Piping Guide

THE 'PIPING GUIDE'

FOR THE DESIGN AND DRAFTING OF INDUSTRIAL PIPING SYSTEMS

David R. Sherwood
Member, American Society of Mechanical Engineers
Member, Institution of Production Engineers (UK)

Dennis J. Whistance BS, MS

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The 'PIPING GUIDE' ....

- Discusses in detail the design and drafting of piping systems
- Describes pipe, piping components most commonly used, valves, and equipment
- Presents charts, tables, and examples for daily reference
- Provides a design reference for companies and consultants
- Supplements existing company standards, information, and methods
- Serves as an instructional aid

PART I - TEXT: explains ....

- Techniques of piping design
- Assembling of piping from components, and methods for connecting to equipment
- Office organization, and methods to translate concepts into finished designs from which plants are built
- Terms and abbreviations concerned with piping

PART II - TABLES: provide .....

- Frequently needed data and information, arranged for quick reference
- Factors for establishing widths of pipeways
- Spacing between pipes, with and without flanges, and for 'jumpovers' and 'rununders'
- Principal dimensions and weights for pipe fittings, flanges, valves, structural steel, etc.
- Conversion for customary and metric units
- Direct-reading metric conversion tables for dimensions

and ....

- A metric supplement with principal dimensional data in millimeters

For PART II, turn to the back cover

The contribution of the companies, designers and engineers who assisted in the development of the **Piping Guide** is gratefully acknowledged. Apart from source material and assistance with production, acknowledged elsewhere, individual acknowledgments are not made, because neither contributors nor the authors or publisher assume liability or responsibility for designs using information presented herein. The user is responsible for complying with the various codes, standards and regulations, National, Federal, State and Municipal, and other legal obligations which may pertain to the construction and safe operation of plants, industrial installations, etc., including modifications to existing facilities.

Sections, figures, charts and tables in **Part I** are referred to numerically, and are located by the margin index. Charts and tables in **Part II** are identified by letter.

The text refers to standards and codes, using designations such as ANSI B31.1, ASTM A-53, ISA S5.1, etc. Full titles of these standards and codes will be found in tables 7.3 thru 7.14.

FOR TERMS NOT EXPLAINED IN THE TEXT, REFER TO THE INDEX.
ABBREVIATIONS ARE GIVEN IN CHAPTER 8.

PART I

CONTENTS:

PIPING: Uses, and Plant Construction

USES OF PIPING 1.1

Piping is used for industrial (process), marine, transportation, civil engineering, and for 'commercial' (plumbing) purposes.

This book is primarily concerned with industrial piping for processing and service systems. ***Process piping*** is used to transport fluids between storage tanks and processing units. ***Service piping*** is used to convey steam, air, water, etc., for processing. Piping here defined as 'service' piping is sometimes referred to as 'utility' piping, but, in the Guide, the term 'utility piping' is reserved for major lines supplying water, fuel gases, and fuel oil (that is, for commodities usually purchased from utilities companies and bulk suppliers).

Marine piping for ships is often extensive. Much of it is fabricated from welded and screwed carbon-steel piping, using pipe and fittings described in this book.

Transportation piping is normally large-diameter piping used to convey liquids, slurries and gases, sometimes over hundreds of miles. Crude oils, petroleum products, water, and solid materials such as coal (carried by water) are transported thru pipelines. Different liquids can be transported consecutively in the same pipeline, and branching arrangements are used to divert flows to different destinations.

Civil piping is used to distribute public utilities (water, fuel gases), and to collect rainwater, sewage, and industrial waste waters. Most piping of this type is placed underground.

Plumbing (commercial piping) is piping installed in commercial buildings, schools, hospitals, residences, etc., for distributing water and fuel gases, for collecting waste water, and for other purposes.

COMMISSIONING, DESIGNING, & BUILDING A PLANT 1.2

When a manufacturer decides to build a new plant, or to expand an existing one, the manufacturer will either employ an engineering company to undertake design and construction, or, if the company's own engineering department is large enough, they will do the design work, manage the project, and employ one or more contractors to do the construction work.

In either procedure, the manufacturer supplies information concerning the purposes of buildings, processes, production rates, design criteria for specific requirements, details of existing plant, and site surveys, if any.

Chart 1.1 shows the principals involved, and the flow of information and material.

SCHEMATIC FOR PLANT CONSTRUCTION **CHART 1.1**

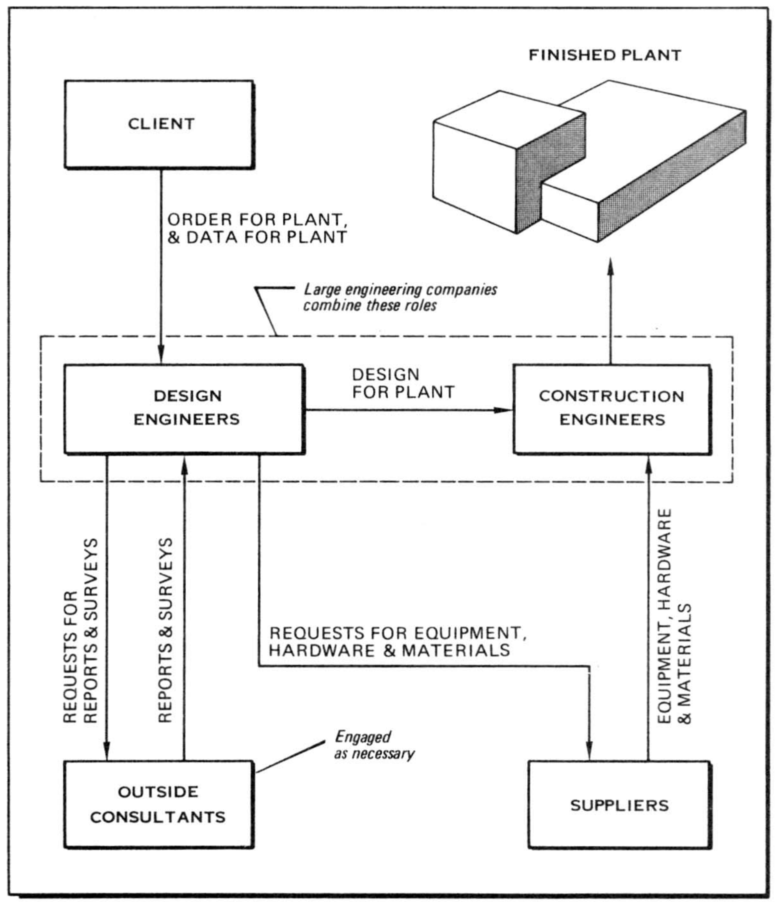


CHART 1.1

The designing and building of an industrial plant is a complex undertaking. Except for the larger industrial concerns, who may maintain their own design staffs, the design and construction of plants and related facilities is usually undertaken by specialist companies.

