CHAPTER IV

DESIGN, INSTALLATION, AND TESTING

840 DESIGN, INSTALLATION, AND TESTING

840.1 General Provisions. The design requirements of this code are intended to be adequate for public safety under all conditions usually encountered in the gas industry. However, special conditions that may cause additional stress in any part of a line or its appurtenances shall be provided for, using good engineering practice. Examples of such special conditions include: long self-supported spans, unstable ground, mechanical or sonic vibrations, weight of special attachments, and thermal forces other than seasonal.

841 STEEL PIPE

841.001 Population Density Indices

(a) Two population density indices, determined at the time of initial construction, are used to classify locations for design and testing purposes: (1) the one-mile density index, which applies to any specific mile of pipeline; and (2) the ten-mile density index, which applies to any specific ten-mile length of pipeline.

(b) To determine the one-mile density indices for a proposed pipeline, lay out a zone one-half mile wide along the route of the pipeline with the pipeline on the center line of this zone. Divide the zone into lengths, each containing one mile of pipeline. Count the number of buildings intended for human occupancy in each of these lengths. These numbers are the one-mile indices for the pipeline.

(c) To determine the ten-mile density indices for any given ten-mile length of pipeline, proceed as follows: Add the one-mile density indices for the ten-mile section. In case a one-mile index equals or exceeds 20, it is to be included in the sum as 20. Divide the sum thus obtained by 10. The quotient is the ten-mile density index for the section.

841.01 Classification of Locations

841.011 Class 1 Locations

Class 1 locations include waste lands, deserts, rugged mountains, grazing land, and farm land, and combinations of these; provided, however, that:

(a) The ten-mile density index for any section of the line is 12 or less.

(b) The one-mile density index for any one mile of line is 20 or less.(1)

841.012 Class 2 Locations

Class 2 locations include areas where the degree of development is intermediate between Class 1 locations and Class 3 locations. Fringe areas around cities and towns, and farm or industrial areas where the one-mile density index exceeds 20 or the ten-mile density index exceeds 12 fall within this location class.

Note (1): It is not intended here that a full mile of lower-stress-level pipeline shall be installed if there are physical barriers or other factors that will limit the further expansion of the more densely populated area to a total distance of less than 1 mile. It is intended, however, that where no such barriers exist, ample allowance shall be made in determining the limits of the lower-stress design to provide for probable further development in the area.

841.013 Class 3 Locations

Class 3 locations include areas subdivided for residential or commercial purposes where, at the time of construction of the pipeline or piping system, 10% or more of the lots abutting on the street or right-of-way in which the pipe is to be located are built upon, and a Class 4 classification is not called for. This permits classifying as Class 3, areas completely occupied by commercial or residential buildings with the prevalent height of three stories or less.

841.014 Class 4 Locations

Class 4 locations include areas where multistory(1) buildings are prevalent, and where traffic is heavy or dense and where there may be numerous other utilities underground.

841.015 It should be emphasized that Location Class (1, 2, 3 or 4), as described in the foregoing paragraphs, is defined as the general description of a geographic area having certain characteristics as a basis for prescribing the types of construction and methods of testing to be used in those locations or in areas that are respectively comparable. A numbered Location-Class refers only to the geography of that location or a similar area, and does not necessarily indicate that a correspondingly numbered Construction-Type will suffice for all construction in that particular location or area. Example: In Location Class 1, all aerial crossings require Type B construction. (See 841.143)

841.016 When classifying locations for the purpose of determining the type of pipeline construction and testing that should be prescribed, due consideration shall be given to the possibility of future development of the area. If at the time of planning a new pipeline this future development appears likely to be sufficient to change the location class, this should be taken into consideration in the design and testing of the proposed pipeline.

It is also anticipated that some increase in population density will occur in all areas after a line is constructed, and this possibility has been taken into account in establishing the design, construction, and testing procedures for each location class.

Note (1): Multistory means 4 or more "floors" above ground including the first or ground floor. The depth of basements or number of basement floors is immaterial.

841.02 CLASSIFICATION OF STEEL PIPE CONSTRUCTION(1)

Four types of steel pipe construction are prescribed in this code. The distinguishing characteristics of each type and the locations in which each type shall be used are as follows:

A. Characteristics	Type A Construction	Type B Construction	Type C Construction	Type D Construction
1. Design Factor F (See 841.11)	.72	.60	.50	.40
B. Locations Where Type of Construction Shall Be Used	(a) On private rights of way in Class 1 locations. (b) Parallel encroachments on: Privately owned roads in Class 1 locations. Unimproved reads in Class 1 locations. (c) Crossings without casings of privately owned roads in Class 1 locations. (d) Crossings in casings of unimproved public roads hard-surfaced roads highways or public streets and railroads in Class 1 locations.	(a) On private rights of way in Class 2 locations. (b) Parallel encroachments on: Privately owned roads in Class 2 locations. Unimproved public roads in Class 2 locations. Hard surfaced roads, highways or public streets and railroads in Class 1 locations. (c) Crossings without casings of: Privately owned roads in Class 2 locations. Unimproved public roads in Class 2 locations Hard surfaced roads, highways or public streets and railroads in Class 1 and Class 2 locations. (d) Crossings in casings of: Hard surfaced roads, highways or public streets and railroads in Class 2 locations. (e) On bridges in Class 1 and Class 2 locations. (See 841.143) (f) Fabricated assemblies in pipelines in location Classes 1 and 2. (See 841.142)	(a) On private rights of way in Class 3 locations. (b) Parallel encroachments on: Privately owned roads in Class 3 locations. Unimproved public roads in Class 3 locations. Hard surfaced roads, highways or public streets and railroads in Class 3 locations (c) Crossings without casings of: Privately owned roads in Class 3 locations. Unimproved public roads in Class 3 locations. Hard surfaced roads, highways or public streets and railroads in Class 2 and 3 locations. (d) Compressor station piping.	(a) In all locations in locati Class 4.

(1) It is necessary to distinguish between construction types, as defined by Section A of this table, and location classes, as defined in 841.01, to avoid confusion. If pipelines or mains are located in private rights of way, the code prescribes that Type A construction be used in Class 1 locations, Type B construction in Class 2 locations, Type C construction in Class 3 locations, and Type D construction in Class 4 locations. There are many exceptions to this association of Class 1 with Type A, etc., however, as Table 841.02 shows, most of which are cases where pipelines or mains are located in highways or on bridges, etc.

841.03 CONSTRUCTION TYPES REQUIRED FOR PARALLEL ENCROACHMENTS OF PIPELINES AND MAINS ON ROADS AND RAILROADS

Kind of Thoroughfare	Construction Type Required			
	Location Class 1	Location Class 2	Location Class 3	Location Class 4
(a) Privately owned roads	Type A	Type B	Type C	Type D
(b) Unimproved public roads	Type A	Type B	Type C	Type D
(c) Hard surface roads, highways or public streets and railroads	Type B	Type B	Type C	Type D

841.04 CONSTRUCTION TYPES REQUIRED FOR PIPELINES AND MAINS CROSSING ROADS AND RAILROADS

Kind of Thoroughfare	Construction Type Required			
	Location Class 1	Location Class 2	Location Class 3	Location Class 4
(a) Privately owned roads	Type A without casing	Type B without casing	Type C without casing	Type D without casing
(b) Unimproved public roads	Type A with casing Type B without casing	Type B without casing	Type C without casing	Type D without casing
(c) Hard surface roads, highways or public streets and railroads	Type A with casing Type B without casing	Type B with casing Type C without casing	Type C without casing	Type D without casing

841.1 Steel Pipe Design Formula. The design pressure for steel gas piping systems or the nominal wall thickness for a given design pressure shall be determined by the following formula:

$$P = \frac{2St}{D} \times F \times E \times T$$

(For exceptions see 841.4)

Where:

P = Design pressure, psig

S = Specified minimum yield strength, psi, stipulated in the specifications under which the pipe was purchased from the manufacturer or determined in accordance with 811.27 H. The specified minimum yield strengths of some of the more commonly used piping steels, whose specifications are incorporated by reference herein, are tabulated for convenience in Appendix "C". For special limitation on S see 841.14 (e) and (f).

D = Nominal outside diameter of pipe, inches

t = Nominal wall thickness, inches.

F = Construction type design factor obtained from 841.11.

E = Longitudinal joint factor obtained from 841.12.

T = Temperature derating factor obtained from Table 841.13.

Table 841.11

Values of Design Factor "F"

Construction Type (See 841.02)	Design Factor F
Type - A	0.72
Type - B	0.60
Type - C	0.50
Type - D	0.40

Table 841.12

Longitudinal Joint Factor "E"

Spec. Number		Pipe Type	E Factor
ASTM	A53	Seamless	1.00
		Electric Resistance Welded	1.00
		Furnace Lap Welded	.80
		Furnace Butt Welded	.60
ASTM	A106	Seamless	1.00
ASTM	A134	Electric Fusion Welded	.80
ASTM	A135	Electric Resistance Welded	1.00
ASTM	A139	Electric Fusion Welded	.80
ASTM	A155	Electric Fusion Welded	1.00
API	5L	Seamless	1.00
		Electric Resistance Welded	1.00
		Electric Flash Welded	1.00
		Furnace Lap Welded	.80
		Furnace Butt Welded	.60
API	5LX	Seamless	1.00
		Electric Resistance Welded	1.00
		Electric Flash Welded	1.00
		Submerged Arc Welded	1.00

Table 841.13

Temperature Derating Factor "T"
For Steel Pipe

Temperature Degrees Fahrenheit	Temperature Derating Factor "T"
250° F. or less	1.000
300° F.	0.967
350° F.	0.933
400° F.	0.900
450° F.	0.867

NOTE: For intermediate temperatures interpolate for derating factor.

841.14 Limitations of Pipe Design Values (a) P for furnace butt welded pipe shall not exceed the restrictions of 841.1 or 60% of the mill test pressure, whichever is the lesser.

(b) P shall not exceed 85% of the mill test pressure for all other pipes; provided, however, that pipe, mill tested to a pressure less than 85% of the pressure required to produce a stress equal to the specified minimum yield, may be retested with a mill type hydrostatic test or tested in place after installation. In the event the pipe is retested to a pressure in excess of the mill test pressure, then P shall not exceed 85% of the retest pressure rather than the initial mill test pressure. It is mandatory to use a liquid as the test medium in all tests in place after installation where the test pressure exceeds the mill test pressure. This paragraph is not to be construed to allow an operating pressure or design pressure in excess of that provided for by 841.1.

(c) Transportation, installation or repair of pipe shall not reduce the wall thickness at any point to a thickness less than 90% of the nominal wall thickness as determined by 841.1 for the design pressure to which the pipe is to be subjected.

(d) "t" shall not be less than shown in Table 841.141. (See page 44.)

(e) When pipe that has been cold worked for the purpose of meeting the specified minimum yield strength is heated to 600°F. or higher (welding excepted), the maximum allowable pressure at which it can be used shall not exceed 75% of the value obtained by use of the steel pipe design formula given in 841.1.

(f) In no case where the code refers to the specified minimum value of a physical property can the actual value of the property be substituted in design calculations, unless the actual is less than the specified minimum. Table 841.141.

841.142 Fabricated Assemblies. When fabricated assemblies, such as connections for separators, main line valve assemblies, cross-connections, river crossing headers, etc., are to be installed in areas defined as location Class 1, Type B construction is required throughout the assembly, and for a distance of 5 pipe diameters in each direction beyond the last fittings. Transition pieces at the end of an assembly and elbows used in place of pipe bends are not considered as fittings under the requirements of this paragraph. See also 830.

841.143 Pipelines or mains supported by railroad, vehicular, pedestrian, or pipeline bridges shall be in accordance with the construction type prescribed for the area in which the bridge is located, except that in Class 1 locations Type B construction shall be used.

841.15 Protection of Pipelines and Mains from Hazards. When pipelines and mains must be installed where they will be subjected to natural hazards, such as washouts, floods, unstable soil, land slides, or

other conditions which may cause serious movement of, or abnormal loads on the pipeline, reasonable precaution shall be taken to protect the pipeline, such as increasing the wall thickness, constructing revetments, erosion prevention, installing anchors, etc. Where pipelines and mains are exposed, such as at spans, trestles, and bridge crossings, the pipelines and mains shall be reasonably protected by distance or barricades from accidental damage by vehicular traffic or other causes.

841.16 Cover and Casing Requirements Under Railroads, Roads, Streets or Highways.

(a) All buried pipelines, mains, and casings when used, shall be installed with a minimum cover of 24 inches unless otherwise provided herein.

(b) Buried pipelines and mains operating at hoop stresses of less than 20% of the specified minimum yield strength and located within private rights-of-way, private thoroughfares, sidewalks or parkways may be installed with less than the minimum cover of 24 inches if it appears that external damage to the pipe will not be likely to result.

(c) Abandoned pipe having a cover less than 24 inches may be used as a casing or conduit for pipelines and mains operating at hoop stresses less than 20% of the specified minimum yield strength.

(d) Buried pipelines and mains installed in areas where farming or other operations might result in deep plowing, or in thoroughfares or other locations where grading is done, or where the area is subject to erosion, should be provided with more cover than the minimum otherwise required.

(e) Where it is impractical to comply with the provisions of 841.16(a) and it is necessary to prevent damage from external loads, the pipe shall be cased or bridged.

(f) Casings shall be designed to withstand the superimposed loads. Where there is a possibility of moisture entering the casing, the ends of the casing shall be sealed. If the end sealing is of a type that will retain the full pressure of the pipe, the casing shall be designed for the same pressure as the pipe but according to Type A construction requirements. Venting of sealed casings is not mandatory; however, if vents are installed they should be protected from the weather to prevent moisture from entering the casing.

841.161 Clearance Between Pipelines or Mains and Other Underground Structures. There should be at least 2 inches clearance wherever possible between any gas main or pipeline and any other underground structure not used in conjunction with the pipeline or main. When this clearance cannot be attained, other suitable precautions to protect the pipe shall be taken, such as the installation of insulating material, installation of casing, etc.

841.17 Corrosion Factors for Design of Steel Pipelines, and Mains.

841.171 (a) The design procedures prescribed by this code for pipelines and mains are applicable without modification only when the gas transported is substantially noncorrosive; and the soil in which the pipeline is installed is either substantially noncorrosive, or suitable steps are taken to mitigate external corrosion.

(b) If a corrosive gas is to be transported, or if suitable means of preventing external corrosion in corrosive soils are not to be provided, the thickness of the pipe shall be increased to provide an allowance for corrosion. The minimum corrosion allowances to be provided in any such case shall not be less than .05 inches for external corrosion and .075 inches for internal corrosion. If both external and internal corrosion are to be expected, add both allowances.

(c) If the thickness obtained by adding the required allowance to the thickness computed by equation 841.1 does not exceed the least allowable wall thickness prescribed in Table 841.141, at least the thickness given in that table shall be used.

(d) If the maximum hoop stress due to gas pressure is less than 20% of the specified minimum yield strength, allowance for corrosion is not mandatory. However, the installation in corrosive soil of unprotected pipe with wall thickness as thin as permitted by Table 841.141 is not recom-

mended even for low-pressure distribution systems.

841.172 Internal Corrosion Criteria

(a) For the purposes of this code, any fuel gas of commercial grade, the water dew point of which is at all times below pipeline temperature, shall be considered to be substantially noncorrosive unless experience with it has indicated otherwise.

(b) Some fuel gases may be substantially noncorrosive even though their water dew point exceeds pipeline temperatures. Such gas shall, however, be assumed to be noncorrosive only if proven so by careful tests or experience.

841.173 External Corrosion Criteria. Suitable investigation shall be made, and if it indicates that protection from external corrosion is needed, steel pipelines or mains shall be protected by any recognized method or combination of methods, such as coating with protective material, application of cathodic protection, and electrical bonding or isolation of sections.

841.2 Installation of Steel Pipelines and Mains

841.21 Construction Specifications. All construction work performed on piping systems in accordance with the requirements of this code shall be done under construction specifications. Preferably the construction specifications shall cover all phases of the work and should be in sufficient detail to cover the requirements of this code.

841.22 Inspection Provisions.

841.221 The operating company shall make provision for suitable inspection. Inspectors shall be qualified by either experience or training.

841.222 The installation inspection provisions for pipelines and other facilities to operate at hoop stresses of 20% or more of the specified minimum yield strength should be adequate either to make possible the following inspections or to do other things that will assure a comparable degree of control of quality of workmanship.

(a) Inspect the surface of the pipe for serious surface defects just prior to the coating operation. See 841.242 (a).

(b) Inspect the surface of the coated pipe as it is lowered into the ditch to find coating lacerations that indicate the pipe might have been damaged after being coated. Damage during the lowering-in process should be found during this inspection.

(c) Inspect the fit-up of the joints before the weld is made.

(d) Visually inspect the stringer beads before subsequent beads are applied.

(e) Inspect the completed welds before they are covered with coating.

(f) Inspect the condition of the ditch bottom just before the pipe is lowered in.

(g) Inspect the fit of the pipe to the ditch before backfilling.

(h) Inspect all repairs, replacements or changes ordered before they are covered up.

(i) Perform such special tests and inspections as are required by the specifications, such as the radiographing of a portion of the welds and the electrical testing of the protective coating.

841.223 The inspector shall have authority to order the removal and replacement of any section that fails to meet the standards of this code.

841.23 Bends, Elbows, and Miters in Steel Pipelines and Mains.

Changes in direction may be made by the use of bends, elbows, or miters under the following limitations:

841.231 The bends shall be free from buckling, cracks or other evidence of mechanical damage. For field cold bends on sizes 12 inch and larger, the longitudinal axis of the pipe shall not be deflected more than 1-1/2 degrees in any length along the pipe axis equal to the diameter of the pipe. All bends other than wrinkle bends shall not have a difference between the maximum and minimum diameters in excess of 2.5% of the nominal diameter.

