	74.06	79.00
80	50.00	55.00	60.00	65.00	70.00	75.00	80.00
81	50.63	55.69	60.75	65.81	70.88	75.94	81.00
82	51.25	56.38	61.50	66.63	71.75	76.88	82.00
83	51.88	57.06	62.25	67.44	72.63	77.81	83.00
84	52.50	57.75	63.00	68.25	73.50	78.75	84.00
85	53.13	58.44	63.75	69.06	74.38	79.69	85.00
86	53.75	59.13	64.50	69.88	75.25	80.63	86.00
87	54.38	59.81	65.25	70.69	76.13	81.56	87.00
88	55.00	60.50	66.00	71.50	77.00	82.50	88.00
89	55.63	61.19	66.75	72.31	77.88	83.44	89.00
90	56.25	61.88	67.50	73.13	78.75	84.38	90.00
91	56.88	62.56	68.25	73.94	79.63	85.31	91.00
92	57.50	63.25	69.00	74.75	80.50	86.25	92.00
93	58.13	63.94	69.75	75.56	81.38	87.19	93.00
94	58.75	64.63	70.50	76.38	82.25	88.13	94.00
95	59.38	65.31	71.25	77.19	83.13	89.06	95.00
96	60.00	66.00	72.00	78.00	84.00	90.00	96.00