The Guide describes in 4.1 the organization and responsibilities of design engineering, with special reference to the duties of individuals engaged in the development of piping designs for plants.

PIPE, FITTINGS, FLANGES, REINFORCEMENTS, In-line Equipment and Support Equipment

PROCESS PIPE 2.1

PIPE & TUBE 2.1.1

Tubular products are termed 'tube' or 'pipe'. Tube is customarily specified by its outside diameter and wall thickness, expressed either in BWG (Birmingham wire gage) or in thousandths of an inch. Pipe is customarily identified by 'nominal pipe size', with wall thickness defined by 'schedule number', 'API designation', or 'weight', as explained in 2.1.3. Non-standard pipe is specified by nominal size with wall thickness stated.

The principal uses for tube are in heat exchangers, instrument lines, and small interconnections on equipment such as compressors, boilers, and refrigerators.

SIZES & LENGTHS COMMONLY USED FOR STEEL PIPE 2.1.2

ANSI standard B36.10M establishes wall thicknesses for pipe ranging from 1/8 to 80-inch nominal diameter ('nominal pipe size'). Pipe sizes normally stocked include: 1/2, 3/4, 1, 1¼, 1½, 2, 2½, 3, 3½, 4, 5, 6, 8, 10, 12, 14, 16, 18, 20 and 24. Sizes 1¼, 2½, 3½, and 5 inch are seldom used (unusual sizes are sometimes required for connecting to equipment, but piping is normally run in the next larger stock size after connection has been made). 1/8, 1/4, 3/8 and 1/2-inch pipe is usually restricted to instrument lines or to service and other lines which have to mate with equipment. 1/2-inch pipe is extensively used for steam tracing and for auxiliary piping at pumps, etc.

Straight pipe is supplied in 'random' lengths (17 to 25 ft), and sometimes 'double random' lengths (38 to 48 ft), if preferred. The ends of these lengths are normally either plain (PE), beveled for welding (BE), or threaded and supplied with one coupling per length ('threaded and coupled', or 'T&C'). If pipe is ordered 'T&C', the rating of the coupling is specified—see chart 2.3. Other types of ends, such as grooved for special couplings, can be obtained to order.

DIAMETERS & WALL THICKNESSES OF PIPE 2.1.3

The size of all pipe is identified by the nominal pipe size, abbreviated 'NPS', which is seldom equal to the true bore (internal diameter) of the pipe—the difference in some instances is large. NPS 14 and larger pipe has outside diameter equal to the nominal pipe size.

Pipe in the various sizes is made in several wall thicknesses for each size, which have been established by three different sources:—

(1) The American National Standards Institute, thru 'schedule numbers'

(2) The American Society of Mechanical Engineers and the American Society for Testing and Materials, thru the designations 'STD' (standard), 'XS' (extra-strong), and 'XXS' (double-extra-strong), drawn from dimensions established by manufacturers. ***In the Guide, these designations are termed 'manufacturers' weights'***

(3) The American Petroleum Institute, through its standard 5L, for 'Line pipe'. Dimensions in this standard have no references for individual sizes and wall thicknesses

'Manufacturers' weights' (second source) were intended, as long ago as 1939, to be superseded by schedule numbers. However, demand for these wall thicknesses has caused their manufacture to continue. Certain fittings are available only in manufacturers' weights.

Pipe dimensions from the second and third sources are incorporated in American National Standard B36.10M. Tables P-1 list dimensions for welded and seamless steel pipe in this standard, and give derived data.

IRON PIPE SIZES were initially established for wrought-iron pipe, with wall thicknesses designated by the terms 'standard (weight)', 'extra-strong', and 'double-extra-strong'. Before the schedule number scheme for steel pipe was first published by the American Standards Association in 1935, the iron pipe sizes were modified for steel pipe by slightly decreasing the wall thicknesses (leaving the outside diameters constant) so that the weights per foot (lb/ft) equalled the iron pipe weights.

Wrought-iron pipe (no longer made) has been completely supplanted by steel pipe, but schedule numbers, intended to supplant iron pipe designations did not. Users continued to specify pipe in iron pipe terms, and as the mills responded, these terms are included in ANSI standard B36.10M for steel pipe. Schedule numbers were introduced to establish pipe wall thicknesses by formula, but as wall thicknesses in common use continued to depart from those proposed by the scheme, schedule numbers now identify wall thicknesses of pipe in the different nominal sizes as ANSI B36.10M states "as a convenient designation system for use in ordering".

STAINLESS-STEEL SIZES American National Standard B36.19 established a range of thin-walled sizes for stainless-steel pipe, indentified by schedules 5S and 10S.

MATERIALS FOR PIPE 2.1.4

STEEL PIPE Normally refers to carbon-steel pipe. Seam-welded steel pipe is made from plate. Seamless pipe is made using dies. Common finishes are 'black' ('plain' or 'mill' finish) and galvanized.

Correctly selected steel pipe offers the strength and durability required for the application, and the ductility and machinability required to join it and form it into piping ('spools' -- see 5.2.9). The selected pipe must withstand the conditions of use, especially pressure, temperature and corrosion conditions. These requirements are met by selecting pipe made to an appropriate standard; in almost all instances an ASTM or API standard (see 2.1.3 and table 7.5).

The most-used steel pipe for process lines, and for welding, bending, and coiling, is made to ASTM A-53 or ASTM A-106, principally in wall thicknesses defined by schedules 40, 80, and manufacturers' weights, STD and XS. Both ASTM A-53 and ASTM A-106 pipe is fabricated seamless or seamed, by electrical resistance welding, in Grades A and B. Grades B have the higher tensile strength. Three grades of A-106 are available—Grades A, B, and C, in order of increasing tensile strength.

The most widely stocked pipe is to ASTM A-120 which covers welded and seamless pipe for normal use in steam, water, and gas (including air) service. ASTM A-120 is not intended for bending, coiling or high temperature service. It is not specified for hydrocarbon process lines.

In the oil and natural gas industries, steel pipe used to convey oil and gas is manufactured to the American Petroleum Institute's standard API 5L, which applies tighter control of composition and more testing than ASTM-120.

Steel specifications in other countries may correspond with USA specifications. Some corresponding european standards for carbon steels and stainless steels are listed in table 2.1.

IRON pipe is made from cast-iron and ductile-iron. The principal uses are for water, gas, and sewage lines.