Table 841.141

Least Nominal Wall Thicknesses (Inches)

Nominal Diameter (Inches)		Location Classes (Note 1) 1	Location Classes (Note 1) 2, 3 & 4		Compressor Stations	
1/8"	Threaded or Plain End	0.068	0.068		0.095	Threaded or Plain End
1/4"		0.088	0.088		0.119	
3/8"		0.091	0.091		0.126	
1/2"		0.109	0.109		0.147	
3/4"		0.113	0.113		0.154	
1"		0.133	0.133		0.179	
1-1/4"		0.140	0.140		0.191	
1-1/2"		0.145	0.145		0.200	
2"		0.154	0.154		0.218	
2-1/2"	Plain End Only	0.103	*0.125	Plain End Only	0.203	Plain End Only
3"		0.104	*0.125		0.216	
3-1/2"		0.104	*0.125		0.226	
4"		0.104	*0.125		0.237	
5"		0.104	*0.125		0.250	
6"		0.104	0.156		0.250	
8"		0.104	0.172		0.250	
10"		0.104	0.188		0.250	
12"		0.104	0.203		0.250	
14"		0.134	0.210		0.250	
16"		0.134	0.219		0.250	
18"		0.134	0.250		0.250	
20"		0.134	0.250		0.250	
22", 24", 26"		0.164	0.250		0.250	
28", 30"		0.164	0.281		0.281	
32", 34", 36"		0.164	0.312		0.312	

Note 1: If threaded pipe is to be used in those sizes for which least nominal wall thicknesses are given for "plain end pipe only," those sizes marked by * shall be increased as follows: 2-1/2" to 0.203, 3" to 0.216, 3-1/2" to 0.226, 4" to 0.237, 5" to 0.258, and add 0.100 inch to all other wall thicknesses given in Table 841.141.

841.232 When a circumferential weld occurs in a bend section, it shall be subjected to X-ray examination after bending.

841.233 Hot bends made on cold worked or heat treated pipe shall be designed for lower stress levels in accordance with 841.14 (e).

841.234 Cold wrinkle bends are permitted, but not preferred on systems operating at 40% or more of the specified minimum yield strength. When wrinkle bends are made in welded pipe, the longitudinal weld shall be located as nearly to 90° with the top of the wrinkle as conditions will permit. Hot wrinkle bends are prohibited in cold worked pipe if the strength induced by cold work is needed to keep within the code design limits. Wrinkle bends with sharp kinks will not be permitted. Wrinkles shall have a spacing not less than the distance equal to the diameter of the pipe measured along the crotch. On pipe 16 inches and larger the wrinkle shall not produce an angle of more than 1-1/2 degrees per wrinkle.

841.235 The longitudinal weld of the pipe shall preferably be near the neutral axis of the bend.

841.236 Mitered bends are permitted subject to the following limitations:

(a) In systems intended to operate at 40% or more of the specified minimum yield strength, mitered bends are not permitted. Deflections caused by misalignment up to 3° are not considered as miters.

(b) In systems intended to operate at 10% but less than 40% of the specified minimum yield strength, the total deflection angle at each miter shall not exceed 12-1/2°.

(c) In systems intended to operate at less than 10% of the specified minimum yield strength, the total deflection angle at each miter shall not exceed 90°.

(d) In systems intended to operate at 10% or more of the specified minimum yield strength, the minimum distance between miters measured at the crotch shall not be less than one pipe diameter.

(e) Care shall be taken in making mitered joints to provide proper spacing and alignment and full penetration.

841.237 Factory made wrought steel welding elbows or transverse segments cut therefrom may be used for changes in direction provided that the arc length measured along the crotch is at least 1 inch on pipe sizes 2 inches and larger.

841.24 Pipe Surface Requirements Applicable to Pipelines and Mains to Operate at a Hoop Stress of 20% or More of the Specified Minimum Yield Strength. Gouges, grooves, and notches have been found to be a very important cause of pipeline failures and all harmful defects of this nature must be prevented or eliminated. Precautions shall be taken during manufacture, hauling, and installation to prevent the gouging or grooving of pipe.

841.241 Detection of Gouges and Grooves

(a) The field inspection provided on each job shall be suitable to reduce to an acceptable minimum the chances that gouged or grooved pipe will get into the finished pipeline or main. Inspection for this purpose just ahead of the coating operation and during the lowering-in and backfill operation is recommended.

(b) When pipe is coated, inspection shall be made to determine that the coating machine does not cause harmful gouges or grooves.

(c) Lacerations of the protective coating should be carefully examined to see if the pipe surface has been damaged.

841.242 Field Repair of Gouges and Grooves

(a) Injurious gouges or grooves shall be removed.

(b) They may be removed by grinding, provided that the resulting wall thickness is not less than the minimum prescribed by this code for the conditions of usage. See 841.14(c).

(c) When the conditions outlined in 841.242(b) cannot be met, the damaged portion of pipe shall be cut out as a cylinder and replaced with a good piece. Insert patching is prohibited.

841.243 Dents. Dents have been found to cause serious stress concentrations in pipelines. Dents that are more than 1/4 inch deep, measured as the gap between the

lowest point of the dent and a prolongation of the original contour of the pipe in any direction are considered harmful, and shall be removed from pipelines or mains intended to operate at 50% or more of the specified minimum yield strength. Removal of dents in the field shall be done by cutting out a cylindrical section of pipe and not by insert-patching or pounding out the dent.

841.244 Arc Burns. Arc burns have been found to cause serious stress concentration in pipelines of grades 5LX or equal and shall be prevented or eliminated in all lines corresponding to these specifications intended to operate at 50% or more of the specified minimum yield strength.

841.245 Elimination of Arc Burns. The metallurgical notch caused by arc burns shall be removed by grinding, provided the grinding does not reduce the remaining wall thickness to less than the minimum prescribed by this code for the conditions of use.(1) In all other cases repair is prohibited and the portion of pipe containing the arc burn must be cut out as a cylinder and replaced with a good piece. Insert-patching is prohibited.

841.25 Application and Inspection of Protective Coatings for Underground Piping (Also see 841.17)

(a) Protective coatings for underground piping shall be applied in accordance with either the coating manufacturer's recommendations or the Company's coating specifications for the particular conditions encountered. These recommendations or specifications shall also cover the patching of damaged spots, the coating of joints, short lengths of pipe and fittings coated in the field.

(b) Crews that apply protective coatings shall be suitably instructed and provided with all of the equipment necessary to accomplish their work in a satisfactory manner.

(c) It is recommended that the protective coating be inspected and tested either completely or on a sampling basis using a recognized "flaw detector" before or after backfilling.

841.26 Electrical Test Leads for Corrosion Control or Electrolysis Testing on Pipelines or Mains to Operate at 20% or More of the Specified Minimum Yield Strength.

841.261 When electrical test leads for corrosion control or electrolysis testing are required, care should be exercised in their installation, particularly on pipelines that are stressed to near the maximum stress levels permitted by this code, to avoid stress concentration.

841.262 The brazing of electrical test leads directly onto the pipe is prohibited.

841.263 All test lead connections and all bare leads shall be protected by coating and/or wrapping.

841.27 Miscellaneous Operations Involved in the Installation of Steel Pipelines and Mains.

841.271 Handling, Hauling and Stringing. Care should be taken in the selection of the handling equipment and in handling, hauling, unloading, and placing the pipe so as not to damage the pipe.

841.272 Installation of Pipe in the Ditch. On pipelines operating at stresses of 20% or more of the specified minimum yield strength, it is very important that stresses induced into the pipeline by construction be minimized. This includes grading the ditch so that the pipe has a firm substantially continuous bearing on the bottom of the ditch. The pipe shall fit the ditch without the use of

Note (1): Complete removal of the metallurgical notch created by an arc burn can be determined as follows: After visible evidence of the arc burn has been removed by grinding, swab the ground area with a 20% solution of ammonium persulfate. A blackened spot is evidence of a metallurgical notch and indicates that additional grinding is necessary.

external force to hold it in place until the backfill is completed. When long sections of pipe that have been welded alongside the ditch are lowered in, care shall be exercised so as not to jerk the pipe or impose any strains that may kink or put a permanent bend in the pipe. Slack loops are not prohibited by this paragraph where laying conditions render their use advisable.

841.273 Backfilling

(a) Backfilling should be performed in a manner to provide firm support under the pipe.

(b) If there are large rocks in the material to be used for backfill, care should be used to prevent damage to the coating, by such means as the use of rock shield material, or by making the initial fill with rock free material to a sufficient depth over the pipe to prevent rock damage.

(c) Where flooding of the trench is done to consolidate the backfill, care shall be exercised to see that the pipe is not floated from its firm bearing on the trench bottom.

841.274 Hot Taps. All hot taps shall be installed by trained and experienced crews.

841.28 Precautions to Avoid Explosions of Gas-Air Mixtures or Uncontrolled Fires during Construction Operations.

841.281 Operations such as gas or electric welding and cutting with cutting torches can be safely performed on pipelines and mains and auxiliary equipment, provided that they are completely full of gas, or air that is free from combustible material. Steps shall be taken to prevent a mixture of gas and air at all points where such operations are to be performed.

841.282 When a pipeline or main can be kept full of gas during a welding or cutting operation, the following procedures are recommended:

(a) Keep a slight flow of gas moving toward the point where cutting or welding is being done.

(b) The gas pressure at the site of the work shall be controlled by suitable means.

(c) Close all slots or open ends immediately after they are cut, with tape, and/or tightly fitted canvas or other suitable material.

(d) Do not permit two openings to remain uncovered at the same time. This is doubly important if the two openings are at different elevations.

841.283 No welding or acetylene cutting should be done on a pipeline, main or auxiliary apparatus that contains air if it is connected to a source of gas, unless a suitable means has been provided to prevent the leakage of gas into the pipeline or main.

841.284 In situations where welding or cutting must be done on facilities which are filled with air and connected to a source of gas and the precautions recommended above cannot be taken, one or more of the following precautions, depending upon circumstances at the job, are suggested:

(a) Purging of the pipe or equipment upon which welding or cutting is to be done, with combustible gas or inert gas.

(b) Testing of the atmosphere in the vicinity of the zone to be heated before the work is started and at intervals as the work progresses, with a combustible gas indicator or by other suitable means.

(c) Careful verification before the work starts that the valves that isolate the work from a source of gas do not leak.

841.285 Purging of Pipelines and Mains

(a) When a pipeline or main full of air is placed in service, the air in it can be safely displaced with gas provided that a moderately rapid and continuous flow of gas is introduced at one end of the line and the air is vented out the other end. The gas flow should be continued without interruption until the vented gas is free from air. The vent should then be closed.

(b) In cases where gas in a pipeline or main is to be displaced with air and the rate at which air can be supplied to the line is too small to make a procedure similar

to, but the reverse of that described in 841.285(a) feasible, a slug of inert gas should be introduced to prevent the formation of an explosive mixture at the interface between gas and air. Nitrogen or carbon dioxide can be used for this purpose.

(c) If a pipeline or main containing gas is to be removed, the operation may be carried out in accordance with 841.282 or the line may be first disconnected from all sources of gas and then thoroughly purged with air, water or with inert gas before any further cutting or welding is done.

(d) If a gas pipeline or main or auxiliary equipment is to be filled with air after having been in service and there is a reasonable possibility that the inside surfaces of the facility are wetted with a volatile inflammable liquid, or if such liquids might have accumulated in low places, purging procedures designed to meet this situation shall be used. Steaming of the facility until all combustible liquids have been evaporated and swept out is recommended. Filling of the facility with an inert gas and keeping it full of such gas during the progress of any work that might ignite an explosive mixture in the facility is an alternative recommendation. The possibility of striking static sparks within the facility must not be overlooked as a possible source of ignition.

841.286 Whenever the accidental ignition in the open air of a gas-air mixture might be likely to cause personal injury or property damage, precautions shall be taken as, for example

(a) Prohibit smoking and open flames in the area, and

(b) Install a metallic bond around the location of cuts in gas pipes to be made by other means than cutting torches, and

(c) Take precautions to prevent static electricity sparks, and

(d) Provide a fire extinguisher of a class approved by the National Fire Protection Association, or the National Board of Fire Underwriters.

841.3 Testing After Construction

841.31 General Provisions. All pipelines, mains and services shall be tested after construction, except as follows:

Tie-ins. Because it is sometimes necessary to divide a pipeline or main into test sections and install test heads, connecting piping, and other necessary appurtenances for testing, it is not required that the tie-in sections of pipe be tested.

841.4 Test Requirements

841.41 Test Required to Prove Strength of Pipelines and Mains to Operate at Hoop Stresses of 30% or More of the Specified Minimum Yield Strength of the Pipe

841.411 All pipelines and mains to be operated at a hoop stress of 30% or more of the specified minimum yield strength of the pipe shall be given a field test to prove strength after construction and before being placed in operation.

841.412 (a) Pipelines and mains located in Location Class 1 shall be tested either with air or gas to 1.1 times the maximum operating pressure or hydrostatically to at least 1.1 times the maximum operating pressure. See 841.5.

(b) Pipelines or mains located in Location Class 2 shall be tested either with air to 1.25 times the maximum operating pressure or hydrostatically to at least 1.25 times the maximum operating pressure. See 841.5.

(c) Pipelines and mains in Location Classes 3 and 4 shall be tested hydrostatically to a pressure not less than 1.4 times the maximum operating pressure.

(d) The test requirements given in 841.412 (a), (b) and (c) above are summarized in Table 841.412 (d).

841.413 Requirements of 841.412 (c) for hydrostatic testing of mains and pipelines in Location Classes 3 and 4 do not apply if at the time the pipeline or main is first

Table 841.412(d)

Test Requirements for Pipelines and Mains to Operate at Hoop Stresses of 30% or More of the Specified Minimum Yield Strength of the Pipe

1	2	3	4	5
Location Class	Permissible Test Fluid	Prescribed Test Pressure		Maximum Allowable Operating Pressure, the lesser of
		Minimum	Maximum	
1	Water	1.1 x m.o.p.	None	t.p. ÷ 1.1 or d.p.
	Air	1.1 x m.o.p.	1.1 x d.p.	
	Gas	1.1 x m.o.p.	1.1 x d.p.	
2	Water	1.25 x m.o.p.	None	t.p. ÷ 1.25 or d.p.
	Air	1.25 x m.o.p.	1.25 x d.p.	
3	Water	1.40 x m.o.p.	None	t.p. ÷ 1.40 or d.p.
4	Water	1.40 x m.o.p.	None	t.p. ÷ 1.40 or d.p.

m.o.p. = maximum operating pressure (not necessarily the maximum allowable operating pressure)

d.p. = design pressure

t.p. = test pressure

Note (1) This table brings out the relationships between test pressures and maximum allowable operating pressures subsequent to the test. If an operating company decides that the maximum operating pressure will be less than the design pressure a corresponding reduction in prescribed test pressure may be made as indicated in Column 3. However, if this reduced test pressure is used the maximum operating pressure cannot later be raised to the design pressure without retesting the line to the test pressure prescribed in Column 4. See 805.14, 845.22 and 845.23.

ready for test, one or both of the following conditions exist:

(a) The ground temperature at pipe depth is 32°F. or less, or might fall to that temperature before the hydrostatic test could be completed, or

(b) Water of satisfactory quality is not available in sufficient quantity.

(c) In such cases an air test to 1.1 times the maximum operating pressure shall be made and the limitations on operating pressure imposed by 841.412(d) above do not apply.

841.414 Other provisions of this code notwithstanding, pipelines and mains crossing highways and railroads may be tested in each case in the same manner and to the same pressure as the pipeline on each side of the crossing.

841.415 Other provisions of this code notwithstanding, fabricated assemblies, including mainline valve assemblies, cross connections, river crossing headers, etc., installed in pipelines in Class 1 locations and designed in accordance with Type B construction, as required in 841.142, may be tested as required for Class 1 locations.

841.416 Notwithstanding the limitations on air testing imposed in 841.412 (c), air testing may be used in Location Classes 3 and 4, provided that all of the following conditions apply:

(a) The maximum hoop stress during test is less than 50% of the specified minimum yield strength in Class 3 locations, and less than 40% of the specified minimum yield strength in Class 4 locations.

(b) The maximum pressure at which the pipeline or main is to be operated does not exceed 80% of the maximum field test pressure used.

(c) The pipe involved is new pipe having a longitudinal joint factor E in Table 841.12 of 1.00.

841.417 Records. The operating company shall maintain in its file for the useful life of each pipeline and main, records showing the type of fluid used for test and the test pressure.

841.42 Tests Required to Prove Strength for Pipelines and Mains to Operate at Less than 30% of the Specified Minimum Yield Strength of the Pipe, but in Excess of 100 psi. Steel piping that is to operate at stresses less than 30% of the specified minimum yield strength but in excess of 100 psi in location classes 2, 3 and 4 shall be tested to at least 1.5 times the maximum operating pressure. The test medium used may be water, air or gas; provided, however, that no medium shall be used to a higher hoop stress during the test than the maximums set in Table 841.421.

Table 841.421

Maximum Hoop Stress Permissible During Test

	Percent of Specified Minimum Yield Strength			
Location class	1	2	3	4
Test medium				
Water	No max.	No max.	No max.	No max.
Air	79.2	75	50	40
Gas	79.2	30	30	30

841.43 Leak Tests for Pipelines or Mains to Operate at 100 psi or More

841.431 Each pipeline and main shall be tested after construction and before being placed in operation to demonstrate that it does not leak. If the test indicates that a leak exists, the leak or leaks shall be located and eliminated, unless it can be determined that no undue hazard to public safety exists.

841.432 The test procedure used shall be capable of disclosing all leaks in the section being tested and shall be selected after giving due consideration to the volumetric content of the section and to its location.

841.433 In all cases where a line is to be stressed in a strength-proof test to 20% or more of the specified minimum yield strength of the pipe, and gas or air is

the test medium, a leak test shall be made at a pressure in the range from 100 psi to that required to produce a hoop stress of 20% of the minimum specified yield, or the line shall be walked while the hoop stress is held at approximately 20% of the specified minimum yield.

841.44 Leak Tests for Pipelines and Mains to Operate at Less Than 100 psi

841.441 At the time of or prior to placing in operation distribution mains and related equipment to operate at less than 100 psi, they shall be tested to determine that they are gas-tight.