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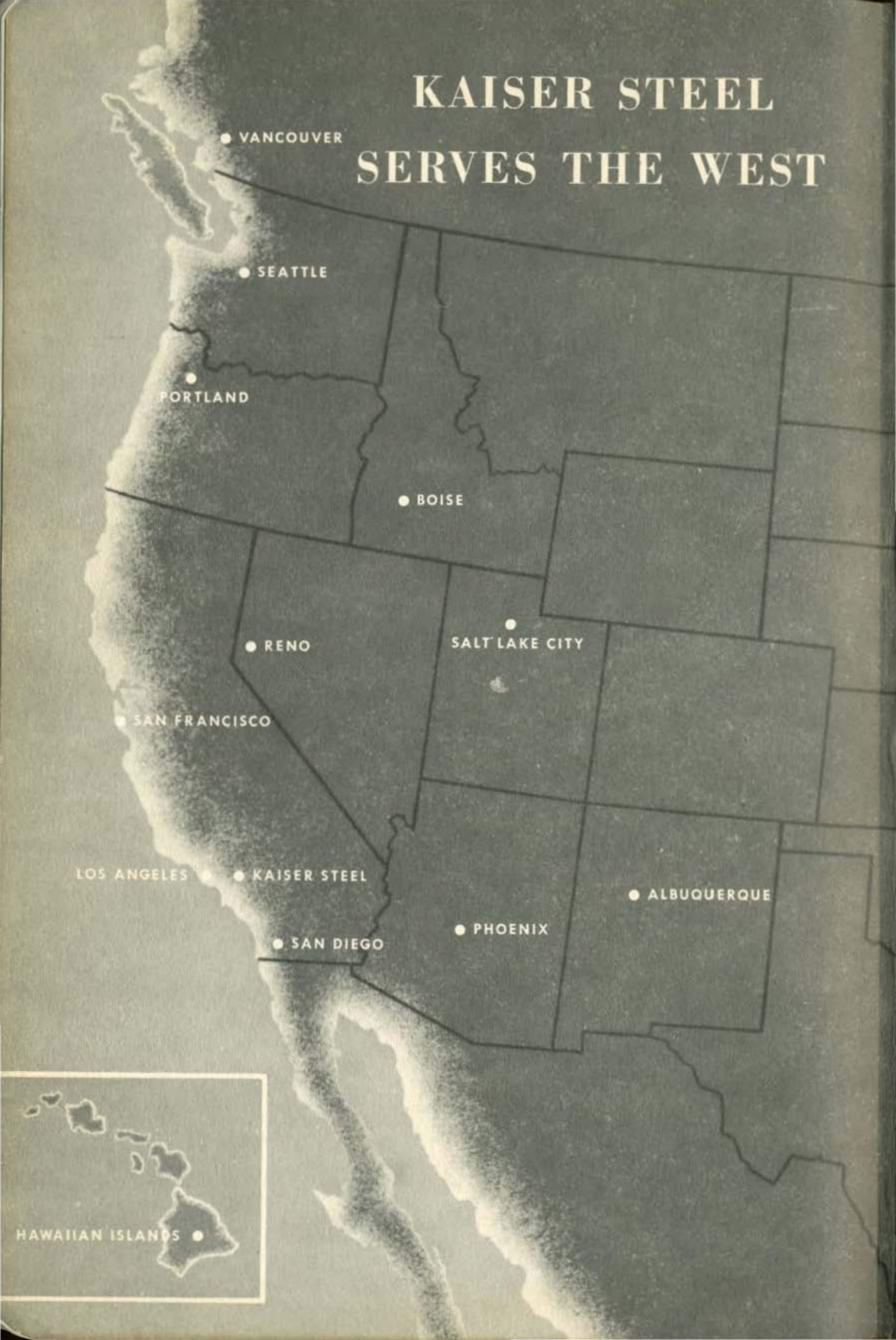
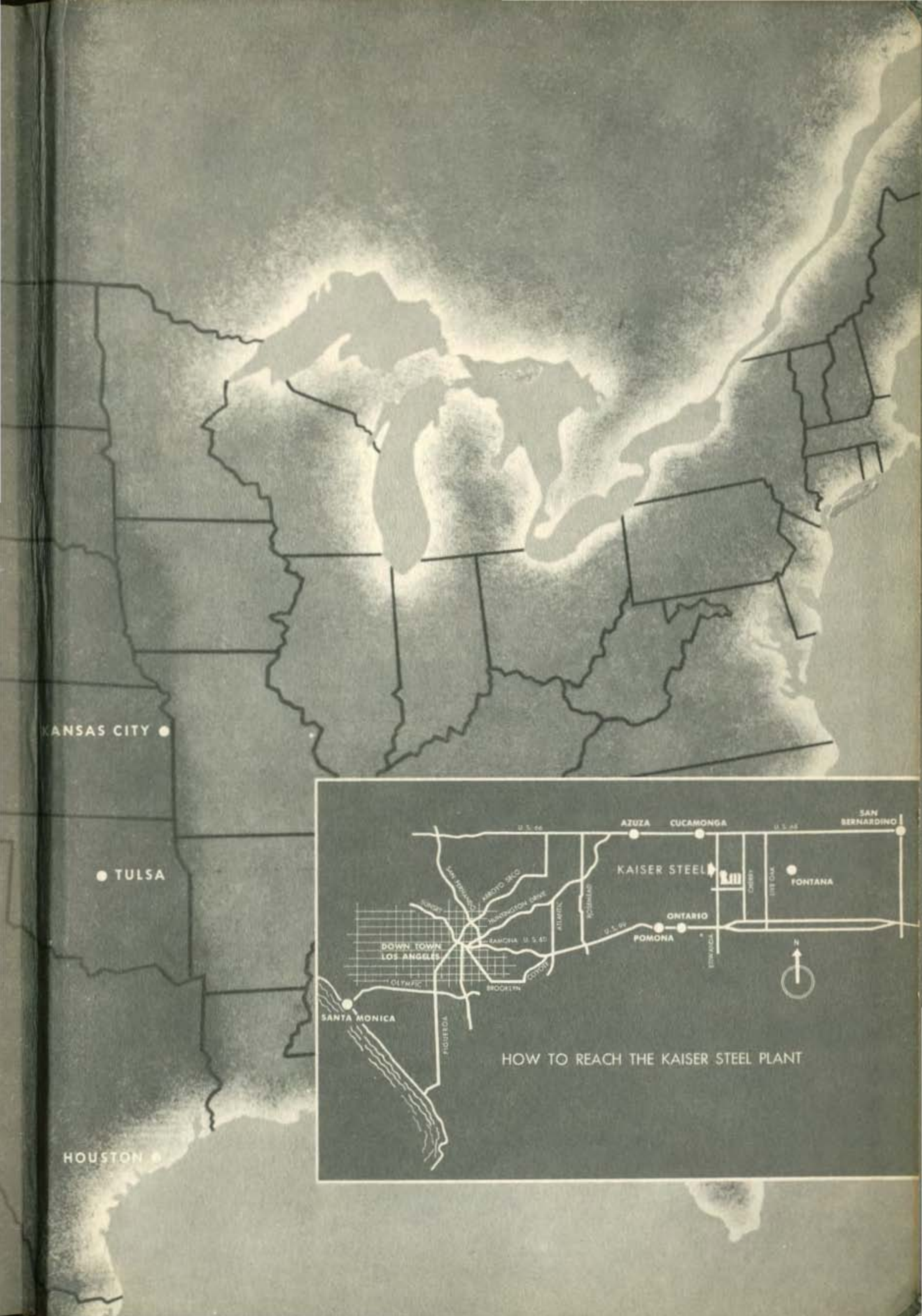

KAISER STEEL
SERVES THE WEST
VANCOUVER
SEATTLE
PORTLAND
BOISE
RENO
SALT LAKE CITY
SAN FRANCISCO
LOS ANGELES
KAISER STEEL
SAN DIEGO
PHOENIX
ALBUQUERQUE
HAWAIIAN ISLANDS



KANSAS CITY
TULSA
HOUSTON
U.S. 66
AZUZA
CUCAMONGA
SAN BERNARDINO
KAISER STEEL
FONTANA
ONTARIO
POMONA
U.S. 99
SAN FERNANDO
ARROYO SECO
SUNSET
HUNTINGTON DRIVE
RAMONA U.S. 60
ATLANTIC
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CHERRY
LIVE OAK
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DOWN TOWN LOS ANGELES
OLYMPIC
BROOKLYN
COYOTE
FIGUEROA
SANTA MONICA
N
HOW TO REACH THE KAISER STEEL PLANT