OTHER METALS & ALLOYS Pipe or tube made from copper, lead, nickel, brass, aluminum and various stainless steels can be readily obtained. These materials are relatively expensive and are selected usually either because of their particular corrosion resistance to the process chemical, their good heat transfer, or for their tensile strength at high temperatures. Copper and copper alloys are traditional for instrument lines, food processing, and heat transfer equipment, but stainless steels are increasingly being used for these purposes.

PLASTICS Pipe made from plastics may be used to convey actively corrosive fluids, and is especially useful for handling corrosive or hazardous gases and dilute mineral acids. Plastics are employed in three ways: as all-plastic pipe, as 'filled' plastic materials (glass-fiber-reinforced, carbon-filled, etc.) and as lining or coating materials. Plastic pipe is made from polypropylene, polyethylene (PE), polybutylene (PB), polyvinyl chloride (PVC), acrylonitrile-butadiene-styrene (ABS), cellulose acetate-butyrate (CAB), polyolefins, and polyesters. Pipe made from polyester and epoxy resins is frequently glass-fiber-reinforced ('FRP') and commercial products of this type have good resistance to wear and chemical attack.

COMPARABLE USA & EUROPEAN SPECIFICATIONS FOR STEEL PIPE — TABLE 2.1

	USA	UK	W. GERMANY	SWEDEN
CARBON-STEEL PIPE	**ASTM A53**	**BS 3601**	**DIN 1629**	
	Grade A SMLS	HFS 22 & CDS 22	St 35	SIS 1233-05
	Grade B SMLS	HFS 27 & CDS 27	St 45	SIS 1434-05
	ASTM A53	**BS 3601**	**DIN 1626**	
	Grade A ERW	ERW 22	Blatt 3 St 34-2 ERW	
	Grade B ERW	ERW 27	Blatt 3 St 37-2 ERW	
	ASTM A53	**BS 3601**	**DIN 1626**	
	FBW	BW 22	Blatt 3 St 34-2 FBW	
	ASTM A106	**BS 3602**	**DIN 17175***	
	Grade A	HFS 23	St 35-8	SIS 1234-05
	Grade B	HFS 27	St 45-8	SIS 1435-05
	Grade C	HFS 35		
	ASTM A134	**BS 3601**	**DIN 1626**	
		EFW	Blatt 2 EFW	
	ASTM A135	**BS 3601**	**DIN 1626**	
	Grade A	ERW 22	Blatt 3 St 34-2 ERW	SIS 1233-06
	Grade B	ERW 27	Blatt 3 St 37-2 ERW	SIS 1434-06
	ASTM A139	**BS 3601**	**DIN 1626**	
	Grade A	EFW 22	Blatt 2 St 37	
	Grade B	EFW 27	Blatt 2 St 42	
	ASTM A155 Class 2	**BS 3602**	**DIN 1626, Blatt 3, with certification C**	
	C 45		St 34-2	
	C 50		St 37-2	
	C 55	EFW 28	St 42-2	
	KC 55		St 42-2 *	
	KC 60	EFW 28S	St 42-2 *	
	KC 65		St 52-3	
	KC 70		St 52-3	
	API 5L	**BS 3601**	**DIN 1629**	
	Grade A SMLS	HFS 22 & CDS 22	St 35	SIS 1233-05
	Grade B SMLS	HFS 27 & CDS 27	St 45	SIS 1434-05
	API 5L	**BS 3601**	**DIN 1625**	
	Grade A ERW	ERW 22	Blatt 3 St 34-2 ERW	SIS 1233-06
	Grade B ERW	ERW 27 †	Blatt 4 St 37-2 ERW	SIS 1434-06 †
	API 5L	**BS 3601 Double-welded**	**DIN 1626**	
	Grade A EFW	EFW 22	Blatt 3 St 34-2 FW	
	Grade B EFW	EFW 27 †	Blatt 4 St 37-2 FW	
	API 5L	**BS 3601**	**DIN 1626**	
	FBW	BW 22	Blatt 3 St 34-2 FBW	
STAINLESS-STEEL PIPE	**ASTM A312**	**BS 3605**	**WSN Designation:**	
	TP 304	Grade 801	4301 X 5 CrNi 18 9	SIS 2333-02
	TP 304H	Grade 811		
	TP 304L	Grade 801L	4306 X 2 CrNi 18 9	SIS 2352-02
	TP 310	Grade 805	4841 X 15 CrNiSi 25 20	SIS 2361-02
	TP 316	Grade 845	4401/ 4436 X 5 CrNiMo 18 10	SIS 2343-02
	TP 316H	Grade 855		
	TP 316L	Grade 845L	4404 X 2 CrNiMo 18 10	SIS 2353-02
	TP 317	Grade 846		
	TP 321	Grade 822 Ti	4541 X 10 CrNiTi 18 9	SIS 2337-02
	TP 321H	Grade 832 Ti		
	TP 347	Grade 822 Nb	4550 X 10 CrNiNb 18 9	SIS 2338-02
	TP 347H	Grade 832 Nb		

**Specify "Si-killed"* †*Specify API 5L Grade B testing procedures for these steels*

The American National Standards Institute has introduced several schedules for pipe made from various plastics. These ANSI standards and others for plastic pipe are listed in table 7.5.

GLASS All-glass piping is used for its chemical resistance, cleanliness and transparency. Glass pipe is not subject to 'crazing' often found in glass-lined pipe and vessels subject to repeated thermal stresses. Pipe, fittings, and hardware are available both for process piping and for drainage. Corning Glass Works offers a Pyrex 'Conical' system for process lines in 1, 1½, 2, 3, 4 and 6-inch sizes (ID) with 450 F as the maximum operating temperature, and pressure ranges 0–65 PSIA (1 in. thru 3 in.), 0–50 PSIA (4 in.) and 0–35 PSIA (6 in.). Glass cocks, strainers and thermowells are available. Pipe fittings and equipment are joined by flange assemblies which bear on the thickened conical ends of pipe lengths and fittings. Corning also offers a Pyrex Acid-Waste Drainline system in 1½, 2, 3, 4 and 6-inch sizes (ID) with beaded ends joined by Teflon-gasketed nylon compression couplings. Both Corning systems are made from the same borosilicate glass.

LININGS & COATINGS Lining or coating carbon-steel pipe with a material able to withstand chemical attack permits its use to carry corrosive fluids. Lengths of lined pipe and fittings are joined by flanges, and elbows, tees, etc., are available already flanged. Linings (rubber, for example) can be applied after fabricating the piping, but pipe is often pre-lined, and manufacturers give instructions for making joints. Linings of various rubbers, plastics, metals and vitreous (glassy) materials are available. Polyvinyl chloride, polypropylene and copolymers are the most common coating materials. Carbon-steel pipe zinc-coated by immersion into molten zinc (hot-dip galvanized) is used for conveying drinking water, instrument air and various other fluids. Rubber lining is often used to handle abrasive fluids.