841.442 Gas may be used as the test medium at the maximum pressure available in the distribution system at the time of the test. In this case the soap bubble test may be used to locate leaks if all joints are accessible during the test.

841.443 Testing at available distribution system pressures as provided for above in 841.442 may not be adequate if substantial protective coatings are used that would seal a split pipe seam. If such coatings are used, the leak test pressure shall be 100 psi.

841.5 Safety During Tests All testing of pipelines and mains after construction shall be done with due regard for the safety of employees and the public during the test. When air or gas is used, suitable steps shall be taken to keep persons not working on the testing operations out of the testing area during the period in which the hoop stress is first raised from 50% of the specified minimum yield to the maximum test stress, and until the pressure is reduced to the maximum operating pressure.

842 CAST IRON

842.1 Cast Iron Pipe Design

842.11 Basic Equation to Determine Required Wall Thickness. Cast iron pipe shall be designed in accordance with the methods set forth in the ASA A21.1 "American Recommended Practice Manual for the Computation of Strength and Thickness of Cast Iron Pipe."

842.12 Maximum Allowable Values of S and R. The values of S, bursting tensile strength, and R, modulus of rupture, to be used in the equations given in ASA A21.1 are:

Specification	Type of Pipe	S Bursting Tensile Strength	R Modulus of Rupture
ASA A21.3	Pit Cast	11,000 psi	31,000 psi
ASA A21.7	Centrifugal (Metal Mold)	18,000 psi	40,000 psi
ASA A21.9	Centrifugal (Sand-lined Mold)	18,000 psi	40,000 psi

842.13 Allowable Thicknesses for Cast Iron Pipe. The least cast iron pipe thicknesses permitted are the lightest standard classes for each nominal pipe size as shown in ASA Specifications A21.3, A21.7 and A21.9.

842.14 Standard Thickness for Cast Iron Pipe. The wall thickness, diameter, and maximum working pressure permitted under ASA A21.1 for the type and sizes of cast iron pipe most commonly used for gas piping are shown in Tables 842.141 and 842.142. For pipe sizes, pressure, thicknesses, or laying conditions not shown in these tables, reference should be made to ASA A21.1 for the method of calculation.

Table 842.141
(See Table on page 53).
Table 842.142
(See Table on page 54).

842.15 Cast Iron Pipe Joints

(a) Caulked Bell and Spigot Joints Dimensions for caulked bell and spigot joints shall conform to the American Standards Association Specifications A21.3, A21.7, A21.9 and A21.10. This type of joint shall not be used for pressures in excess of 25 psig, unless reinforced with mechanical clamps.

(b) Mechanical Joints Mechanical joints shall utilize gaskets made of a resil-

ient material as their sealing medium. The material selected for gaskets shall be of a type not adversely affected by the gas or condensates in the main. The gaskets shall be suitably confined and retained under compression by a separate gland or follower ring. A joint of this type is shown in ASA Specification A21.11.

(c) Threaded Joints. The use of threaded joints to couple lengths of cast iron pipe is not recommended.

(d) Flanged Joints. The dimensions and drilling for flanges shall conform to the ASA B-16 series of the American Standard for Cast Iron Pipe Flanges and Flanged Fittings. Flanges shall be cast integrally with fittings or valves.

(e) Special Joints. Special joints are not prohibited provided they are properly qualified and utilized in accordance with appropriate provisions of this code.

TABLE 842.141

STANDARD THICKNESSES OF CAST IRON PIT CAST PIPE FOR GAS

Thickness in Inches, Working Pressure in Pounds per Square Inch.
Thicknesses Include Allowances for Foundry Practice and Corrosion

Laying Condition A—Flat Bottom Trench, Without Blocks, Untamped Backfill
Laying Condition B—Flat Bottom Trench, Without Blocks, Tamped Backfill
Laying Condition C—Pipe Laid on Blocks, Untamped Backfill
Laying Condition D—Pipe Laid on Blocks, Tamped Backfill

Size Inches	Working Pressure	3½ FEET OF COVER				5 FEET OF COVER				8 FEET OF COVER			
		Laying Condition				Laying Condition				Laying Condition			
		A	B	C	D	A	B	C	D	A	B	C'	D
4	10	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.46	.40
	50	.40	.40	.40	.40	.40	.40	.40	.40	.40	.40	.50	.40
	100	.40	.40	.40	.40	.40	.40	.43	.40	.40	.40	.50	.40
	150	.40	.40	.40	.40	.40	.40	.43	.40	.40	.40	.50	.40
6	10	.43	.43	.46	.43	.43	.43	.50	.43	.43	.43	.54	.43
	50	.43	.43	.46	.43	.43	.43	.50	.43	.43	.43	.54	.43
	100	.43	.43	.46	.43	.43	.43	.50	.43	.43	.43	.58	.43
	150	.43	.43	.50	.43	.43	.43	.50	.43	.43	.43	.58	.43
8	10	.46	.46	.50	.46	.46	.46	.54	.46	.46	.46	.58	.46
	50	.46	.46	.54	.46	.46	.46	.54	.46	.46	.46	.63	.46
	100	.46	.46	.54	.46	.46	.46	.58	.46	.46	.46	.63	.46
	150	.46	.46	.54	.46	.46	.46	.58	.46	.46	.46	.63	.46
10	10	.50	.50	.54	.50	.50	.50	.58	.50	.50	.50	.68	.50
	50	.50	.50	.58	.50	.50	.50	.58	.50	.50	.50	.68	.54
	100	.50	.50	.58	.50	.50	.50	.63	.50	.54	.50	.68	.54
	150	.50	.50	.58	.50	.50	.50	.63	.50	.54	.50	.68	.58
12	10	.54	.54	.58	.54	.54	.54	.63	.54	.54	.54	.68	.58
	50	.54	.54	.58	.54	.54	.54	.63	.54	.58	.54	.73	.58
	100	.54	.54	.63	.54	.54	.54	.63	.54	.58	.58	.73	.58
	150	.54	.54	.63	.58	.58	.54	.68	.58	.63	.58	.79	.63
16	10	.58	.58	.68	.58	.58	.58	.68	.63	.68	.63	.79	.68
	50	.58	.58	.68	.63	.63	.58	.73	.63	.68	.63	.79	.73
	100	.63	.58	.73	.63	.63	.58	.73	.68	.73	.68	.85	.73
20	10	.66	.66	.77	.71	.71	.66	.83	.71	.77	.71	.90	.83
	50	.71	.66	.77	.71	.71	.66	.83	.77	.77	.71	.90	.83
	100	.71	.66	.83	.77	.77	.71	.83	.77	.83	.77	.97	.83
24	10	.74	.74	.80	.74	.80	.74	.86	.80	.86	.80	.93	.86
	50	.80	.74	.86	.80	.80	.74	.93	.86	.86	.80	1.00	.93
	100	.80	.74	.93	.86	.86	.80	.93	.86	.93	.86	1.00	.93
30	10	.87	.87	.94	.87	.94	.87	1.02	.94	1.02	.87	1.10	1.02
	50	.94	.87	1.02	.94	.94	.87	1.10	1.02	1.10	.94	1.19	1.10
36	10	1.05	.97	1.05	.97	1.05	.97	1.13	1.05	1.13	.97	1.22	1.13
	50	1.05	.97	1.13	1.05	1.13	.97	1.22	1.13	1.22	1.05	1.32	1.22
42	10	1.16	1.07	1.16	1.07	1.16	1.07	1.25	1.16	1.35	1.07	1.35	1.25
	50	1.16	1.07	1.25	1.16	1.25	1.07	1.35	1.25	1.35	1.16	1.46	1.35
48	10	1.27	1.18	1.37	1.18	1.37	1.18	1.37	1.27	1.48	1.18	1.60	1.37
	50	1.27	1.18	1.37	1.27	1.37	1.18	1.48	1.37	1.48	1.27	1.60	1.48

Note: This table is taken from ASA A21.3

TABLE 842.142

STANDARD THICKNESSES OF CAST IRON GAS PIPE CENTRIFUGALLY CAST IN METAL MOLDS OR SAND LINED MOLDS

Thickness in Inches. Working Pressure in Pounds per Square Inch.
Thicknesses Include Allowances for Foundry Practice and Corrosion

Laying Condition A—Flat Bottom Trench, Without Blocks, Untamped Backfill
Laying Condition B—Flat Bottom Trench, Without Blocks, Tamped Backfill
Laying Condition C—Pipe Laid on Blocks, Untamped Backfill
Laying Condition D—Pipe Laid on Blocks, Tamped Backfill

Size Inches	Working Pressure	3½ FEET OF COVER				5 FEET OF COVER				8 FEET OF COVER			
		Laying Condition				Laying Condition				Laying Condition			
		A	B	C	D	A	B	C	D	A	B	C	D
4	10	.35[1]	.35	.35	.35	.35	.35	.35	.35	.35	.35	.41	.35
		.38[2]	.38	.38	.38	.38	.38	.38	.38	.38	.38	.41	.38
	50	.35[1]	.35	.35	.35	.35	.35	.35	.35	.35	.35	.41	.35
		.38[2]	.38	.38	.38	.38	.38	.38	.38	.38	.38	.41	.38
	100	.35[1]	.35	.35	.35	.35	.35	.35	.35	.35	.35	.41	.35
		.38[2]	.38	.38	.38	.38	.38	.38	.38	.38	.38	.41	.38
	150	.35[1]	.35	.35	.35	.35	.35	.38	.35	.35	.35	.41	.35
		.38[2]	.38	.38	.38	.38	.38	.38	.38	.38	.38	.41	.38
6	10	.38[1]	.38	.41	.38	.38	.38	.41	.38	.38	.38	.48	.38
		.41[2]	.41	.41	.41	.41	.41	.41	.41	.41	.41	.48	.41
	50	.38[1]	.38	.41	.38	.38	.38	.41	.38	.38	.38	.48	.38
		.41[2]	.41	.41	.41	.41	.41	.41	.41	.41	.41	.48	.41
	100	.38[1]	.38	.41	.38	.38	.38	.44	.38	.38	.38	.48	.38
		.41[2]	.41	.41	.41	.41	.41	.44	.41	.41	.41	.48	.41
	150	.38[1]	.38	.41	.38	.38	.38	.44	.38	.38	.38	.48	.38
		.41[2]	.41	.41	.41	.41	.41	.44	.41	.41	.41	.48	.41
8	10	.41	.41	.44	.41	.41	.41	.48	.41	.41	.41	.52	.41
	50	.41	.41	.44	.41	.41	.41	.48	.41	.41	.41	.52	.41
	100	.41	.41	.48	.41	.41	.41	.48	.41	.41	.41	.56	.41
	150	.41	.41	.48	.41	.41	.41	.48	.41	.41	.41	.56	.41
10	10	.44	.44	.48	.44	.44	.44	.52	.44	.44	.44	.60	.44
	50	.44	.44	.48	.44	.44	.44	.52	.44	.44	.44	.60	.44
	100	.44	.44	.52	.44	.44	.44	.52	.44	.44	.44	.60	.48
	150	.44	.44	.52	.44	.44	.44	.56	.44	.48	.44	.60	.48
12	10	.48	.48	.52	.48	.48	.48	.56	.48	.48	.48	.60	.52
	50	.48	.48	.52	.48	.48	.48	.56	.48	.48	.48	.60	.52
	100	.48	.48	.56	.48	.48	.48	.56	.48	.52	.48	.65	.52
	150	.48	.48	.56	.48	.48	.48	.56	.48	.52	.48	.65	.52
16	10	.54	.50	.58	.54	.54	.50	.63	.58	.58	.54	.73	.63
	50	.54	.50	.63	.54	.54	.50	.63	.58	.63	.58	.73	.63
	100	.54	.54	.63	.58	.58	.54	.68	.58	.63	.58	.73	.68
20	10	.62	.57	.67	.62	.62	.57	.72	.67	.67	.62	.78	.72
	50	.62	.57	.72	.62	.67	.57	.72	.67	.72	.62	.78	.72
	100	.62	.57	.72	.67	.67	.62	.78	.67	.72	.67	.84	.78
24	10	.68	.63	.73	.68	.73	.63	.79	.73	.79	.68	.85	.79
	50	.68	.63	.79	.68	.73	.63	.79	.73	.79	.73	.85	.79
	100	.73	.63	.79	.73	.73	.68	.85	.79	.79	.73	.92	.85
30	10	.79	.73	.85	.79	.85	.73	.92	.85	.92	.79	.99	.92
	50	.85	.73	.85	.85	.85	.79	.92	.85	.92	.85	.99	.92
36	10	.87	.81	.94	.87	.94	.81	1.02	.94	1.02	.87	1.10	1.02
	50	.94	.81	1.02	.94	1.02	.87	1.10	.94	1.10	.94	1.19	1.02
42	10	1.05	.90	1.05	.97	1.05	.90	1.13	1.05	1.13	.97	1.22	1.13
	50	1.05	.90	1.13	1.05	1.13	.97	1.13	1.05	1.22	1.05	1.32	1.13
48	10	1.14	.98	1.14	1.06	1.14	.98	1.23	1.14	1.33	1.06	1.33	1.23
	50	1.14	.98	1.23	1.14	1.23	1.06	1.33	1.14	1.33	1.14	1.44	1.33

[1]Class 22 Thickness.
[2]Class 23 Thickness offers increased factor of safety and is recommended for use in areas of dense population and heavy traffic.

NOTE: This table is taken from ASA A21.7 and A21.9

842.2 Installation of Cast Iron Pipe

842.21 Underground cast iron pipe shall be laid in accordance with the applicable field conditions described in the ASA "American Recommended Practice Manual" A21.1.

842.22 Underground cast iron pipe shall be installed with a minimum cover of 24 inches unless prevented by other underground structures.

842.23 Where sufficient cover cannot be provided to protect the pipe from external loads or damage and the pipe is not designed to withstand such external loads, the pipe shall be cased or bridged to protect the pipe.

842.24 Cast iron pipe installed in unstable soils shall be provided with suitable supports.

842.25 Suitable harnessing or buttressing shall be provided at points where the main deviates from a straight line and the thrust if not restrained would part the joints.

842.26 Making and Testing of Cast Iron Field Joints

(a) Cast iron pipe joints shall conform to 842.15, and shall be assembled according to recognized AWWA, or ASA Specifications, or in accordance with the manufacturer's written recommendations.

(b) Cast iron pipe joints shall be leak tested in accordance with 841.44 of this code.

843 COMPRESSOR STATIONS

843.1 Compressor Station Design

843.11 Location of Compressor Building. The main compressor building for gas compressor stations should be located at such clear distances from adjacent property not under control of the company as to minimize the hazard of communication of fire to the compressor building from structures on adjacent property. Sufficient open space should be provided around the building to permit the free movement of fire-fighting equipment.

843.12 Building Construction. All compressor station buildings which house gas piping in sizes larger than 2 inches in diameter, or equipment handling gas (except equipment for domestic purposes) shall be constructed of noncombustible materials as defined by the National Board of Fire Underwriters (Special Interest Bulletin No. 294: Definition of Noncombustible Building Construction Material and National Building Code).

843.13 Exits. A minimum of two exits shall be provided for each operating floor of a main compressor building and basements and any elevated walkway or platform 10 feet or more above ground or floor level. Individual engine catwalks shall not require two exits. These exits may be fixed ladders, stairways, etc. of each such building. The maximum distance from any point on an operating floor to an exit shall not exceed 75 feet measured along the centerline of aisles or walkways. Said exits shall be unobstructed doorways so located as to provide a convenient possibility of escape and shall provide unobstructed passage to a place of safety. Door latches shall be of a type which can be readily opened from the inside, without a key. All swinging doors located in an exterior wall shall swing outward.

843.14 Fenced Areas. Any fence which may hamper or prevent escape of persons from the vicinity of a compressor station in an emergency shall be provided with a minimum of two gates. These gates shall be so located as to provide a convenient opportunity for escape to a place of safety. Any such gates located within 200 feet of any compressor plant building shall open outward and shall be unlocked (or openable from the inside without a key) when the area within the enclosure

is occupied. Alternatively, other facilities affording a similarly convenient exit from the area may be provided.

843.2 Electrical Facilities. All electrical facilities inside, and within 25 feet of the outside, of any compressor building, meter or regulator building or any other building in which gas is continuously handled, gauge and instrument lines excepted, at pressures in excess of 50 psig, shall conform to Class 1 Group D requirements of the National Electrical Code (ASA CI) insofar as it is possible with commercially available equipment. All other buildings on compressor station property (except residences) not specifically covered by National Board of Fire Underwriter's specifications, shall be wired with rigid conduit and shall conform to the requirements of the National Electrical Code (ASA CI) for such construction.

843.3 Corrosion Control. Suitable investigation shall be made and if it indicates that corrosion protection is needed, gas piping within compressor stations shall be protected by any recognized method or combination of methods including coating with protective material, the application of cathodic current, or electrical isolation by sections. After installation of piping, periodic inspections or tests of the piping shall be conducted to determine whether or not the pipe metal is adequately protected.

843.4 Compressor Station Equipment

843.41 Gas Treating Facilities

843.411 Liquid Removal. When condensable vapors are present in the gas stream in sufficient quantity to liquefy under the anticipated pressure and temperature conditions, the suction stream to each stage of compression (or to each unit, for centrifugal compressors) shall be protected against the introduction of dangerous quantities of entrained liquids into the compressor. Every liquid separator used for this purpose shall be provided with manually operated facilities for removal of liquids therefrom. In addition, automatic liquid removal facilities or an automatic compressor-shutdown device or a high liquid level alarm shall be used where slugs of liquid might be carried into the compressors.

843.412 Liquid Removal Equipment. Liquid separators, unless constructed of pipe and fittings and no internal welding is used, shall be manufactured in accordance with Section VIII, Unfired Pressure Vessels, of the ASME Boiler and Pressure Vessel Code. Liquid separators when constructed of pipe and fittings without internal welding, shall be in accordance with Type D construction requirements.