TEMPERATURE & PRESSURE LIMITS 2.1.5

Carbon steels lose strength at high temperatures. Electric-resistance-welded pipe is not considered satisfactory for service above 750 F, and furnace-butt-welded pipe above about 650 F. For higher temperatures, pipe made from stainless steels or other alloys should be considered.

Pressure ratings for steel pipe at different temperatures are calculated according to the ANSI B31 Code for Pressure Piping (detailed in table 7.2). ANSI B31 gives stress/temperature values for the various steels from which pipe is fabricated.

METHODS FOR JOINING PIPE 2.2

The joints used for most carbon-steel and stainless-steel pipe are:

- BUTT-WELDED . . . . SEE 2.3
- SOCKET-WELDED . . . . SEE 2.4
- SCREWED . . . . SEE 2.5
- BOLTED FLANGE . . . . SEE 2.3.1, 2.4.1 & 2.5.1
- BOLTED QUICK COUPLINGS . . . . .SEE 2.8.2

WELDED & SCREWED JOINTS 2.2.1

Lines NPS 2 and larger are usually butt-welded, this being the most economic leakproof way of joining larger-diameter piping. Usually such lines are subcontracted to a piping fabricator for prefabrication in sections termed 'spools', then transported to the site. Lines NPS 1½ and smaller are usually either screwed or socket-welded, and are normally field-run by the piping contractor from drawings. Field-run and shop-fabricated piping are discussed in 5.2.9.

SOCKET-WELDED JOINTS 2.2.2

Like screwed piping, socket welding is used for lines of smaller sizes, but has the advantage that absence of leaking is assured: this is a valuable factor when flammable, toxic, or radioactive fluids are being conveyed—the use of socket-welded joints is not restricted to such fluids, however.

BOLTED-FLANGE JOINTS 2.2.3

Flanges are expensive and for the most part are used to mate with flanged vessels, equipment, valves, and for process lines which may require periodic cleaning.

Flanged joints are made by bolting together two flanges with a gasket between them to provide a seal. Refer to 2.6 for standard forged-steel flanges and gaskets.

FITTINGS 2.2.4

Fittings permit a change in direction of piping, a change in diameter of pipe, or a branch to be made from the main run of pipe. They are formed from plate or pipe, machined from forged blanks, cast, or molded from plastics.

Chart 2.1 shows the ratings of butt-welding fittings used with pipe of various schedule numbers and manufacturers' weights. For dimensions of butt-welding fittings and flanges, see tables D-1 thru D-6, and tables F-1 thru F-7. Drafting symbols are given in charts 5.3 thru 5.5.

Threaded fittings have Pressure Class designations of: 2000, 3000 and 6000. Socket-welding fittings have Pressure Class designations of: 3000, 6000 and 9000. How these Pressure Class designations relate to schedule numbers and manufacturers' weights for pipe is shown in table 2.2.

CORRELATION OF CLASS OF THREADED & SOCKET-WELDING FITTINGS WITH SCHEDULES/WEIGHTS OF PIPE **TABLE 2.2**

	PIPE DESIGNATION SCH/MFR'S			
Pressure Class	2000	3000	6000	9000
Threaded fittings	80/XS	160	XXS	
Socketed fittings		80/XS	160	XXS

Sections 2.1.3 thru 2.2.4 have shown that there is a wide variety of differently-rated pipe, fittings and materials from which to make a choice. Charts 2.1 thru 2.3 show how various weights of pipe, fittings and valves can be combined in a piping system.

COMPONENTS FOR BUTT-WELDED PIPING SYSTEMS 2.3

WHERE USED: For most process, utility and service piping

ADVANTAGE OF JOINT: Most practicable way of joining larger pipes and fittings which offers reliable, leakproof joints

DISADVANTAGE OF JOINT: Intruding weld metal may affect flow

HOW JOINT IS MADE: The end of the pipe is beveled as shown in chart 2.1. Fittings are similarly beveled by the manufacturer. The two parts are aligned, properly gapped, tack welded, and then a continuous weld is made to complete the joint

Chart 2.1 shows the ratings of pipe, fittings and valves that are commonly combined or may be used together. It is a guide only, and not a substitute for a project specification.

FITTINGS, BENDS, MITERS & FLANGES FOR BUTT-WELDED SYSTEMS 2.3.1

Refer to tables D, F and W-1 for dimensions and weights of fittings and flanges.

ELBOWS or 'ELLS' make 90- or 45-degree changes in direction of the run of pipe. The elbows normally used are 'long radius' (LR) with centerline radius of curvature equal to 1½ times the nominal pipe size for NPS 3/4 and larger sizes. 'Short radius' (SR) elbows with centerline radius of curvature equal to the nominal pipe size are also available. 90-degree LR elbows with a straight extension at one end ('long tangent') are still available in STD weight, if required.

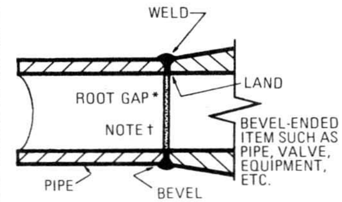
REDUCING ELBOW makes a 90-degree change in direction with change in line size. Reducing elbows have centerline radius of curvature 1½ times the nominal size of the pipe to be attached to the larger end.

RETURN changes direction of flow thru 180 degrees, and is used to construct heating coils, vents on tanks, etc.

BENDS are made from straight pipe. Common bending radii are 3 and 5 times the pipe size (3R and 5R bends, where R = nominal pipe size—nominal diameter, ***not*** radius). 3R bends are available from stock. Larger radius bends can be custom made, preferably by hot bending. Only seamless or electric-resistance-welded pipe is suitable for bending.

BUTT-WELDED PIPING — CHART 2.1

CARBON-STEEL PIPE & FORGED-STEEL FITTINGS

END PREPARATION OF PIPE, & METHOD OF JOINING TO BEVEL-ENDED PIPE, FITTING, FLANGE, VALVE, OR EQUIPMENT			
MINIMUM LINE SIZE NORMALLY BUTT-WELDED	NPS 2		
WEIGHT OF PIPE & FITTINGS NORMALLY USED. CHOICE OF OTHER MATERIALS OR HEAVIER-WEIGHT PIPE & FITTINGS WILL DEPEND ON PRESSURE, TEMPERATURE &/OR THE CORROSION ALLOWANCE REQUIRED. NPS 2 AND LARGER PIPE IS USUALLY ORDERED TO ASTM A-53, Grade B. SEE 2.1.4, UNDER 'STEELS'	FOR NOMINAL PIPE SIZE:	NPS 2 to NPS 6	NPS 8 and larger CALCULATE WALL THICKNESS FROM CODE
	SCHEDULE NUMBER	SCH 40	SCH 20 or SCH 30
	MFRS' WEIGHT	STD	——

VALVES

PRESSURE RATING CLASS	FOR NPS 2 AND LARGER VALVES	150, 300, 600, 900 AND HIGHER ACCORDING TO SYSTEM PRESSURE
	FOR NPS 1½ AND SMALLER VALVES	SEE CHARTS 2.2 AND 2.3
	FOR CONTROL VALVES	USUALLY 300 MINIMUM (SEE 3.1.10)

*See 5.3.5 under 'Dimensioning spools'

†A 'backing ring'—sometimes termed a 'chill ring'—may be inserted between any butt-welding joint prior to welding. Preventing weld spatter and spikes ('icicles') of weld metal from forming inside the pipe during welding, the ring also serves as an alignment aid. Normally used for severe service, but should be considered for process fluids such as fibrous suspensions, where weld icicles could result in material collecting at joints and choking lines. See 2.11

BACKING RING **FIGURE 2.1**

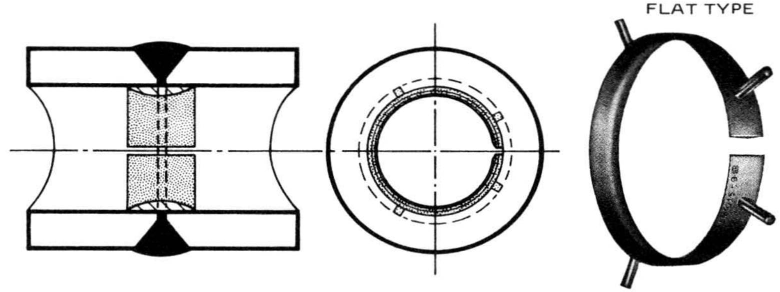
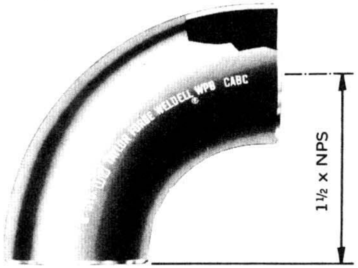
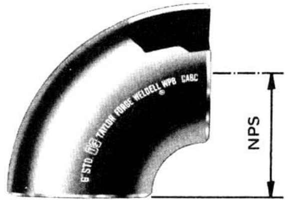


FIGURE 2.2

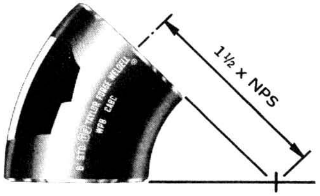
90° LONG-RADIUS ELBOW



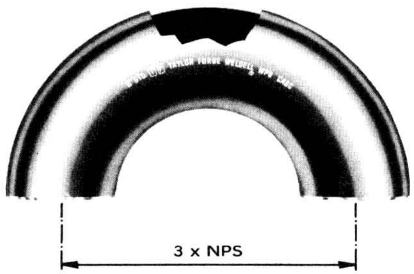
90° SHORT-RADIUS ELBOW



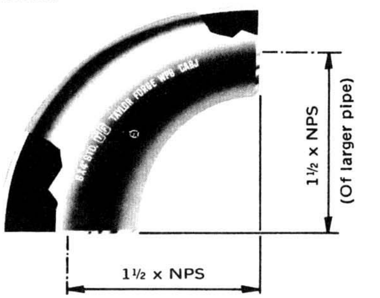
45° ELBOW (LR)



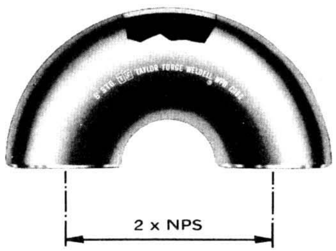
LONG-RADIUS RETURN



REDUCING ELBOW



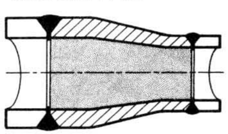
SHORT-RADIUS RETURN



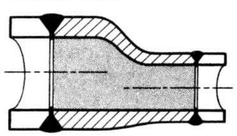
REDUCER (or INCREASER) joins a larger pipe to a smaller one. The two available types, concentric and eccentric, are shown. The eccentric reducer is used when it is necessary to keep either the top or the bottom of the line level—offset equals ½ x (larger ID minus smaller ID).

REDUCERS **FIGURE 2.3**

CONCENTRIC

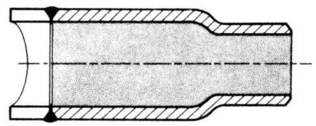


ECCENTRIC

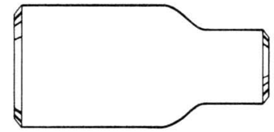


SWAGE is employed to connect butt-welded piping to smaller screwed or socket-welded piping. In butt-welded lines, used as an alternative to the reducer when greater reductions in line size are required. Regular swages in concentric or eccentric form give abrupt change of line size, as do reducers. The 'venturi' swage allows smoother flow. Refer to table 2.3 for specifying swages for joining to socket-welding items, and to table 2.4 for specifying swages for joining to screwed piping. For offset, see 'Reducer'.

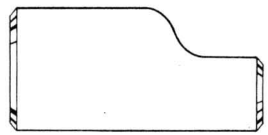
SWAGES, or SWAGED NIPPLES **FIGURE 2.4**



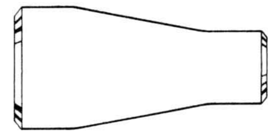
CONCENTRIC



ECCENTRIC



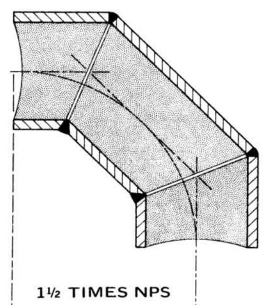
VENTURI TYPE



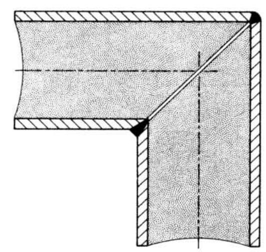
MITERED ELBOWS are fabricated as required from pipe—they are not fittings. The use of miters to make changes in direction is practically restricted to low-pressure lines 10-inch and larger if the pressure drop is unimportant; for these uses regular elbows would be costlier. A 2-piece, 90-degree miter has four to six times the hydraulic resistance of the corresponding regular long-radius elbow, and should be used with caution. A 3-piece 90-degree miter has about double the resistance to flow of the regular long-radius elbow—refer to table F-10. Constructions for 3-, 4-, and 5-piece miters are shown in tables M-2.