843.42 Fire Protection. Fire protection facilities should be provided in accordance with the National Fire Protection Association and National Board of Fire Underwriters' recommendations. If fire pumps are a part of such facilities, their operation shall not be affected by emergency shut-down facilities.

843.43 Safety Devices

843.431 Emergency Shutdown Facilities.

(a) Each transmission compressor station shall be provided with an emergency shutdown system by means of which all gas compressing equipment, all gas fires, and all electrical facilities in the vicinity of gas headers and in the compressor building can be shut down and the gas can be blocked out of the station and the station gas piping blown down. The emergency shutdown system shall be operable from any one of at least two locations outside the gas area of the station, preferably near exit gates in the station fence, but not more than 500 feet from the limits of the station. Blowdown piping shall extend to a location where the discharge of gas is not likely to create a hazard to the compressor station or surrounding area. Unattended field compressor stations of 1,000 horsepower and less are excluded from the provisions of this paragraph.

(b) Each compressor station supplying gas directly to a distribution system shall be provided with emergency shutdown facilities located outside of the compressor

station buildings by means of which all gas can be blocked out of the station provided there is another adequate source of gas for the distribution system. These shutdown facilities can be either automatic or manually operated as local conditions designate. When no other gas source is available, then no shutdown facilities shall be installed that might function at the wrong time and cause an outage on the distribution system.

843.432 Engine Overspeed Stops. Every compressor prime mover except electric induction or synchronous motors shall be provided with an automatic device which is designed to shut down the unit before the speed of the prime mover or of the driven unit exceeds the maximum safe speed of either, as established by the respective manufacturers.

843.44 Pressure Limiting Requirements in Compressor Stations

843.441 Pressure relief or other suitable protective devices of sufficient capacity and sensitivity shall be installed and maintained to assure that the maximum allowable operating pressure of the station piping and equipment is not exceeded by more than 10%.

843.442 A pressure relief valve shall be installed in the discharge line of each positive-displacement transmission compressor between the gas compressor and the first discharge block valve. The relieving capacity shall be equal to or greater than the capacity of the compressor. If the relief valves on the compressor do not prevent the possibility of overpressuring the pipeline, as specified in 845, a relieving device shall be installed on the pipeline to prevent it from being over-pressured.

843.443 An acceptable relief device, in accordance with 845, or automatic compressor shutdown device shall be installed in the discharge of each positive displacement distribution compressor between the gas compressor and the first discharge block valve. The relieving device shall be installed and maintained to prevent the maximum allowable operating pressure of the compressor and discharge piping from being exceeded by more than 10%.

843.444 Vent lines provided to exhaust the gas from the pressure relief valves to atmosphere shall be extended to a location where the gas may be discharged without undue hazard. Vent lines shall have sufficient capacity so that they will not interfere with the performance of the relief valve.

843.45 Fuel Gas Control. An automatic device shall be provided on each gas engine operating with pressure gas injection, which is designed to shut off the fuel gas when the engine stops. The engine distribution manifold shall be simultaneously automatically vented.

843.46 Cooling and Lubrication Failures. All gas compressor units shall be equipped with shutdown or alarm devices to operate in the event of inadequate cooling or lubrication of the units.

843.47 Explosion Prevention.

843.471 Mufflers. The external shell of mufflers for engines using gas as fuel shall be designed in accordance with good engineering practice and shall be constructed of ductile materials. It is recommended that all compartments of the muffler shall be manufactured with vent slots or holes in the baffles to prevent gas from being trapped in the muffler.

843.472 Building Ventilation. Ventilation shall be sufficient so that employees are not endangered, under normal operating conditions (or such abnormal conditions as a blown gasket, packing gland, etc.), by accumulations of hazardous concentrations of flammable or noxious vapors or gases in rooms, sumps, attics, pits, or similarly enclosed places, or in any portion thereof.

843.5 Compressor Station Piping

843.51 Gas Piping (other than station fuel)

843.511 Specifications for Gas Piping. All compressor station gas piping, other than instrument, control and sample piping, to and including connections to the main pipeline shall be of steel and shall be Type C Construction.

843.512 Installation of Gas Piping. The provisions of 841.2, "Installation of Steel Pipelines and Mains", shall apply where appropriate to gas piping in compressor stations.

843.513 Testing of Gas Piping. All gas piping within a compressor station shall be tested hydrostatically after installation to at least 1.4 times the maximum operating pressure except that small additions to operating stations need not be tested where operating conditions make it impractical to test.

843.514 Identification of Valves and Piping. All emergency valves and controls shall be identified by signs. All important gas pressure piping shall be identified by signs or color codes as to their function.

843.52 Fuel Gas Piping

843.521 All fuel gas lines within a compressor station, serving the various buildings and residential area, shall be provided with master shutoff valves located outside of any building or residential area.

843.522 The pressure regulating facilities for the fuel gas system for a compressor station shall be provided with pressure limiting devices to prevent the normal operating pressure of the system from being exceeded by more than 25%, or the maximum allowable operating pressure by more than 10%.

843.523 Suitable provision shall be made to prevent fuel gas from entering the power cylinders of an engine and actuating moving parts while work is in progress on the engine or on equipment driven by the engine.

843.524 All fuel gas used for domestic purposes at a compressor station, which has an insufficient odor of its own to serve as a warning in the event of its escape, shall be odorized as prescribed in 861.

843.53 Air Piping System.

843.531 All air piping within gas compressing stations shall be constructed in accordance with Division 1 under Section 2 of the latest ASA B31.1 Code for Pressure Piping.

843.532 The starting air pressure, storage volume, and size of connecting piping shall be adequate to rotate the engine at the cranking speed and for the number of revolutions necessary to purge the fuel gas from the power cylinder and muffler. The recommendations of the engine manufacturer may be used as a guide in determining these factors. Consideration should be given to the number of engines installed and to the possibility of having to start several of these engines within a short period of time.

843.533 A check valve shall be installed in the starting air line near each engine to prevent backflow from the engine into the air piping system. A check valve shall also be placed in the main air line on the immediate outlet side of the air tank or tank. It is recommended that equipment for cooling the air and removing the moisture and entrained oil be installed between the starting air compressor and the air storage tanks.

843.534 Suitable provision shall be made to prevent starting air from entering the power cylinders of an engine and actuating moving parts while work is in progress on the engine or on equipment driven by the engines. Acceptable means of accomplishing this are installation of a blind flange, removal of a portion of the air supply piping or locking closed a stop valve and locking open a vent downstream from it.

843.535 Air Receivers. Air receivers or air storage bottles, for use in com-

pressor stations, shall be constructed and equipped in accordance with Section VIII, Unfired Pressure Vessels, of the ASME Boiler and Pressure Vessel Code.

843.54 Lubricating Oil Piping. All lubricating oil piping within gas compressing stations shall be constructed in accordance with Division A under Section 3 of the latest edition of ASA B31.1 Code for Pressure Piping.

843.55 Water Piping. All water piping within gas compressing stations shall be constructed in accordance with Section 1 of the latest ASA B31.1 Code for Pressure Piping.

843.56 Steam Piping. All steam piping within gas compressing stations shall be constructed in accordance with Section 1 of the latest edition of the ASA B31.1 Code for Pressure Piping.

843.57 Hydraulic Piping. All hydraulic power piping within gas compressing stations shall be constructed in accordance with Division A under Section 3 of the latest edition of ASA B31.1 Code for Pressure Piping.

844 PIPE-TYPE AND BOTTLE-TYPE HOLDERS

844.1 Pipe-Type Holders in Rights-of-Way Not Under Exclusive Use and Control of the Operating Company. A pipe-type holder which is to be installed in streets, highways or in private rights-of-way not under the exclusive control and use of the operating company shall be designed, installed, and tested in accordance with the provisions of this code applicable to a pipe line installed in the same location and operated at the same maximum pressure.

844.2 Bottle-type holders shall be located on land owned or under the exclusive control and use of the operating company.

844.3 Pipe-Type and Bottle-Type Holders on Property under the Exclusive Use and Control of the Operating Company

844.31 The storage site shall be entirely surrounded with fencing to prevent access by unauthorized persons.

844.32 (a) A pipe-type or bottle-type holder which is to be installed on property under the exclusive control and use of the operating company shall be designed in accordance with construction design factors the selection of which depends upon the location class in which the site is situated, the clearance between the pipe containers or bottles and the fence, and the maximum operating pressure, as follows:

Design Factors

Holder Site Location Class	Minimum Clearance between Containers and Fenced Boundaries of Site 25' to 100'	Minimum Clearance between Containers and Fenced Boundaries of Site 100' or Over
1	.72	.72
2	.60	.72
3	.60	.60
4	.40	.40

(b) The minimum clearance between containers and the fenced boundaries of the site is fixed by the maximum operating pressure of the holder as follows:

Maximum Operating Pressure	Minimum Clearance
Less than 1000 psi	25'
1000 psi or more	100'

(c) Minimum clearance between pipe containers or bottles. The minimum distance in inches between pipe containers or bottles shall be determined by the following formula:

$$C = \frac{3D \times P \times "F"}{1000}$$

in which:

C = Minimum clearance between pipe containers or bottles in inches.
D = Outside diameter of pipe container or bottle in inches.
P = Maximum allowable operating pressure in pounds per square inch gage.
"F" = Design Factor

(d) Pipe containers shall be installed underground with the top of each container not less than 24 inches below the ground surface.

(e) Bottles shall be installed underground with the top of each container below the normal frost line but in no case closer than 24 inches to the surface.

(f) Pipe-type holders shall be tested in accordance with the provisions of 841.41 for a pipeline located in the same location class as the holder site; provided, however, that in any case where the test pressure will produce a hoop stress of 80% or more of the specified minimum yield strength of the pipe, water shall be used as the test medium.

844.4 Special Provisions Applicable to Bottle-type Holders Only.

844.41 A bottle-type holder may be manufactured from steel which is not weldable under field conditions, subject to all of the following limitations:

(a) Bottle-type holders made from alloy steel shall meet the chemical and tensile requirements for the various grades of steel in API Standard 5A, "Specification for Casing, Tubing and Drill Pipe," or ASTM A372, "Specification for Carbon and Alloy Steels for Pressure Vessel Shells".

(b) In no case shall the ratio of actual yield strength to actual tensile strength exceed .85.

(c) Welding shall not be performed on such bottles after they have been heat treated and/or stress relieved, except that it shall be permissible to attach small copper wires to the small diameter portion of the bottle end closure for cathodic protection purposes using a localized thermit welding process.

(d) Such bottles shall be given a hydrostatic test in the mill, and need not be re-tested hydrostatically at the time of installation. The mill test pressure shall not be less than that required to produce a hoop stress equal to 85% of the specified minimum yield strength of the steel. Careful inspection of the bottles at the time of installation shall be made and no damaged bottle shall be used.

(e) Such bottles and connecting piping shall be tested for tightness after installation using air or gas at a pressure of 50 psi above the maximum operating pressure.

844.5 General Provisions Applicable to Both Pipe-type and Bottle-type Holders.

(a) Suitable measures shall be taken to protect the storage system against external corrosion. (See 841.17)

(b) No gas containing more than 0.1 grain of hydrogen sulfide per 100 cubic feet at 14.7 psia and 60° F. shall be stored.

(c) Provision shall be made to prevent the formation or accumulation of liquids in the holder, connecting piping and auxiliary equipment, that might cause corrosion or might interfere with the safe operation of the storage equipment.

(d) Relief valves shall be installed in accordance with provisions of this code which will have relieving capacity adequate to limit the pressure imposed on the filling line and thereby on the storage holder to 110% of the design pressure of the holder, or to that pressure which produces a hoop stress of 75% of the specified minimum yield strength of the steel, whichever is the lesser.

845 CONTROL AND LIMITING OF GAS PRESSURE

845.1 Basic Requirement for Protection Against Accidental Over-pressuring. Every pipeline, main, distribution system, customer's meter and connected facilities, compressor station, pipe type holder, bottle type holder, container fabricated from pipe and fittings, and all special equipment, if connected to a compressor or to a gas source where the failure of pressure control or other causes might result in a pressure which would exceed the maximum allowable operating pressure of the facility (refer to 805.14), shall be equipped with suitable pressure relieving or pressure limiting devices in accordance with the provisions of 845.

845.2 Control and Limiting of Gas Pressure in Holders, Pipelines, and All Facilities that Might at Times be Bottle Tight

845.21 Suitable types of protective devices to prevent overpressuring of such facilities are:

(a) Spring loaded relief valves of types approved for unfired pressure vessels by the ASME.

(b) Pilot loaded back-pressure regulators used as relief valves, so designed that failure of the pilot system or control lines will cause the regulator to open.

845.22 Maximum Allowable Operating pressure for Pipelines or Mains. This pressure is by definition the maximum operating pressure to which the pipeline or main may be subjected in accordance with the requirements of this code. For a pipeline or main in good operating condition, the maximum allowable operating pressure is the lesser of the two pressures described in (a) and (b) below.

(a) The design pressure (defined in 805.11) of the weakest element of the pipeline or main. Assuming that all fittings, valves and other accessories in the line have an adequate pressure rating, the maximum allowable operating pressure of a steel pipeline or main shall be the design pressure determined in accordance with 841.1.

(b) The pressure obtained by dividing the pressure to which the pipeline or main is tested after construction by the appropriate factor for the location class involved, as follows:

Location Class No.	Pressure
1	Test Pressure / 1.10
2	Test Pressure / 1.25
3	Test Pressure(1) / 1.40
4	Test Pressure (1) / 1.40

Note (1): Other factors than 1.4 should be used if the line was tested under the special conditions described in 841.413, 841.416 and 841.42. In such cases use factors that are consistent with the applicable requirements of these sections.

(c) In some cases the operating company will consider that the maximum operating pressure to which a pipeline or main should be subjected is less than the pressure determined by either (a) or (b) above. Pipelines that are known to be seriously corroded or that have other defects seriously affecting their strength and which have been operated for years at lower pressures, fall into this category. In such cases the operating company shall decide the maximum pressure it considers safe, and shall install over-pressure protective devices designed to prevent accidentally exceeding this maximum pressure, if there is a reasonable possibility that the pressure will be exceeded.

(d) If services are connected to the pipeline or main, there are additional considerations that might in some cases limit the maximum allowable operating pressure of the facility. See 845.33.

845.23 Qualifying a Pipeline or Main for a New and Higher Maximum Allowable Operating Pressure. Note: This paragraph applies to pipelines or mains where the new and higher maximum allowable operating pressure will produce a hoop stress of 30% or more of the specified minimum yield strength of the pipe. When the new and higher maximum allowable operating pressure is equal to or less than this value the provisions of 845.34 shall apply.

Before increasing the maximum allowable operating pressure of a pipeline or main that has been operating for a period of several years or more at a pressure less than that determined by 845.22(a) above, it is required that:

(a) The following investigative and corrective measures be taken:

(1) The design and previous testing of the pipeline and the materials

and equipment in it be reviewed to determine that the proposed increase in allowable operating pressure is safe and in general agreement with the requirements of this code.

(2) The condition of the line be determined by field inspections, examination of maintenance records, or other suitable means.

(3) Repairs, replacements or alterations in the pipeline disclosed to be necessary by steps (1) and (2) be made.

(b) The maximum allowable operating pressure may be increased after compliance with (a) above and one of the following provisions:

(1) If the physical condition of the line as determined by (a) above indicates that the line is capable of withstanding the desired increased operating pressure in accordance with the design requirements of this code and the line has previously been tested to a pressure equal to or greater than that required by this code for a new line for the proposed new maximum allowable operating pressure, the line may be operated at the increased maximum allowable operating pressure.

(2) If the physical condition of the line as determined by (a) above indicates that the ability of the line to withstand the increased maximum operating pressure has not been satisfactorily verified or the line has not been previously tested to the levels required by this edition of the code for a new line for the proposed new maximum allowable operating pressure, the line may by operated at the increased maximum allowable operating pressure if the line shall successfully withstand the test required by this edition of the code for a new line to operate under the same conditions.

(3) If, under the foregoing provisions of (b) above, it is necessary to test a pipeline or main before it can be up-rated to a new maximum allowable operating pressure, and if it is not practical to test the line either because of the expense or difficulties created by taking it out of service, or because of other operating conditions, a new and higher maximum allowable operating pressure may be established as follows:

3.1 Perform the requirements of (a) above.

3.2 Select a new maximum allowable operating pressure consistent with the condition of the line and the design requirements of this code; provided, however, that,

3.3 In no such case shall the new maximum allowable operating pressure exceed 80% of that permitted for a new line of the same design in the same location.

(c) In no case shall the maximum allowable operating pressure of a pipeline be raised to a value higher than would be permitted by this code for a new line constructed of the same materials and in the same locations.

The rate of pressure increase to the new maximum allowable operating pressure should be gradual so as to allow sufficient time for periodic observations of the pipeline.

845.3 Control and Limiting of Gas Pressure in High-Pressure Distribution Systems

845.31 Each high-pressure distribution system or main, supplied from a source of gas which is at a higher pressure than the maximum allowable operating pressure for the system, shall be equipped with pressure regulating devices of adequate capacity, and designed to meet the pressure, load and other service conditions under which they will operate or to which they may be subjected.

845.32 In addition to the pressure regulating devices prescribed in 845.31, a suitable method shall be provided to prevent accidental over-pressuring of a high-pressure distribution system.

Suitable types of protective devices to prevent overpressuring of high pressure distribution systems are:

(a) Relief valves as prescribed in 845.21 (a) and (b).

(b) Weight loaded relief valves

(c) A monitoring regulator installed in series with the primary pressure regulator.

(d) A series regulator installed upstream from the primary regulator, and set to continuously limit the pressure on the inlet of the primary regulator to the maximum allowable operating pressure of the distribution system or less.

(e) An automatic shut-off device installed in series with the primary pressure regulator, and set to shut off when the pressure on the distribution system reaches the maximum allowable operating pressure, or less. This device must remain closed until manually reset. It should not be used where it might cause an interruption in service to a large number of customers.

845.33 Maximum Allowable Operating Pressure for High-Pressure Distribution Systems. This pressure shall be the maximum pressure to which the system can be subjected in accordance with requirements of this code. It shall not exceed:

(a) The design pressure of the weakest element of the system as defined in 805.11.