3-PIECE & 2-PIECE MITERS **FIGURE 2.5**

3-PIECE MITER



2-PIECE MITER



THE 2-PIECE MITER HAS HIGH FLOW RESISTANCE (See TABLE F-10)

2 .2.4 .3.1

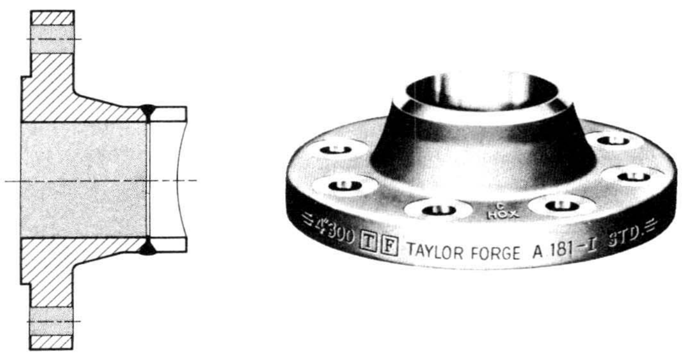
CHART 2.1

FIGURE 2.1–2.5

The following five flange types are used for butt-welded lines. The different flange facings available are discussed in 2.6.

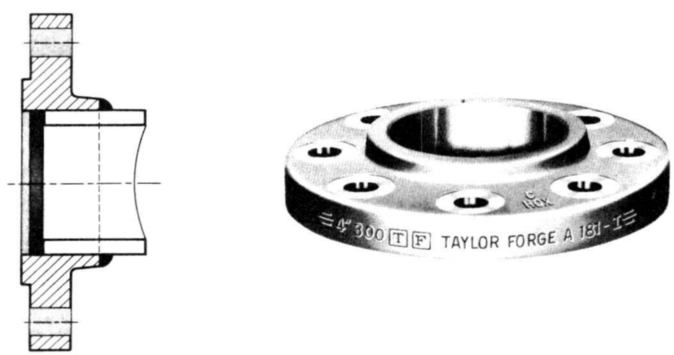
WELDING-NECK FLANGE, REGULAR & LONG *Regular welding-neck flanges are used with butt-welding fittings.* Long welding-neck flanges are primarily used for vessel and equipment nozzles, rarely for pipe. Suitable where extreme temperature, shear, impact and vibratory stresses apply. Regularity of the bore is maintained. Refer to tables F for bore diameters of these flanges.

WELDING-NECK FLANGE **FIGURE 2.6**



SLIP-ON FLANGE is properly used to flange pipe. Slip-on flanges can be used with long-tangent elbows, reducers, and swages (not usual practice). The internal weld is slightly more subject to corrosion than the butt weld. The flange has poor resistance to shock and vibration. It introduces irregularity in the bore. It is cheaper to buy than the welding-neck flange, but is costlier to assemble. It is easier to align than the welding-neck flange. Calculated strengths under internal pressure are about one third that of the corresponding welding-neck flanges. The pipe or fitting is set back from the face of the flange a distance equal to the wall thickness –0" + 1/16".

SLIP-ON FLANGE **FIGURE 2.7**

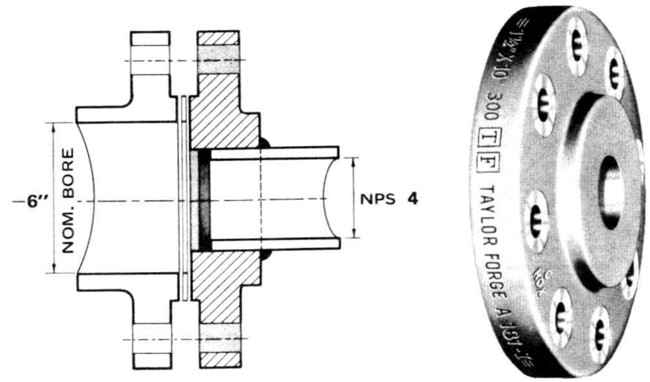


REDUCING FLANGE Suitable for changing line size, but should not be used if abrupt transition would create undesirable turbulence, as at pump connections. Available to order in welding-neck and eccentric types, and usually from stock in slip-on type. Specify by nominal pipe sizes, stating the size of the larger pipe first. Example: a slip-on reducing flange to connect a NPS 4 pipe to a Class 150 NPS 6 line-size flange is specified:

RED FLG NPS 6 x 4 Class 150 SO

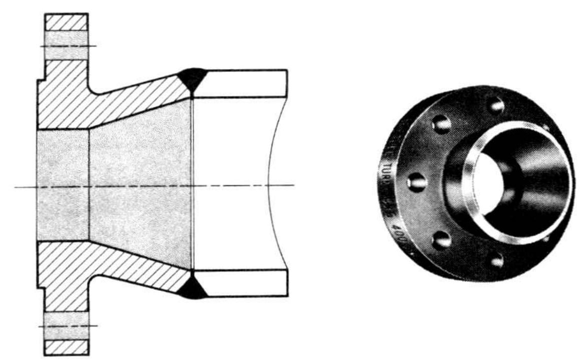
For a welding-neck reducing flange, correct bore is obtained by giving the pipe schedule number or manufacturers' weight of the pipe to be welded on.

REDUCING SLIP-ON FLANGE **FIGURE 2.8**



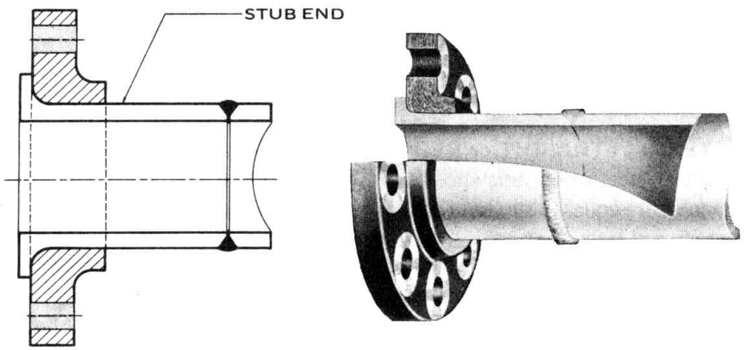
EXPANDER FLANGE Application as for welding-neck flange—see above. Increases pipe size to first or second larger size. Alternative to using reducer and welding-neck flange. Useful for connecting to valves, compressors and pumps. Pressure ratings and dimensions are in accord with ANSI B16.5.