(b) 60 psig if the services in the system are not equipped with series regulators or other pressure limiting devices as prescribed in 845.53.

(c) 25 psig in cast iron systems having unreinforced bell and spigot joints as prescribed in 842.15 (a).

(d) 2 psig in high-pressure distribution systems equipped with service regulators not meeting the requirements of 845.51 and which do not have an overpressure protective device as required in 845.52.

In some cases the operating company will consider the maximum pressure to which a system should be subjected is less than the pressure obtained by applying the applicable limits in 845.33 (a), (b), (c) or (d). Systems that are known to be corroded and that have been operated for years at lower pressures than these limits fall into this category. In such cases the operating company shall decide the maximum pressure it considers safe, and shall install overpressure protective devices to prevent accidentally exceeding this maximum pressure if there is a reasonable possibility that the pressure will be exceeded.

845.34 Qualifying a High-Pressure Distribution System for a New and Higher Maximum Allowable Operating Pressure. Note: This paragraph applies to high-pressure distribution mains and to pipelines where the new and higher maximum allowable operating pressure is less than that required to produce a hoop stress of 30% of the specified minimum yield strength of the pipe. When the new and higher maximum allowable operating pressure is more than this value the provisions of 845.23 shall apply.

(a) Before increasing the maximum allowable operating pressure of a high-pressure distribution system, that has been operating at less than the applicable maximum pressure stated in 845.33, to a new maximum allowable operating pressure equal to or less than the maximum applicable pressure in 845.33, it is recommended that the following factors be taken in consideration:

(1) The design of the system including kinds of material and equipment used.

(2) Past maintenance records including results of any previous leakage surveys.

(b) Before increasing the pressure the following steps should be taken:

(1) Make a leakage survey, if past maintenance records indicate that such a survey is advisable, and repair leaks found.

(2) Repair or replace parts of the system found to be inadequate for the higher operating pressure.

(3) If the new maximum allowable operating pressure is to be over 60 psig, install suitable devices on the services to regulate and limit the pressure of the gas in accordance with 845.51.

(4) At bends or offsets in coupled or bell and spigot pipe, reinforce or replace anchorages determined to be inadequate for the higher operating pressure.

(c) The rate of pressure increase to the new maximum allowable operating pressure should be gradual so as to allow sufficient time for periodic observations of the system.

845.4 Control and Limiting of Gas Pressure in Low-Pressure Distribution Systems

845.41 Each low-pressure distribution system or low pressure main supplied from a gas source which is at a higher pressure than the maximum allowable operating pressure for the low-pressure system, shall be equipped with pressure regulating devices of adequate capacity, designed to meet the pressure, load and other service conditions under which they will have to operate.

845.42 In addition to the pressure regulating devices prescribed in 845.41, a suitable device shall be provided to prevent accidental overpressuring.

Suitable types of protective devices to prevent overpressuring of low pressure distribution systems are:

(a) A liquid seal relief valve that can be set to open accurately and consistently at the desired pressure, and to close again when the pressure in the distribution system returns to normal.

(b) Weight loaded relief valves.

(c) An automatic shut-off device as described in 845.32 (e).

(d) A pilot loaded back-pressure regulator as described in 845.21 (b).

(e) A monitoring regulator as described in 845.32 (c).

(f) A series regulator as described in 845.32 (d).

845.43 Maximum Allowable Operating Pressure for Low Pressure Distribution Systems. The maximum allowable operating pressure for a low pressure distribution system shall not exceed either (a) or (b) below.

(a) A pressure which would cause the unsafe operation of any connected and properly adjusted low pressure gas burning equipment, or

(b) A pressure of 2 psig.

845.44 Conversion of Low-Pressure Distribution Systems to High-Pressure Distribution Systems.

(a) Before converting a low-pressure distribution system to a high-pressure distribution system, it is recommended that the following factors be taken into consideration:

(1) The design of the system including kinds of material and equipment used.

(2) Past maintenance records including results of any previous leakage surveys.

(b) Before increasing the pressure the following steps (not necessarily in sequence shown) should be taken:

(1) Make a leakage survey, if past maintenance records indicate that such a survey is advisable, and repair leaks found.

(2) Reinforce or replace parts of the system found to be inadequate for the higher operating pressures.

(3) Install a service regulator on each service, and test each regulator to determine that it is functioning. In some

cases it may be necessary to raise the pressure slightly to permit proper operation of the service regulator.

(4) Isolate the system from adjacent low-pressure systems.

(5) At bends or offsets in coupled or bell and spigot pipe, reinforce or replace anchorages determined to be inadequate for the higher pressures.

(c) The pressure in the system being converted should be increased by steps, with a period to check the effect of the previous increase before making the next increase. The desirable magnitude of each increase and the length of the check period will vary depending upon conditions. The objective of this procedure is to afford an opportunity to discover before excessive pressures are reached any unknown open and unregulated connections to adjacent low-pressure systems or to individual customers.

845.5 Control and Limiting of the Pressure of Gas Delivered to Domestic and Small Commercial Customers from High-Pressure Distribution Systems. Note: The requirements for the control and limiting of the pressure of gas delivered to industrial customers are included in 845.1.

845.51 If the maximum actual operating pressure of the distribution system is between 2 psig and 60 psig and a service regulator having the characteristics listed below is used, no other pressure limiting device is required:

(a) A pressure regulator capable of reducing distribution line pressure (pounds per square inch) to pressures recommended for household appliances (inches of water column).

(b) Single port valve with orifice diameter no greater than that recommended by the manufacturer for the maximum gas pressure at the regulator inlet.

(c) The valve seat shall be made of resilient material designed to withstand abrasion of the gas, impurities in gas, cutting by the valve, and to resist permanent deformation when it is pressed against the valve port.

(d) Pipe connections to the regulator shall not exceed 2 inches in diameter.

(e) The regulator must be of a type that is capable under normal operating conditions of regulating the downstream pressure within the necessary limits of accuracy and of limiting the build-up of pressure under no-flow conditions to 50% or less of the discharge pressure maintained under flow conditions.

(f) A self-contained service regulator with no external static or control lines.

845.52 If the maximum actual operating pressure of the distribution system is between 2 psig and 60 psig and a service regulator not having all of the characteristics listed in 845.51 is used, or if the gas contains materials that seriously interfere with the operation of service regulators, suitable protective devices shall be installed to prevent accidental overpressuring of the customer's appliances should the service regulator fail. Some of the suitable types of protective devices to prevent overpressuring of customer's appliances are:

(a) A monitoring regulator
(b) A relief valve
(c) An automatic shut-off device

These devices may be installed as an integral part of the service regulator or as a separate unit.

845.53 If the maximum actual operating pressure of the distribution system exceeds 60 psig, suitable methods shall be used to regulate and limit the pressure of the gas delivered to the customer, such as the following:

(a) A service regulator having the characteristics listed in 845.51 above and a secondary regulator located upstream from the service regulator. The secondary regulator is usually set to maintain a pressure of from 5 to 10 psi on the inlet of the service regulator, and shall in no case be set to maintain a pressure higher than 60 psi. A device shall be installed between the secondary regulator and the service regulator to limit the pressure on the inlet of the service regulator to 60 psi or less in case the second-

ary regulator fails to function properly. This device may be either a relief valve, or an automatic shut-off that shuts, if the pressure on the inlet of the service regulator exceeds the set pressure (60 psi or less), and remains closed until manually reset.

(b) A service regulator and a monitoring regulator set to limit to a maximum safe value the pressure of the gas delivered to the customer.

(c) A service regulator with a relief valve vented to the outside atmosphere, and set to open if the pressure of the gas going to the customer exceeds a maximum safe value. The relief valve may either be built into the service regulator or it may be a separate unit installed downstream from the service regulator. This combination may be used alone only in those cases where the inlet pressure on the service regulator does not exceed the manufacturer's safe working pressure rating of the service regulator, and is not recommended for use where the inlet pressure on the service regulator exceeds 125 psi. For higher inlet pressures, method (a) or (b) above should be used.

845.6 Requirements for Design of All Pressure Relief and Pressure Limiting Installations

845.61 All pressure relief or pressure limiting devices shall:

(a) Be constructed of materials such that the operation of the device will not normally be impaired by corrosion of external parts by the atmosphere, or of the internal parts by gas.

(b) Have valves and valve seats that are designed not to stick in a position that will make the device inoperative and result in failure of the device to perform in the manner for which it was intended.

(c) Be designed and installed so that they can be readily operated to determine if the valve is free; and can be tested to determine the pressure at which they will operate; and can be tested for leakage when in the closed position.

845.62 The discharge stacks, vents, or outlet ports of all pressure relief devices shall be located where gas can be discharged into the atmosphere without undue hazard. Consideration should be given to all exposures in the immediate vicinity. All discharge stacks, or vents, shall be protected with rain caps to preclude the entry of water into the stack.

845.63 The size of the openings, pipe and fittings located between the system to be protected and the pressure relieving device, and the vent line, shall be of adequate size to prevent hammering of the valve and to prevent impairment of relief capacity.

845.64 Precautions shall be taken to prevent unauthorized operation of any stop valve which will make a pressure relief valve inoperative. This provision shall not apply to valves, the operation of which will isolate the system under protection from its source of pressure. Acceptable methods for complying with this provision are:

(a) Lock the stop valve in the open position. Instruct authorized personnel of the importance of not inadvertently leaving the stop valve closed and of being present during the entire period that the stop valve is closed so that they can lock it in the open position before they leave the location.

(b) Install duplicate relief valves, each having adequate capacity by itself to protect the system, and arrange the isolating valves or 3-way valve so that mechanically it is possible to render only one safety device inoperative at a time.

845.65 Precautions shall be taken to prevent unauthorized operation of any valve which will make pressure limiting devices inoperative. This provision applies to isolating valves, by-pass valves, and valves on control or float lines which are located between the pressure limiting device and the system which the device protects. A method similar to 845.64 (a) shall be considered acceptable in complying with this provision.

845.66 (a) When a monitoring regulator, series regulator, system relief or system shut-off, is installed at a district

regulator station to protect a piping system from overpressuring, the installation shall be designed and installed to prevent any single incident such as an explosion in a vault or damage by a vehicle from affecting the operation of both the overpressure protective device and the district regulator.

(b) Special attention shall be given to control lines. All control lines shall be protected from falling objects, excavations by others, or other foreseeable causes of damage and shall be designed and installed to prevent damage to any one control line from making both the district regulator and the overpressure protective device inoperative.

845.7 Required Capacity of Pressure Relieving and Pressure Limiting Devices.

845.71 Each pressure relieving device, or group of such devices, installed to protect a piping system shall have sufficient capacity and shall be set to operate to prevent the pressure from exceeding the maximum allowable operating pressure, plus 10%, or the pressure which would produce a hoop stress of 75% of the specified minimum yield strength, whichever is lower.

845.72 Each pressure limiting device shall be set to prevent the pressure in the facility which it protects from exceeding the maximum allowable operating pressure.

845.73 When more than one pressure regulating or compressor station feeds into a pipeline or distribution system and pressure relief devices are installed at such stations, the relieving capacity at the remote stations may be taken into account in sizing the relief devices at each station. However, in doing this the assumed remote relieving capacity must be limited to the capacity of the piping system to transmit gas to the remote location or to the capacity of the remote relief device, whichever is less.

845.8 Proof of Adequate Capacity and Satisfactory Performance of Pressure Limiting and Pressure Relief Devices.

845.81 Where the safety device consists of an additional regulator which is associated with or functions in combination with one or more regulators in a series arrangement to control or limit the pressure in a piping system, suitable checks shall be made to determine that the equipment will operate in a satisfactory manner to prevent any pressure in excess of the established maximum allowable operating pressure of the system should any one of the associated regulators malfunction or remain in the wide open position.

845.82 Suitable checks shall be made periodically to insure that the combined capacity of the relief devices on a piping system or facility is adequate to limit the gas pressure at all times to values prescribed by this code. This check should be based on the operating conditions that create the maximum probable requirement for relief capacity in each case, even though such operating conditions actually occur infrequently and/or for only short periods of time.

845.9 Instrument, Control and Sample Piping

(a) Scope

(1) The requirements given in this section apply to the design of instrument, control and sampling piping for safe and proper operation of the piping itself and do not cover design of piping to secure proper functioning of instruments for which the piping is installed.

(2) This section does not apply to permanently closed piping systems, such as fluid-filled temperature-responsive devices.

(b) Materials and Design

(1) The materials employed for valves, fittings, tubing, and piping shall be designed to meet the particular conditions of service.

(2) Take-off connections and attaching bosses, fittings, or adapters shall be made of suitable material and shall be capable of withstanding the maximum service pressure and temperature of the piping or equip-

ment to which they are attached. They shall be designed to satisfactorily withstand all stresses without failure by fatigue.

(3) A shut-off valve shall be installed in each take-off line as near as practicable to the point of take-off. Blow-down valves shall be installed where necessary for the safe operation of the piping, instruments and equipment.

(4) Brass pipe or copper pipe or tubing shall not be used for metal temperatures greater than 400° F.

(5) Piping subject to clogging from solids or deposits shall be provided with suitable connections for cleaning.

(6) Pipe or tubing of diameters smaller than the minimum diameters required under this section may be specified by the manufacturers of the instrument, control apparatus, or sampling device, provided that the safety of the smaller pipe or tubing as installed is at least equal to that otherwise required under the code.

(7) Piping which may contain liquids shall be protected by heating or other suitable means from damage due to freezing.

(8) Piping in which liquids may accumulate shall be provided with drains or drips.

(9) The arrangement of piping and supports shall be designed to provide not only for safety under operating stresses, but also to provide protection for the piping against detrimental sagging, external mechanical injury, abuse, and damage due to unusual service conditions other than those connected with pressure, temperature, and service vibration.

(10) Suitable precautions, such as increasing the pipe wall thickness, shall be taken where internal corrosive conditions may exist. All underground piping shall be protected against corrosion where soil tests or experience indicate that the soil is corrosive. Refer to 841.172 and 841.173.

(11) Joints between sections of tubing and/or pipe and between tubing and/or pipe and valves or fittings shall be made in a manner suitable for the pressure and temperature condition, such as by means of flared, flareless, and compression type fittings, or equal, or they may be of the brazed, screwed, or socket-welded type. If screwed-end valves are to be used with flared, flareless, or compression type fittings, adapters are required.

Slip type expansion joints shall not be used; expansion shall be taken care of by providing flexibility.

846 CUSTOMERS' METERS AND REGULATORS

846.1 Location for Customers' Meter and Regulator Installations

(a) Customers' meters and regulators may be located either inside or outside of buildings, depending upon local conditions, except, that on services requiring series regulation, in accordance with 845.53 (a), the upstream regulator shall be located outside of the building.

(b) When installed within a building, the service regulator shall be in a readily accessible location near the point of gas service entrance and, whenever practical, the meters shall be installed at the same location. Meters shall not be installed in bedrooms, closets, bathrooms, under combustible stairways or in unventilated or inaccessible places, nor closer than three feet to sources of ignition, including furnaces and water heaters. On services supplying large industrial customers or installations where gas is utilized at higher than standard service pressure, the regulators may be installed at other readily accessible locations.

(c) When located outside of buildings, meters and service regulators shall be installed in readily accessible locations where they will be reasonably protected from damage.

(d) Regulators requiring vents for their proper and effective operation shall be vented to the outside atmosphere in accordance with the provisions of 846.34.

846.2 Operating Pressures for Customers' Meter Installations.

Iron or aluminum case meters shall not be used at a maximum operating pressure higher than the manufacturer's rating for the meter. New

tinned steel case meters shall not be used at a pressure in excess of 50% of the manufacturer's test pressure; rebuilt tinned steel case meters shall not be used at a pressure in excess of 50% of the pressure used to test the meter after rebuilding.

846.3 Protection of Customers' Meter and Regulator Installations from Damage

846.31 Meters and service regulators shall not be installed where rapid deterioration from corrosion or other causes is likely to occur.

846.32 A suitable protective device such as a backpressure regulator, or a check valve, shall be installed downstream of the meter if and as required under the following conditions:

(a) If the nature of the utilization equipment is such that it may induce a vacuum at the meter, install a back-pressure regulator downstream from the meter.

(b) Install a check valve or equivalent if

The utilization equipment might induce a back-pressure.

The gas utilization equipment is connected to a source of oxygen or compressed air.

Liquefied petroleum gas or other supplementary gas is used as standby and might flow back into the meter. A three-way valve installed to admit the standby supply and at the same time shut off the regular supply, can be substituted for a check valve if desired.

846.33 All service regulator vents, and relief vents where required, shall terminate in the outside air in rain and insect resistant fittings. The open end of the vent shall be located where, if a regulator failure resulting in the release of gas occurs, the gas can escape freely into the atmosphere and away from any openings into the buildings. At locations where service regulators might be submerged during floods, either a special anti-flood type breather vent fitting shall be installed, or the vent line shall be extended above the height of the expected flood waters.

846.34 Pits and vaults, housing customers' meters and regulators, shall be designed to support vehicular traffic when installed in the following locations:

(a) Travelled portions of alleys, streets and highways.

(b) Driveways.

846.4 Installation of Meters and Regulators All meters and regulators shall be installed in such a manner as to prevent undue stresses upon the connecting piping and/or the meter. Lead connections, or other connections made of material which can be easily damaged, shall not be used. The use of standard weight close nipples is prohibited.

847 GAS SERVICES

847.1 General Provisions Applicable to both Steel and Copper Services.

847.11 Installation of Services

(a) Services shall be installed at a depth which will protect them from excessive external loadings, and local activities, such as gardening. It is recommended that a minimum depth of 12 inches in private property and a minimum depth of 18 inches in streets and roads be maintained. Where this cannot be done, due to existing substructures, etc., less cover is permitted provided however that where such services are subject to excessive superimposed loads, those portions of the service shall be cased or bridged to avoid harmful additional loads on the pipe, or strengthened to resist them.

(b) Service piping shall be properly supported at all points on undisturbed or well compacted soil, so that the pipe will not be subject to excessive external loading by the backfill. The material used for the backfill shall be free of rocks, building materials, etc., that might cause damage to the pipe or the protective coating.

(c) Where there is evidence of condensate in the gas in sufficient quantities to cause interruptions in the gas supply to the

customer, the service shall be graded so as to drain in the main or to drip at the low points in the service.

847.12 Types of Valves Suitable for Service Shut-offs

(a) Valves or cocks used as service shut-offs shall meet the applicable requirements of 810 and 831.11.

(b) The use of soft seat shut-off valves or cocks is not recommended.

(c) A valve incorporated in a meter bar which permits the meter to be by-passed does not qualify under this code as a service shut-off.

(d) Service shut-offs on high pressure services, installed either inside of buildings or in confined locations outside of buildings where the blowing of gas would be hazardous, shall be designed and constructed to minimize the possibility of the removal of the core of the valve or cock accidentally or willfully with ordinary household tools.

(e) The operating company shall make certain that the shut-off valves or cocks installed on high pressure services are suitable for this use either by making their own tests or by reviewing the tests made by the manufacturers.

(f) On services designed to operate at pressures in excess of 60 psig the service shut-off valve or cock shall be the equivalent of a pressure lubricated cock or a needle type valve. Other types of valves or cocks may be used where tests by the manufacturer or by the user indicate that they are suitable for this kind of service.

847.13 Location of Service Shut-Offs

(a) Service shut-offs shall be installed on all new services (including replacements) in a readily accessible location.

(b) Shut-offs shall be located upstream of the meter if there is no regulator, or upstream of the regulator, if there is one.

(c) All gas services operating at a pressure greater than 10 psig, and all services 2 inches in diameter or larger, shall be equipped with a shut-off located on the service line outside of the building, except that whenever gas is supplied to a theatre, church, school, factory or other building where large numbers of persons assemble, an outside shut-off in such case will be required regardless of the size of the service or of the service pressure.

(d) Underground shut-offs shall be located in a covered durable curb box or standpipe, which is designed to permit ready operation of the valve.

847.14 Location of Service Connections to Main Piping. It is recommended that services be connected to either the top or the side of the main. The connection to the top of the main is preferred, in order to minimize the possibility of dust and moisture being carried from the main into the service.

847.15 Testing of Services After Construction. Each service shall be tested after construction and before being placed in service to demonstrate that it does not leak.

Services to operate at a pressure between 1 psig and 40 psig, shall be given a stand-up air or gas pressure test at not less than 50 psig for at least five minutes before being placed in service.

Services to operate at pressures in excess of 40 psig, but stressed less than 20% of the specified minimum yield, shall be tested to the maximum operating pressure or 100 psig, whichever is the lesser. Services stressed to 20% or more of the specified minimum yield shall be tested in accordance with the requirements for mains.

The service connection to the main need not be included in these pressure tests if it is not feasible to do so.

847.2 Steel Services

847.21 Design of Steel Services

(a) Steel pipe, when used for gas services, shall conform to the applicable requirements of Chapter I.

(b) Underground steel services, when installed below grade through the outer foundation wall of a building, shall be either encased in a sleeve or otherwise protected against corrosion. The service pipe and/or sleeve shall be sealed at the foundation wall to prevent entry of gas or water.

(c) Steel services, where installed underground under buildings, shall be encased in a gas tight conduit. When such a service supplies the building it subtends, the conduit shall extend into a normally usable and accessible portion of the building and, at the point where the conduit terminates, the space between the conduit and the service pipe shall be sealed to prevent the possible entrance of any gas leakage.

(d) Where practical, welded joints or compression type fittings should be used in all underground steel services.

(e) Consideration shall be given to insulating, near or within the building, those services which are connected through the house piping to water services, electrical ground, etc., so as to eliminate possible galvanic corrosion. This is especially important in areas where stray current electrolysis is prevalent, or where copper or lead water services are used.

847.22 Installation of Steel Services in Bores. When coated steel pipe is to be installed as a service pipe in a bore, care should be exercised to prevent damage to the coating during installation. For all installations to be made by boring, driving or similar methods or in a rocky type soil, the following practices or their equivalents are recommended:

(a) When a service is to be installed by boring or driving and a coated steel pipe is to be used for the service, the coated pipe should not be used as the bore pipe or drive pipe and left in the ground as part of the service. It is preferable to make such installations by first making an oversize bore, removing the pipe used for boring and then inserting the coated pipe.

(b) Coated steel pipe preferably should not be inserted through a bore in exceptionally rocky soil where there is a likelihood of damage to the coating resulting from the insertion.

847.23 The recommendations in (a) and (b) above do not apply when bare steel pipe is used as the service pipe, or where coated pipe is installed under conditions where the coating is not likely to be damaged, such as in sandy soil.

847.24 Service Connections to Steel Mains. Services may be connected to steel mains by:

(a) Welding a service tee or similar device to the main.

(b) Using a service clamp or saddle

(c) Compression fittings using rubber or rubber-like gaskets or welded connections may be used to connect service pipe to the main connection fitting. Gaskets used in a manufactured gas system shall be of a type that resists effectively that type of gas.

847.3 Cast Iron Services

847.31 Use of Cast Iron Services When used for gas services, cast iron pipe shall meet the applicable requirements of 842. The use of cast iron pipe less than 6 inches in diameter for gas services is prohibited. Cast iron pipe 6 inches or larger in diameter, may be used for gas services except for that portion of the service which extends through the building wall. The latter portion shall be of steel pipe. Cast iron services shall not be installed in unstable soils or under buildings.

847.32 Service Connections to Cast Iron Mains. Services may be connected to cast iron mains by:

(a) Drilling and tapping the main; provided, however, that the diameter of the tapped hole shall not exceed the limitations imposed by 831.33 (b).

(b) Using a reinforcing sleeve.

847.321 Service connections shall not be brazed directly to cast iron mains.

847.322 Compression fittings using rubber or rubber-like gaskets or welded connections may be used to connect the service pipe to the main connection fitting. Gaskets used in a manufactured gas system shall be of a type that resists effectively that type of gas.

847.4 Copper Services (and Mains)

847.41 Copper Pipe Design Requirements. The following requirements shall apply to copper pipe, or tubing, when used for gas mains or services:

(a) Copper pipe, or tubing, shall not be used for services or mains where the pressure exceeds 100 psig.

(b) Copper pipe, or tubing, shall not be used for services or mains where the gas carried contains more than an average of 0.3 grains of hydrogen sulfide per 100 standard cubic feet of gas. This is equivalent to a trace as determined by the lead-acetate test.

(c) Copper pipe, or tubing, shall not be used for services or mains where the piping strain or external loading may be excessive.

(d) Copper services may be installed within buildings, provided that the service is not concealed and is suitably protected against external damage.

(e) Copper tubing, or pipe for mains, shall have a minimum wall thickness of 0.065 inches and shall be hard drawn.

(f) The minimum wall thickness for copper pipe, or tubing used for gas services, shall be not less than Type "L" as specified in ASTM specifications for Copper Water Tube, designation B-88, or any subsequent revision thereof.

(g) Underground copper services, where installed through the outer foundation wall of a building, shall be either encased in a sleeve, or otherwise protected against corrosion. The service pipe, or tubing, and/or sleeve shall be sealed at the foundation wall to prevent entry of gas or water.

(h) Copper services, where installed underground under buildings, shall be free of joints and shall be encased in a conduit which is designed to prevent gas leaking from the service and getting into the building.

847.42 Valves in Copper Lines. Valves installed in copper lines may be made of any suitable material permitted by this code, except that, ferrous valves installed on underground copper services shall be protected from contact with the soil and/or insulated from the copper pipe.

847.43 Fittings in Copper Lines. It is recommended that fittings in a copper line and exposed to the soil, such as service tees, pressure control fittings, etc., be made of bronze, copper or brass. If iron or steel fittings are used, they shall be protected as specified above for valves. When mechanical couplings are used, inserts shall be used in the tubing or other precautions taken to prevent possible collapse of the tubing.

847.44 Joints in Copper Pipe and Tubing. Copper pipe shall be joined by using either a compression type coupling or a brazed or soldered lap joint. The filler material used for brazing shall be a copper-phosphorous alloy or silver base alloy. Butt welds are not permissible for joining copper pipe or tubing. Copper tubing shall not be threaded but copper pipe with wall thickness equivalent to the comparable size of Schedule 40 steel pipe may be threaded and used for connecting screw fittings or valves.

847.45 Protection Against Galvanic Action Caused by Copper. Provision shall be made to prevent harmful galvanic action where copper is connected underground to steel. This can be accomplished in most cases by using one or the other of the following methods:

(a) Install an insulating type coupling, or an insulating flange, between the copper and the steel, or

(b) Protect the copper and steel for a distance of two feet or more in all directions from the junction with insulating pipe corrosion protection material.

847.46 Service Connections to Copper Mains

(a) Connections using a copper or cast bronze service tee or extension fitting sweat-brazed to the copper main, are recommended for copper mains.

(b) Butt welds are not permitted.

(c) Fillet-brazed joints are not recommended.

(d) The requirements of 847.44 shall apply to:

(1) Joints not specifically men-

tioned above, and,

(2) All brazing material.

848 VALVES (1)

848.1 Required Spacing of Valves

848.11 Transmission Lines. Sectionalizing block valves on transmission lines shall be installed at a spacing not to exceed 20 miles within areas conforming to location Class 1, 15 miles within areas conforming to location Class 2, 8 miles within areas conforming to location Class 3, and 5 miles within areas conforming to location Class 4.

848.12 Valves on distribution mains, whether for operating or emergency purposes, shall be spaced as follows:

(a) High Pressure Distribution Systems. Valves shall be installed in high pressure distribution systems in accessible locations in order to reduce the time to shut down a section of main in an emergency. In determining the spacing of the valves consideration should be given to the operating pressure and size of the mains and local physical conditions as well as the number and type of consumers that might be affected by a shutdown.

(b) Low Pressure Distribution Systems. Valves may be used on low pressure distribution systems, but are not required except as specified in 848.22 (a).

848.2 Location of Valves

848.21 Transmission Valves

(a) Sectionalizing block valves shall be accessible and protected from damage and tampering. If a blow-down valve is involved it shall be located where the gas can be blown to the atmosphere without undue hazard.

(b) Sectionalizing valves may be installed above ground, in a vault, or buried. In all installations an operating device to open or close the valve shall be readily accessible to authorized persons. All valves shall be suitably supported to prevent settlement, or movement of the attached piping.

(c) Blow-down valves shall be provided so that each section of pipeline between main line valves can be blown down. The sizes and capacity of the connections for blowing down the line shall be such that under emergency conditions the section of line can be blown down as rapidly as is practicable.

(d) This code does not require the use of automatic valves, nor does the code imply that the use of automatic valves presently developed will provide full protection to a piping system. Their use and installation shall be at the discretion of the operating company.

848.22 Distribution System Valves

(a) A valve shall be installed on the inlet piping of each regulator station controlling the flow or pressure of gas in a distribution system. The distance between the valve and the regulator or regulators shall be sufficient to permit the operation of the valve during an emergency, such as a large gas leak or a fire in the station.

(b) Valves on distribution mains, whether for operating or emergency purposes, shall be located in a manner that will provide ready access and facilitate their operation during an emergency. Where a valve is installed in a buried box or enclosure, only ready access to the operating stem or mechanism is implied.

849 VAULTS

849.1 Structural Design Requirements

Underground vaults or pits for valves, pressure relieving, pressure limiting or pressure regulating stations, etc., shall be designed and constructed in accordance with the following provisions:

(a) All vaults or pits in roads, streets or highways which may be exposed to vehicular traffic shall be composed of durable structural materials and shall be designed to withstand without damage the heaviest loads to which they may be subjected. Where local regulations do not specify structural limitations, the roof slab or cover shall be designed to carry a 15,000

Note (1): See 847.12 and 847.13 for valves in services.

lb. wheel load distributed over a contact area of the road surface 15 inches in diameter. The walls shall be designed to resist a uniform horizontal pressure of 250 lbs. per square foot without damage. Vaults and pits not subject to vehicular loads shall be designed and constructed in accordance with good structural engineering practice.

(b) Sufficient working space shall be provided so that all of the equipment required in the vault can be properly installed, operated and maintained.

(c) In the design of vaults and pits for pressure limiting, pressure relieving and pressure regulating equipment, consideration shall be given to the protection of the equipment installed from damage, such as that resulting from an explosion within the vault or pit, which may cause portions of the roof or cover to fall into the vault.

(d) Piping entering, and within, regulator vaults or pits shall be steel for sizes 10 inches and less except that control and gauge piping may be copper. Where piping extends through the vault or pit structure, provision shall be made to prevent the passage of gases or liquids through the opening and to avert strains in the piping. Equipment and piping shall be suitably sustained by metal, masonry, or concrete supports. The control piping shall be placed and supported in the vault or pit so that its exposure to injury or damage is reduced to a minimum.

(e) Vault or pit openings shall be located so as to minimize the hazards of tools or other objects falling upon the regulator, piping, or other equipment. The control piping and the operating parts of the equipment installed shall not be located under a vault or pit opening where workmen can step on them when entering or leaving the vault or pit, unless such parts are suitably protected.

(f) Whenever a vault or pit opening is to be located above equipment which could be damaged by a falling cover, a circular cover should be installed or other suitable precautions taken.

849.2 Accessibility. Consideration shall be given, in selecting a site for a vault, to its accessibility. Some of the important factors to consider in selecting the location of a vault are as follows:

(a) Exposure to traffic. The location of vaults in street intersections or at points where traffic is heavy or dense should be avoided.

(b) Exposure to flooding. Vaults should not be located at points of minimum elevation, near catch basins, or where the access cover will be in the course of surface waters.

(c) Exposure to adjacent subsurface hazards. Vaults should be located as far as is practical from water, electric, steam, or other facilities.

849.3 Vault Ventilation. Underground vaults and closed top pits composing either a pressure regulating or reducing station, or a pressure limiting or relieving station, shall be ventilated as follows:

(a) When the internal volume exceeds 200 cubic feet, such vaults or pits shall be ventilated with two ducts each having at least the ventilating effect of a pipe 4 inches in diameter.

(b) The ventilation provided shall be sufficient to minimize the possible formation of a combustible atmosphere in the vault or pit.

(c) The ducts shall extend to a height above grade adequate to disperse any gas-air mixtures that might be discharged. The outside end of the ducts shall be equipped with a suitable weatherproof fitting or vent-head designed to prevent foreign matter from entering or obstructing the duct. The effective area of the openings in such fittings or vent-heads shall be at least equal to the cross-sectional area of a 4-inch duct. The horizontal section of the ducts shall be as short as practical and shall be pitched to prevent the accumulation of liquids in the line. The number of bends and offsets shall be reduced to a minimum and provisions shall be incorporated to facilitate the periodic cleaning of the ducts.

(d) Such vaults or pits having an internal volume between 75 cubic feet and 200 cubic feet may be either tightly closed or ventilated. If not ventilated, all openings

shall be equipped with tight fitting covers without open holes through which an explosive mixture might be ignited. Means shall be provided for testing the internal atmosphere before removing the cover.

(e) If vaults or pits referred to in (d) above are ventilated by means of openings in the covers or gratings and the ratio of the internal volume, in cubic feet, to the effective ventilating area of the cover or grating, in square feet, is less than 20 to 1, no additional ventilation is required.

(f) Such vaults or pits having an internal volume less than 75 cubic feet may be ventilated or not at the option of the operating company.

849.4 Drainage and Waterproofing

(a) Provisions shall be made to minimize the entrance of water into vaults, and vault equipment shall always be designed to operate safely, if submerged.

(b) No vault containing gas piping shall be connected by means of a drain connection to any other substructure, such as a sewer.

(c) Electrical equipment in vaults shall conform to the requirements of Class 1, Group D, of the National Electrical Code (ASA C1).

CHAPTER V

OPERATING AND MAINTENANCE PROCEDURES

850 OPERATING AND MAINTENANCE PROCEDURES AFFECTING THE SAFETY OF GAS TRANSMISSION AND DISTRIBUTION FACILITIES

850.1 Because of many variables, it is not possible to prescribe in a national code a set of operating and maintenance procedures that will be adequate from the standpoint of public safety in all cases without being burdensome and impractical in some.

850.2 It is possible, however, for each operating company to develop operating and maintenance procedures based on experience, knowledge of its facilities and conditions under which they are operated, which will be entirely adequate from the standpoint of public safety.

850.3 Basic Requirement. Each operating company having gas transmission or distribution facilities within the scope of this code shall:

(a) Have a plan covering operating and maintenance procedures in accordance with the purpose of this code.

(b) Operate and maintain its facilities in conformance with this plan.

(c) Keep records necessary to administer the plan properly.

(d) Modify the plan from time to time as experience with it dictates and as exposure of the public to the facilities and changes in operating conditions require.

850.4 Essential Features of the Plan. The plan prescribed in 850.3 (a) above should include:

(a) Detailed plans and instructions to employees covering operating and maintenance procedures for gas facilities during normal operations and repairs, and during emergencies.

(b) Items recommended for inclusion in the plan for specific classes of facilities are given in 851 to 857, inclusive.

(c) Particular attention should be given to those portions of the facilities presenting the greatest hazard to the public in the event of an emergency or because of construction or extraordinary maintenance requirements.

851 PIPELINE MAINTENANCE

851.1 Pipeline Patrolling. Each operating company should maintain a periodic pipeline patrol program to observe surface conditions on and adjacent to the pipeline right of way, indications of leaks, construction activity other than that performed by the company, and any other factors affecting the safety and operation of the pipeline. Weather, terrain, size of line, operating pressures and other conditions will be factors in determining the frequency of patrol. Main highway and railroad crossings should be inspected with greater frequency and more closely than pipelines in open country.

851.2 External Corrosion of Pipelines. Periodic inspections and tests should be conducted to determine if the installed corrosion control methods used are adequate and are properly maintaining protection to the pipe metal. Whenever any portion or section of underground facilities is uncovered, an inspection should be made to determine if protection is needed or if installed protection is adequate.