EXPANDER (or INCREASER) FLANGE **FIGURE 2.9**



LAP-JOINT, or 'VAN STONE', FLANGE Economical if costly pipe such as stainless steel is used, as the flange can be of carbon steel and only the lap-joint stub end need be of the line material. A stub end must be used in a lap joint, and the cost of the two items must be considered. If both stub and flange are of the same material they will be more expensive than a welding-neck flange. Useful where alignment of bolt holes is difficult, as with spools to be attached to flanged nozzles of vessels.

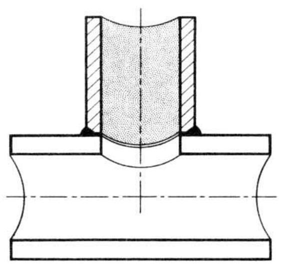
LAP-JOINT FLANGE (with Stub-end) **FIGURE 2.10**



BUTT-WELDING FITTINGS FOR BRANCHING FROM BUTT-WELDED SYSTEMS 2.3.2

STUB-IN Term for a branch pipe welded directly into the side of the main pipe run—it is not a fitting. This is the commonest and least expensive method of welding a full-size or reducing branch for pipe 2-inch and larger. A stub-in can be reinforced by means set out in 2.11.

STUB-IN **FIGURE 2.11**

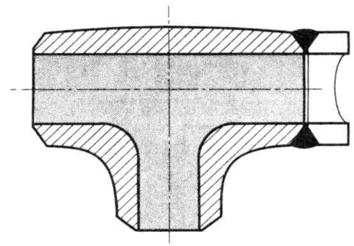


BUTT-WELDING TEES, STRAIGHT or REDUCING, are employed to make 90-degree branches from the main run of pipe. Straight tees, with branch the same size as the run, are readily available. Reducing tees have branch smaller than the run. Bullhead tees have branch larger than the run, and are very seldom used but can be made to special order. None of these tees requires reinforcement. Reducing tees are ordered as follows:—

SPECIFYING SIZE OF BUTT-WELDING REDUCING TEES

HOW TO SPECIFY TEES:	RUN INLET	RUN OUTLET	BRANCH	EXAMPLE
REDUCING ON BRANCH	6″	6″	4″	RED TEE 6 x 6 x 4″

BUTT-WELDING TEES **FIGURE 2.12**

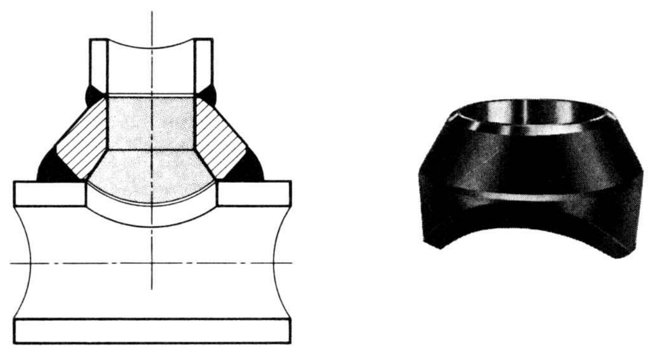


STRAIGHT BUTT-WELDING TEE REDUCING BUTT-WELDING TEE

The next four branching fittings are made by Bonney Forge.
These fittings offer an alternate means of connecting into the main run, and do not require reinforcement. They are preshaped to the curvature of the run pipe.

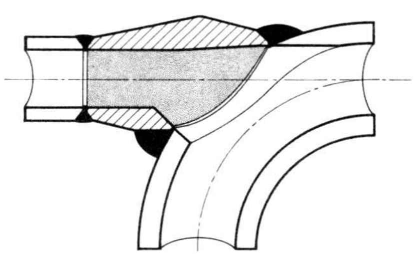
WELDOLET makes a 90-degree branch, full-size or reducing, on straight pipe. Closer manifolding is possible than with tees. Flat-based weldolets are available for connecting to pipe caps and vessel heads.

WELDOLET **FIGURE 2.13**

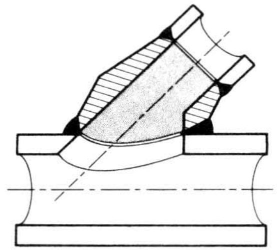


BUTT-WELDING ELBOLET makes a reducing tangent branch on long-radius and short-radius elbows.

ELBOLET
FIGURE 2.14



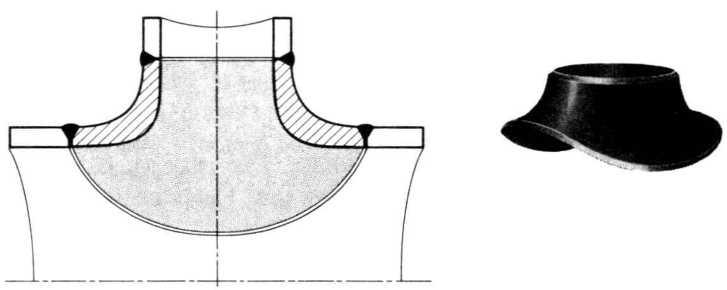
BUTT-WELDING LATROLET
FIGURE 2.15



BUTT-WELDING LATROLET makes a 45-degree reducing branch on straight pipe.

SWEEPOLET makes a 90-degree reducing branch from the main run of pipe. Primarily developed for high-yield pipe used in oil and gas transmission lines. Provides good flow pattern, and optimum stress distribution.

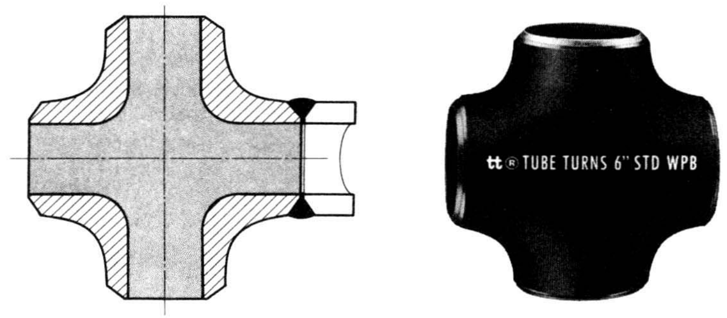
SWEEPOLET **FIGURE 2.16**



The next three fittings are usually used for special designs:

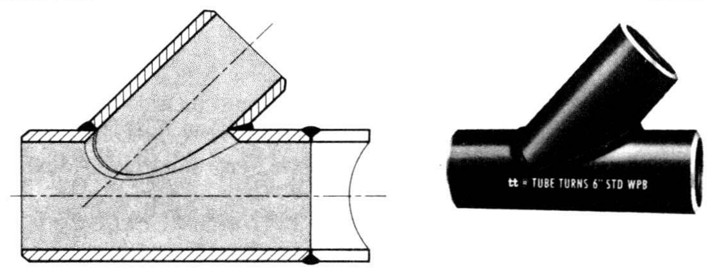
CROSS, STRAIGHT or REDUCING Straight crosses are usually stock items. Reducing crosses may not be readily available. For economy, availability and to minimize the number of items in inventory, it is preferred to use tees, etc., and not crosses, except where space is restricted, as in marine piping or 're-vamp' work. Reinforcement is not needed.