851.3 Internal Corrosion of Pipelines. When active corrosive agents are known to be present in the gas being transmitted, or if evidence of internal corrosion is discovered, the gas should be periodically analyzed to determine the concentration of any corrosive agent and precautions taken,

if necessary, to prevent the development of a hazardous condition. Whenever a pipeline is cut for any reason, the internal surface should be carefully inspected for evidence of internal corrosion.

851.4 Corrosion Records. Records should be made of each pipeline inspection for external or internal corrosion covering conditions found, adequacy of cathodic protection, if so protected, condition of pipe coating, depth of pits noted and extent of corroded area. If repairs are made, method used should be stated.

851.5 Pipeline Leak Records. Records should be made covering all leaks discovered and repairs made. All pipeline breaks should be reported in detail. These records along with leakage survey records, line patrol records and other records relating to routine or unusual inspections should be kept in the file of the operating company involved, as long as the section of line involved remains in service.

852 DISTRIBUTION PIPING MAINTENANCE

852.1 Patrolling. Distribution mains, which are installed in locations or on structures where abnormal physical movement or abnormal external loading could cause failure or leakage, shall be patrolled periodically and the frequency of the patrolling shall be determined by the severity of the conditions which could cause failure or leakage and the consequent hazards to public safety.

852.2 Leakage Surveys and Routine Procedures

852.21 Each operating company having a gas distribution system shall set up in its operating and maintenance plan a provision for the making of periodic leakage surveys. The types of surveys prescribed in the plan shall be one or more of the following employed singly or in combination, or some other effective procedure for locating leaks in underground piping systems.

(a) Gas detector surveys.
(b) Bar test surveys.
(c) Vegetation surveys.
(d) Pressure drop surveys.
(e) Soapsuds testing on exposed pipe and fittings.

852.22 The nature of the operations and local conditions of each individual company shall determine the type and scope of the leakage control program most suitable. The character of the general service area together with housing concentration should determine the frequency of the inspection program.

It is recommended that the inspection program should include at least the following provisions:

(a) At least once a year a gas detector survey should be conducted in business districts, involving tests of the atmosphere in gas, electric, telephone, sewer and water system manholes, at cracks in pavement and sidewalks and at other locations providing an opportunity for finding gas leaks. Leakage surveys, using one or more of the types referred to in 852.21, should be made of the distribution system outside of the principal business areas as frequently as experience indicates that they are necessary but not less than once every five years.

(b) Leaks located by these surveys shall be investigated promptly and any necessary repairs shall be made. When the condition of a main or a service, as indicated by leak frequency records or visual observation, deteriorates to the point where it should not be retained in service, it should be replaced or reconditioned.

852.3 Abandoning Inactive Services and Mains

Each operating company shall have a plan in its operation and maintenance procedures for sealing off the supply of gas to all abandoned services and mains by means of valves or other effective methods. This plan shall include procedures for abandoning services that have remained inactive for a period of years and for which there is no planned use. It is recommended that the plan include the following provisions:

(a) If a main is abandoned in place and is disconnected or separated, the ends shall be capped, plugged or otherwise effectively sealed.

(b) If abandoned services are not removed, both ends shall be sealed or other effective means employed to prevent the possible passage of any gas leakage. In cases where a main is abandoned, together with the services connected to it, only the customer's end of such services need be sealed as stipulated above.

853 COMPRESSOR STATION MAINTENANCE

853.1 Compressors and Prime Movers. The starting, operating and shut-down procedures for all gas compressor units shall be established by the operating company and the operating company shall take appropriate steps to see that the approved practices are followed.

853.2 Inspection and Testing of Relief Valves. All pressure relieving devices in compressor stations except rupture disks shall be inspected and/or tested in accordance with 855 and shall be operated periodically to determine that they open at the correct set pressure. Any defective or inadequate equipment found shall be promptly repaired or replaced. All remote control shut-down devices shall be inspected and tested periodically to determine that they function properly.

853.3 Inspection for Corrosion. In existing plants where corrosive or potentially corrosive situations exist, procedures shall be set up for periodic inspections at sufficiently frequent intervals to enable the discovery of corrosion before serious impairment of the strength of the piping or equipment has occurred. Prompt repairs or replacements shall be made when needed.

853.4 Isolation of Equipment for Maintenance or Alterations. The operating company shall establish procedures for isolation of units or sections of piping for maintenance, and for purging prior to returning units to service, and shall follow these established procedures in all cases.

853.5 Storage of Combustible Materials. All flammable or combustible materials in quantities beyond those required for everyday use or other than those normally used in compressor buildings, shall be stored in a separate structure built of Non-combustible material located a suitable distance from the compressor building. All above ground oil or gasoline storage tanks shall be protected in accordance with the National Fire Protection Association and the National Board of Fire Underwriters Standard No. 30.

853.6 No Smoking Signs. Smoking shall be prohibited in all areas of a compressor station in which the possible leakage or presence of gas constitutes a hazard of fire or explosion. Suitable signs shall be posted to serve as warnings of these areas.

854 PROCEDURES FOR MAINTAINING PIPE-TYPE AND BOTTLE-TYPE HOLDERS IN SAFE OPERATING CONDITION

854.1 Each operating company having a pipe-type or bottle-type holder shall prepare and place in its files a plan for the systematic, routine inspection and testing of the facilities which provides that:

854.11 Procedures shall be followed to enable the detection of external corrosion before the strength of the container has been impaired.

854.12 Periodic sampling and testing of gas in storage will be made to determine the dew point of vapors contained in the stored gas that might cause internal corrosion or interiere with the safe operations of the storage plant.

854.13 The pressure control and pressure limiting equipment will be inspected and tested periodically to see if it is in a safe operating condition and has adequate capacity.

854.2 Each operating company, having prepared such a plan as prescribed in 854.1 above, shall follow the plan, and keep records which detail the inspection and testing work done and the conditions found.

854.3 All unsatisfactory conditions found shall be promptly corrected.

855 MAINTENANCE OF PRESSURE LIMITING AND PRESSURE REGULATING STATIONS

855.1 All pressure limiting stations, relief devices, and pressure regulating stations and equipment shall be subjected to systematic periodic inspections and/or tests to determine that they are:

(a) In good mechanical condition.

(b) Adequate from the standpoint of capacity and reliability of operation for the service in which they are employed.

(c) Set to function at the correct pressure.

(d) Properly installed and protected from dirt, liquids, or other conditions that might prevent proper operation.

855.2 (a) Every distribution system supplied by more than one district pressure regulating station shall be equipped with telemetering or recording pressure gauges to indicate the gas pressure in the district.

(b) On distribution systems supplied by a single district pressure regulating station the operating company shall determine the necessity of installing such gauges in the district. In making this determination the operating company shall take into consideration the operating conditions such as the number of customers supplied, the operating pressures, and the capacity of the installation, etc.

(c) If there are indications of abnormal high or low pressure the regulator and the auxiliary equipment shall be inspected and the necessary measures shall be employed to rectify any unsatisfactory operating conditions. Suitable periodic inspections of single district pressure regulation stations not equipped with telemetering or recording gauges shall be made to determine that the pressure regulating equipment is functioning properly.

855.3 Whenever it is practicable to do so, pressure relief valves should be tested in place to determine that they have sufficient capacity to limit the pressure on the facilities to which they are connected to the desired maximum pressure. If such tests are not feasible, periodic review and calculation of the required capacity of the relieving equipment at each station should be made and these required capacities compared with the rated or experimentally determined relieving capacity of the installed equipment for the operating conditions under which it works. If it is determined that the relieving equipment is of insufficient capacity, steps shall be taken to install new or additional equipment to provide capacity.

856 VALVE MAINTENANCE

856.1 Pipeline Valves that might be required during an emergency shall be inspected periodically and partially operated at least once per year to provide safe and proper operating conditions.

856.2 Distribution System Valves. Valves, the use of which may be necessary for the safe operation of a gas distribution system, shall be checked and serviced, including lubrication where necessary, at sufficiently frequent intervals to be reasonably assured of their satisfactory operation. Inspection shall include checking of alignment to permit use of a key or wrench and clearing from the valve box or vault any debris which would interfere with or delay the operation of the valve.

857 VAULT MAINTENANCE. Regularly scheduled inspections shall be made of each vault housing pressure regulating and pressure limiting equipment and having a volumetric internal content of 200 cubic

feet or more to determine if it is in good physical condition and adequately vented. This inspection shall include the testing of the atmosphere in the vault for combustible gas. If gas is found in the vault atmosphere, the equipment in the vault shall be inspected for leaks and leaks found shall be repaired. The ventilating equipment shall also be inspected to determine if it is functioning properly. If the ventilating ducts are obstructed, they shall be cleared. The condition of the vault covers shall be carefully examined to see that they do not present a hazard to public safety.

CHAPTER VI

MISCELLANEOUS

860 MISCELLANEOUS

861 ODORIZATION. Any gas, distributed to consumers through gas mains or gas services or used for domestic purposes in compressor plants, which does not naturally possess a distinctive odor to the extent that its presence in the atmosphere is readily detectable at concentrations well below that required to produce an explosive mixture shall have an odorant added to it to make it so detectable. Odorization is not necessary, however, for such gas as is delivered for further processing or use where the odorant would serve no useful purpose as a warning agent.

862 LIQUEFIED PETROLEUM GAS (LPG) SYSTEMS

862.1 Liquefied petroleum gases, generally, include butane and propane, and mixtures of them that can be stored as liquids under moderate pressures (approximately 80 psig to 250 psig) at ambient temperatures.

862.2 This code is concerned only with certain safety aspects of liquefied petroleum gases when they are vaporized and used as gaseous fuels.

862.3 All of the requirements of Standards No. 58 and No. 59 of the National Board of Fire Underwriters and the National Fire Protection Association and of this code, concerning design, construction, and operation and maintenance of piping facilities shall apply to piping systems handling butane, propane, or mixtures of these gases.

862.4 Special Safety Requirements for LPG Systems

862.41 Odorization. Liquefied petroleum gases are usually nontoxic, but for safety when distributed for consumer use, or used as fuel in a place of employment, they shall be odorized. Criteria for odorization are given in 861. (1)

862.42 Ventilation

(a) All liquefied petroleum gases are heavier than air, hence structures above ground for housing regulators, meters, etc., shall have open vents near the floor level. Such equipment shall not be installed in pits or in underground vaults, except in cases where suitable provisions for forced ventilation are made.

(b) Special care is required in the location of relief valve discharge vents releasing LPG to the atmosphere, to prevent accumulation of the heavy gases at or below ground level. Likewise, special precautions are necessary for adequate ventilation where excavations are made for the repair of leaks in an underground LPG distribution system.

863 PIPELINES ON PRIVATE RIGHT OF-WAY OF ELECTRIC TRANSMISSION LINES. Where gas pipelines parallel overhead electric transmission lines on the same right of way, the company operating the pipelines shall take the following precautions:

863.1 Employ blow-down connections that will direct the gas away from the electric conductors.

863.2 Install a bonding conductor across points where the main is to be

Note: (1) Refer to National Board of Fire Underwriters and the National Fire Protection Association Bulletins No. 58 - Storage and Handling of Liquified Petroleum Gases, and No. 59 - Liquified Petroleum Gases at Utility Gas Plants

separated and maintain this connection while the pipeline is separated. The current carrying capacity of the bonding conductor should be at least one-half of the capacity of the overhead line conductors.

863.3 Make a study in collaboration with the electric company on the common problems of corrosion and electrolysis, taking the following factors into consideration:

(a) The possibility of the pipeline carrying either unbalanced line currents or fault currents.

(b) The possibility of lightning or fault currents inducing voltages sufficient to puncture pipe coatings or pipe.

(c) Cathodic protection of the pipeline, including location of ground beds, especially if the electric line is carried on steel towers.

(d) Desirability of installing electric bonding connections between the pipeline and either the steel tower footings or the buried ground facilities or the groundwire of the overhead electric system.

863.4 Investigate the necessity of protecting insulating joints in the pipeline against induced voltages or currents resulting from lightning strokes. Such protection can be obtained by connecting buried sacrificial anodes to the pipe near the insulating joints or by bridging the pipeline insulator with a spark-gap or by other effective means.

CHAPTER VII

APPENDICES

APPENDIX A

List of Standards and Specifications incorporated in this Code by reference showing year dates effective as of January 1955.*

ASTM Standards

A 7 -1953T
A 41-1936
A 42-1952T
A 47-1952
A 48-1948
A 53-1954T
A 56-1939
A 72-1952T
A 84-1952T
A 95-1944
A105-1946
A106-1952T
A107-1952aT
A120-1954
A125-1952
A126-1942
A134-1954
A135-1954T
A139-1954
A141-1952T
A155-1952aT
A181-1949
A182-1953T
A193-1953aT
A194-1953
A197-1947
A211-1954
A212-1954aT
A216-1953T
A217-1949T
A225-1954T
A234-1952aT
A242-1953T
A261-1954
A283-1954
A285-1954T
A307-1953T
A377-1954T
B 21-1954
B 42-1954
B 43-1954
B 61-1952
B 62-1952
B 68-1954
B 75-1954
B 88-1954
B132-1952
B249-1953T
B251-1954T

ASA Standards

A21.1-1939
A21.3-1953
A21.7-1953
A21.9-1953
A21.10-1952
A21.11-1953
B1.1-1949
3rd Edition
B1.4-1945
B2.1-1945
B16.1-1948
B16b-1944
B16b1-1931
B16b2-1931
B16.3-1951
B16.4-1949
B16.5-1953
B16.8-1951
B16.11-1946
B16.18-1950
B16.20-1952
B16.24-1953
B18.2-1952
B31.1-1951
and Suppl. 1,
B31.1a-1953
B36.10-1950
C1-1953
Z21.30-1950

MSS Standard Practices

SP-6-1951
SP-25-1954
SP-44-1953

API Standards

5A, 19th Edn. 1954
5L, 13th Edn. 1954
5LX, 5th Edn. 1954
6A, 6th Edn. 1954
6D, 6th Edn. 1949
1102, 1st Edn. 1949
1104, 2nd Edn. 1954

ASME Code

ASME Boiler and Pressure Vessel Code 1952

AWWA Standard

C100-1952T

AWS Standard

A3.0-1949

CIPRA Standards

Cast Iron Mechanical Joint Fittings

NBFU Publications**

Standard No. 30-1954
Pamphlet No. 58-1954
Pamphlet No. 59-1954
Bulletin No. 294-1954

*Under some conditions the application of these standards and specifications is limited by provisions of this code.

**Publications listed under NBFU are recommended by the National Fire Protection Association.

Standards and specifications of the following organizations appear in the above list:

API	American Petroleum Institute 50 West 50th St., New York 20, N. Y.
ASA	American Standards Association 70 East 45th St., New York 17, N. Y.
ASME	American Society of Mechanical Engineers 29 West 39th St., New York 18, N. Y.
ASTM	American Society for Testing Materials 1916 Race St., Philadelphia 3, Pa.
AWS	American Welding Society 33 West 39th St., New York 18, N. Y.
AWWA	American Water Works Association 521 Fifth Ave., New York 17, N. Y.
MSS	Manufacturers Standardization Society of the Valve and Fittings Industry 420 Lexington Ave., New York 17, N. Y.
CIPRA	Cast Iron Pipe Research Association 122 S. Michigan Ave., Chicago 3, Ill.
NBFU	National Board of Fire Underwriters 85 John Street, New York, N. Y.
NFPA	National Fire Protection Assn. 60 Batterymarch St., Boston 10, Mass.

APPENDIX B

List of Material Specifications Incorporated in this Code by Reference.

STRUCTURAL MATERIALS:

Brass (rods and bars for structural use) . . . . . ASTM B 21
Bronze (manganese bronze castings) . . . . . ASTM B 132
Carbon-steel (plates) ASTM A 285
Cast iron (ordinary gray-iron castings) . . . . . ASTM A 48
Chains . . . . . ASTM A 56
High tensile carbon-silicon steel plates . . . . . ASTM A 212
Low alloy structural steel . . . . ASTM A 242
Manganese vanadium steel plates . . . . . ASTM A 225
Malleable-iron castings. . . . . ASTM A 47
Springs, helical (for use on spring hangers). . . . . ASTM A 125
Steel, structural . . . . . ASTM A 7
Steel, structural (plates) . . . . . ASTM A 283
Steel, structural (rivets) . . . . . ASTM A 141
Wrought iron (refined bars) . . . ASTM A 41
Wrought iron (plates) . . . . . ASTM A 42
Wrought iron (extra-refined bars). . . . . ASTM A 84

FITTINGS, VALVES, AND FLANGES:

Brass castings. . . . . ASTM B 62
Bronze castings . . . . . ASTM B 61
Cast-iron castings . . . . . ASTM A 126
ASA A 21.10
ASA A 21.11
AWWA C100
Malleable iron for castings . . . ASTM A 197
Steel (alloy castings) for high-temperature service . . . . . ASTM A 217
Steel (cast carbon) for high-temperature service . . . . . ASTM A 95
Steel (cast carbon) for fusion welding for high-temperature service . ASTM A 216
Steel (forged or rolled) for high temperature service . . . . . ASTM A 105
Steel (forged or rolled) for general service. . . . . ASTM A 181
Steel (forged or rolled alloy) for high-temperature service . . . ASTM A 182
Steel (factory-made wrought carbon steel and ferritic alloy steel welding fittings) . . . . . ASTM A 234

BOLTING:

Steel (alloy) for high-temperature service . . . . . ASTM A 193
Steel (carbon and alloy) for nuts . ASTM A 194
Steel (carbon) bars . . . . . ASTM A 107
Steel (heat-treated carbon) bolting material . . . . . ASTM A 261
Steel machine bolts and nuts (Grade B). . . . . ASTM A 307

PIPE AND TUBING:

Brass (seamless) pipe. . . . . ASTM B 43
Cast-iron (centrifugally cast) pipe . . . . . ASA A 21.7
ASA A 21.9
ASA A 21.11
Cast-iron (pit-cast) pipe . . . . . ASA A 21.3
ASA A 21.11
Copper (seamless) pipe . . . . . ASTM B 42
Copper (seamless) tubing. . . . . ASTM B 75
Copper (seamless) bright annealed tubing . . . . . ASTM B 68
Copper (seamless) water tubing . ASTM B 88
Steel (electric-fusion-welded) 18 in. and larger pipe for high-temperature and high-pressure service . . . . . ASTM A 155
Steel (electric-resistance-welded) pipe . . . . . ASTM A 135
Steel (electric-fusion-welded) pipe . . . . . ASTM A 139
Steel (electric-fusion-welded) large size pipe. . . . . ASTM A 134
Steel and iron (seamless and welded) line pipe . . . . . API 5 L
Steel (seamless and welded) high test line pipe . . . . . API 5 LX
Steel (seamless and welded) and iron (welded) casing, drill pipe and tubing . . . . . API 5A
Steel (seamless) pipe for high-temperature service . . . . . ASTM A 106
Steel or iron (spiral-welded) pipe . . . . . ASTM A 211
Steel (welded and seamless) pipe for ordinary uses . . . . . ASTM A 120
Steel (welded and seamless) pipe for coiling and bending, ... ASTM A 53
Wrought-iron (welded) pipe . . . . ASTM A 72

APPENDIX C

Specified minimum yield strength (See 841.1) for steel pipe commonly used in piping systems. Note: This table is not complete. For the minimum specified yield strength of other approved specifications, refer to the particular specification.