BUTT-WELDING CROSS **FIGURE 2.17**



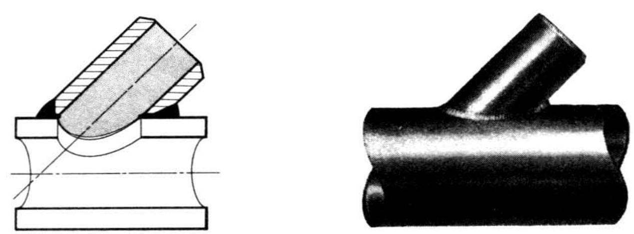
LATERAL, STRAIGHT or REDUCING, permits odd-angled entry into the pipe run where low resistance to flow is important. Straight laterals with branch bore equal to run bore are available in STD and XS weights. Reducing laterals and laterals at angles other than 45 degrees are usually available only to special order. Reinforcement is required where it is necessary to restore the strength of the joint to the full strength of the pipe. Reducing laterals are ordered similarly to butt-welding tees, except that the angle between branch and run is also stated.

LATERAL **FIGURE 2.18**



SHAPED NIPPLE Now rarely used, but can be obtained from stock in 90- and 45-degree angles, and in any size and angle, including offset, to special order. The run is field-cut, using the nipple as template. Needs reinforcement if it is necessary to bring the strength of the joint up to the full strength of the pipe.

SHAPED NIPPLE **FIGURE 2.19**

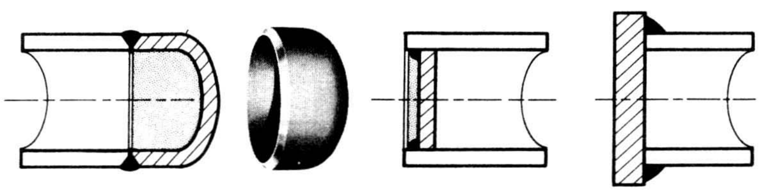


CAP is used to seal the end of pipe. (See figure 2.20(a).)

FLAT CLOSURES Flat plates are normally cut especially from platestock by the fabricator or erector. (See figure 2.20 (b) and (c).)

THREE WELDED CLOSURES **FIGURE 2.20**

(a) BUTT-WELDING CAP (b) FLAT CLOSURE (c) FLAT CLOSURE



ELLIPSOIDAL, or DISHED, HEADS are used to close pipes of large diameter, and are similar to those used for constructing vessels.

COMPONENTS FOR SOCKET-WELDED PIPING SYSTEMS 2.4

WHERE USED: For lines conveying flammable, toxic, or expensive material, where no leakage can be permitted. For steam: 300 to 600 PSI, and sometimes 150 PSI steam. For corrosive conditions, see Index under 'Corrosion'

ADVANTAGES OF JOINT:
(1) Easier alignment on small lines than butt welding. Tack welding is unnecessary
(2) No weld metal can enter bore
(3) Joint will not leak, when properly made

DISADVANTAGES OF JOINT:
(1) The 1/16-inch recess in joint (see chart 2.2) pockets liquid
(2) Use not permitted by ANSI B31.1 - 1989 if severe vibration or crevice corrosion is anticipated

HOW JOINT IS MADE: The end of the pipe is finished flat, as shown in chart 2.2. It is located in the fitting, valve, flange, etc., and a continuous fillet weld is made around the circumference

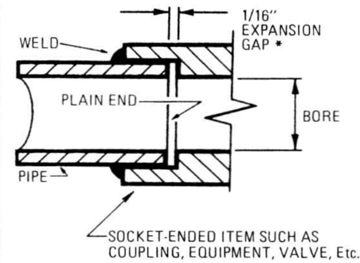
2 .3.2 .4

Chart 2.2 shows the ratings of pipe, fittings and valves that are commonly combined, or may be used together. The chart is a guide only, and not a substitute for a project specification.

SOCKET-WELDED PIPING — CHART 2.2

CARBON-STEEL PIPE & FORGED-STEEL FITTINGS

END PREPARATION OF PIPE, AND METHOD OF JOINING TO FITTING, FLANGE, VALVE, OR EQUIPMENT



MAXIMUM LINE SIZE NORMALLY SOCKET WELDED			NPS 1½ (NPS 2½ IN MARINE PIPING)		
AVAILABILITY OF FORGED-STEEL SOCKET-WELDING FITTINGS			NPS 1/8 to NPS 4		
WEIGHTS OF PIPE AND PRESSURE CLASSES OF FITTINGS WHICH ARE COMPATIBLE	PIPE	SCHEDULE NUMBER	SCH 80	SCH 160	——
	PIPE	MFRS' WEIGHT	XS	——	XXS
	FITTINGS	FITTING CLASS	3000	6000	9000
	FITTINGS	FITTING BORED TO:	SCH 40	SCH 160	XXS

MOST COMMON COMBINATION: CHOICE OF MATERIAL OR HEAVIER-WEIGHT PIPE AND FITTING WILL DEPEND ON PRESSURE, TEMPERATURE AND/OR CORROSION ALLOWANCE REQUIRED. PIPE NPS 1½ AND SMALLER IS USUALLY ORDERED TO ASTM SPECIFICATION A-106 Grade B. REFER TO 2.1.4, UNDER 'STEELS'

VALVES

MINIMUM PRESSURE (RATING) CLASS	CONTROL VALVES (USUALLY FLANGED)	USUALLY 300 (SEE 3.1.10)
	VALVES OTHER THAN CONTROL VALVES	600 (ANSI) 800 (API)

* ANSI B16.11 recommends a 1/16th-inch gap to prevent weld from cracking under thermal stress

† Socket-ended fittings are now only made in classes 3000 6000 and 9000 (ANSI B16.11)

CHART 2.2

FIGURES 2.14–2.20