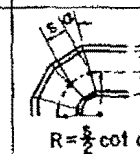
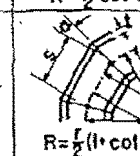
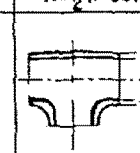
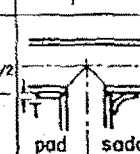
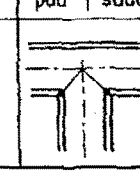
Specification	Specified Minimum Yield Strength (psi)
API 5L Grade A Seamless or Electric-welded	30,000
API 5L Grade B Seamless or Electric-welded	35,000
API 5L Lap-welded or Butt-welded Class I Open-Hearth	25,000
API 5L Lap-welded or Butt-welded Class II Open-Hearth	28,000
API 5L Lap-welded or Butt-welded Bessemer	30,000
API 5L Lap-welded or Butt-welded Open-Hearth Iron or Wrought Iron	24,000
API 5LX Grade X42	42,000
API 5LX Grade X46	46,000
API 5LX Grade X52	52,000
ASTM A53 Grade A	30,000
ASTM A53 Grade B	35,000
ASTM A53 Lap-welded and Butt-welded Open Hearth or Electric Furnace	25,000
ASTM A53 Lap-welded and Butt-welded Bessemer Steel	30,000
ASTM A72	24,000
ASTM A106 Grade A	30,000
ASTM A106 Grade B	35,000
ASTM A135 Grade A	30,000
ASTM A135 Grade B	35,000
ASTM A139 Grade A	30,000
ASTM A139 Grade B	35,000

APPENDIX D

TABLE 1.

FLEXIBILITY FACTORS k AND STRESS INTENSIFICATION FACTORS i

Description	Flexibility Factor k	Stress Intens. Factor i
BUTT WELDED JOINT, REDUCER, or WELDING NECK FLANGE	1	1.0
DOUBLE-WELDED SLIP-ON or SOCKET WELDING FLANGE	1	1.2
FILLET WELDED JOINT, or SINGLE-WELDED SOCKET WELDING FLANGE	1	1.3
LAP JOINT FLANGE (with ASA B16.9 lap joint stub)	1	1.6
SCREWED PIPE JOINT, or SCREWED FLANGE	1	2.3
CORRUGATED PIPE, straight or curved, or CREASED BEND	5	2.5

Description	Flexibility Factor k'	Stress Intens. Factor i'	Flexibility Characteristic h	Sketch
WELDING ELBOW, or PIPE BEND‡	$\frac{1.65}{h}$	$\frac{0.9}{h^{2/3}}$	$\frac{tR}{r^2}$	
MITRE BEND†* with close spacing: $s < r\,(1 + \tan\alpha)$	$\frac{1.52}{h^{5/6}}$	$\frac{0.9}{h^{2/3}}$	$\frac{\cot\alpha}{2}\frac{ts}{r^2}$	 $R=\frac{s}{2}\cot\alpha$
MITRE BEND,§* with wide spacing: $s \geq r\,(1 + \tan\alpha)$	$\frac{1.52}{h^{5/6}}$	$\frac{0.9}{h^{2/3}}$	$\frac{1+\cot\alpha}{2}\frac{t}{r}$	 $R=\frac{r}{2}(1+\cot\alpha)$
WELDING TEE per ASA B16.9	1	$\frac{0.9}{h^{2/3}}$	$4.4\frac{t}{r}$	
REINFORCED FABRICATED TEE, with pad or saddle	1	$\frac{0.9}{h^{2/3}}$	$\frac{(t+1/2\,T)^{5/2}}{t^{3/2}r}$	 pad saddle
UNREINFORCED FABRICATED TEE	1	$\frac{0.9}{h^{2/3}}$	$\frac{t}{r}$	

+ The flexibility factors k and stress intensification factors i in the Table apply to fittings of the same nominal weight or schedule as the pipe used in the system, and shall in no case be taken as less than unity. They apply over the effective arc length (shown by dash-dot lines in the sketches) for curved and mitre elbows, and to the intersection point for tees.

‡ Where flanges are attached to one or both ends the values of k and i in the Table shall be multiplied by the following factors:

One end flanged: $(h)^{1/6}$ Both ends flanged: $(h)^{1/3}$

§ Also includes single-mitre joint.

*Subject to limitations of 841.236

APPENDIX E

EXAMPLES ILLUSTRATING THE APPLICATION OF THE RULES FOR REINFORCEMENT OF WELDED BRANCH CONNECTIONS

Example 1.

An 8 inch outlet is welded into a 24 inch header. The header material is API 5LX 46 with 5/16 inch wall. The outlet is API 5L Grade B (Seamless) Sched. 40 with 0.322 inch wall. The working pressure is 650 psi. The construction is Type B, used in Location Class 1, in accordance with 841.01. The joint efficiency is 1.00. The temperature is 100°. Design Factors (841.1) F = 0.60 E = 1.00 T = 1.00 For dimensions see Figure for Example 1, Appendix E.

Header:

Theoretical minimum wall thickness:

$$t = \frac{PD}{2S\,FET} = \frac{650 \times 24}{2 \times 46000 \times .60 \times 1.00 \times 1.00} = 0.283 \text{ inch}$$

Excess thickness in header wall (H - t) = .312 - .283 = .029 inch

Outlet:

Theoretical minimum wall thickness:

$$t_b = \frac{650 \times 8.625}{2 \times 35000 \times .60 \times 1.00 \times 1.00} = 0.133 \text{ inch}$$

Excess thickness in outlet wall ($B - t_b$) = .322 - .133 = .189 inch

d = diameter of opening = 8.625 - (2 x .322) = 7.981 inch

Reinforcement required:

$A_R = d \times t = 7.981 \times .283 = 2.26$ sq. in.

Reinforcement provided:

$A_1 = (H - t)\,d = .029 \times 7.981 = 0.23$ sq. in.

Effective area in outlet:

Height (L) 2-1/2 B + M (Assume 1/4 inch Pad) =

2-1/2 x .322 + 0.25 = 1.05 inch

or 2-1/2 H = 2.5 x .312 = 0.78 inch Use 0.78 inch

$A_2 = 2 (B - t_b) L = 2 \times .189 \times .78 = 0.295$ sq. in.

This must be multiplied by 35000/46000. (831.41(f))

Effective $A_2 = 0.295 \times \frac{35000}{46000} = 0.22$ sq. in.

Required area $A_3 = A_R - A_1 - A_2 = 2.26 - 0.23 - 0.22 = 1.81$ sq. in.

Use reinf. pl. 1/4 inch thick (minimum practicable) x 15.5 inch diameter

Area (15.50 - 8.62) x 0.25 = 1.72 sq. in.

Fillet welds (assuming two 1/4 inch welds each side)

$.25 \times .25 \times .50 \times 2 \times 2$ = .12 sq. in.

Total A_3 provided 1.84 sq. in.

Example 2.

A 16 inch outlet is welded into a 24 inch header. The header material is API 5LX 46 with 5/16 inch wall. The outlet is API 5L Grade B (Seamless) Sched. 20 with .312 wall. The working pressure is 650 psi. The construction is Type B, used in Location, Class 1, in accordance with 841.01. By 831.42 the reinforcement must be of the complete encirclement type. The joint efficiency is 1.00. The temperature is 100°. Design Factors (841.1) F = 0.60 E = 1.00 T = 1.00 For dimensions see Figure for Example 2 in Appendix E.

Header:

Theoretical minimum wall thickness:

$$t = \frac{PD}{2S\,FET} = \frac{650 \times 24}{2 \times 46000 \times .60 \times 1.00 \times 1.00} = 0.283 \text{ inch}$$

Excess thickness in header wall (H - t) = .312 - .283 = .029 inch

Outlet:

Theoretical minimum wall thickness:

$$t_b = \frac{650 \times 16}{2 \times 35000 \times 0.60 \times 1.00 \times 1.00} = .248 \text{ inch}$$

Excess thickness in outlet wall $(B - t_b)$ = .312 - .248 = .064 inch

d = diameter of opening = 16.000 - (2 x .312) = 15.376 inch

Reinforcement required:

A_R = d x t = 15.376 x 0.283 = 4.35 sq. in.

Reinforcement provided:

A_1 = (H - t) d = .029 x 15.376 = 0.44 sq. in.

Effective area in outlet:

Height (L) 2-1/2 B + M (Assume 5/16 inch Pl.)

2.5 x .312 + .312 = 1.09 inch

or 2-1/2 H = 2.5 x .312 = 0.78 inch Use 0.78 inch

A_2 = 2 (B - t_b) L = 2. x .064 x .78 = 0.10 sq. in.

This must be multiplied by 35000/46000 (831.41(f))

Effective A_2 = $0.10 \times \frac{35000}{46000}$ = 0.08 sq. in.

Required area A_3 = A_R - A_1 - A_2 = 4.35 - 0.44 - 0.08 = 3.83 sq. in.

Approx. required thickness of reinforcement

3.83 ÷ (30 - 16) = 0.27 inch

Use 5/16 inch Pl. Net reqd. length (Neglecting welds)

3.83 ÷ .312 = 12.3 inch

Use Plate 29 inch long.

A_3 = .312 x (29 - 16) = 4.05 sq. in.

Two 1/4 inch welds to outlet

2 x .25 x .25 x .50 = .06 sq. in.

A_3 provided 4.11 sq. in.

The use of end welds is optional. See Figure 831-D

APPENDIX E

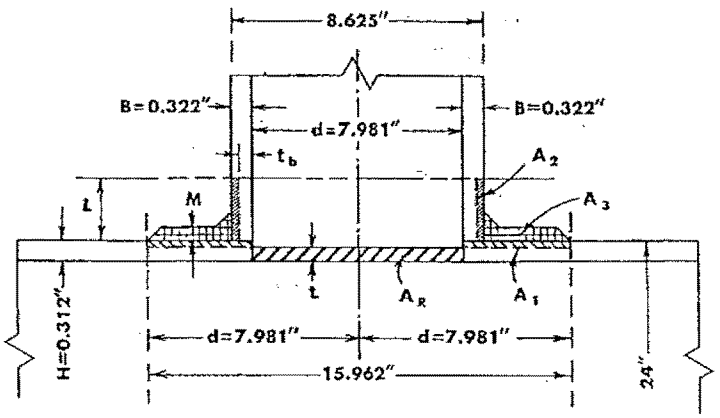


FIGURE FOR EXAMPLE 1

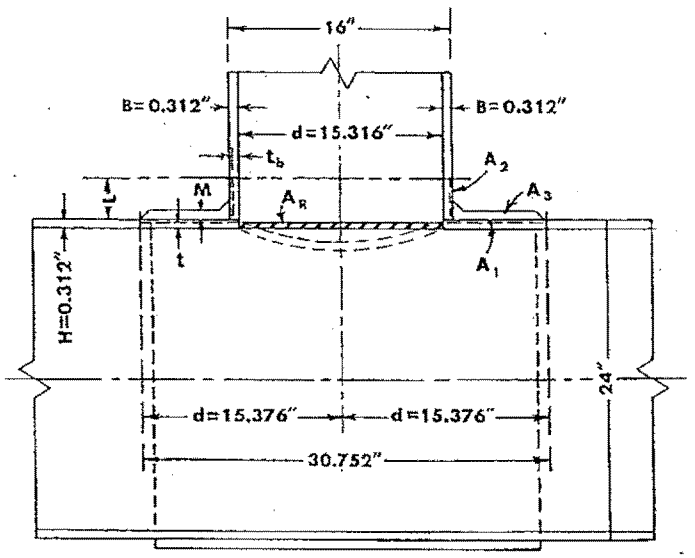


FIGURE FOR EXAMPLE 2

APPENDIX F (Referred to in 824.11)

TESTS OF WELDERS WHO ARE LIMITED TO WORK ON LINES OPERATING AT HOOP STRESSES OF LESS THAN 20% OF THE SPECIFIED MINIMUM YIELD STRENGTH:

(1) An initial test shall qualify a man for work and thereafter his work shall be checked either by requalification at one year intervals or by cutting out and testing production work at least every six months.

(2) The test may be made on pipe of any diameter 12 inches or smaller. The test weld shall be made with the pipe in a horizontal fixed position so that the test weld includes at least one section of overhead position welding.

(3) The beveling, root opening and other details must conform to the procedure specification under which the welder is qualified.

(4) The test weld shall be cut into four coupons and subjected to the root bend test. If, as a result of this test, a crack develops in the weld material or between the weld and base metal more than 1/8 inch long in any direction, this shall be cause for rejection. Cracks occurring on the corner of the specimen during testing shall not be considered. If no more than one coupon is rejected, the weld is to be considered as acceptable.

(5) Welders who are to make welded service connections to mains should be required to satisfactorily pass the following tests:

(a) Weld a service connection fitting to a pipe section having the same diameter as a typical main. This weld should be made in the same position as this type of weld is made in the field.

The weld should be rejected if it shows a serious undercutting or if it has rolled edges.

(b) The weld should be tested by attempting to break the fitting off the run pipe by any available means (knocking off).

A sample shall be rejected if the broken weld at the junction of the fitting and run pipe shows incomplete fusion, overlap, or poor penetration.

(6) For the periodic checking of welders who work on small services only (2 inches or smaller in diameter), the following special field test may be employed. This test should not be used as a substitute for the original qualifying test.

(a) Two sample welds made by the welder under test should be taken from steel service pipe. Each sample shall be cut 8 inches long with the weld located approximately in the center. One sample shall have the ends flattened and the entire joint subjected to the tensile strength test. Failure must be in the parent metal and not adjacent to or in the weld metal to be acceptable. The second sample shall be centered in the guided bend testing machine and bent to the contour of the die for a distance of 2 inches on each side of the weld. The sample to be acceptable must show no breaks or cracks after removal from the bending machine.

When a tensile strength testing machine is not available, two bend test samples will be acceptable in lieu of one tension and one bending test.

(7) Tests for Copper Joints. Personnel who are to work on copper piping should satisfactorily pass the following tests:

(a) A brazed copper bell joint should be made on any size of copper pipe used, with the axis of the pipe stationary and in the horizontal position. The joint so welded is to be sawed open, longitudinally at the top of the pipe. (The top being the uppermost point on the circumference at time joint is brazed.) The joint should be spread apart for examination. The bell end of the joint must be completely bonded. The spigot end of the joint must give evidence that the brazing alloy has reached at least 75% of the total area of the telescoped surfaces. At least 50% of the length at the top of the joint must be joined.

(8) Records shall be kept of the original tests and all subsequent tests conducted on the work of each welder.

APPENDIX G

FLATTENING TEST FOR PIPE

See 811.27 B

From ASTM Spec. A53-52T

(a) The flattening test shall be made on standard weight and extra strong pipe over 2 inches in nominal diameter. It shall not be required for double extra strong pipe.

(b) For lap-welded and butt-welded pipe the test section shall be 4 to 6 inches in length and the weld shall be located 45° from the line of direction of the applied force.

(c) For electric-resistance-welded pipe, the test section shall be 4 to 6 inches in length and the weld shall be located 90° from the line of direction of the applied force.

(d) For seamless pipe the test section shall not be less than 2-1/2 inches in length.

(e) The test shall consist in flattening a section of pipe between parallel plates until the opposite walls meet. For welded pipe, no opening in the weld shall take place until the distance between the plates is less than 3/4 of the original outside diameter for butt-weld, or 2/3 the outside diameter for lap-weld and electric-resistance-weld, and no cracks or breaks in the metal elsewhere than in the weld shall occur until the distance between the plates is less than shown below. For seamless pipe no breaks or cracks in the metal shall occur until the distance between the plates is less than that shown below:

Kind of Pipe	Distance Between Plates "H"
For butt-welded pipe	60% of outside diameter
For lap-welded pipe	one-third the outside diameter
For electric-resistance-welded pipe, grades A and B . . .	one-third the outside diameter
For seamless pipe, grades A and B . . .	to the distance "H" developed by the following formula:

$$H = \frac{(1 + e)t}{e + t/D}$$

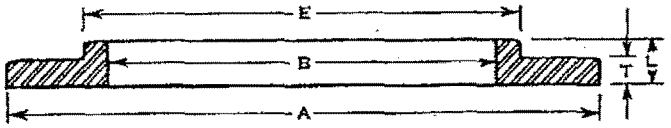
where:

H = distance between flattening plates in inches,
t = nominal wall thickness of pipe in inches,
D = actual outside diameter of pipe in inches, and
e = deformation per unit length (constant for a given grade of steel, 0.09 for grade A and 0.07 for grade B).

APPENDIX H

LIGHT WEIGHT FLANGES *

Maximum Pressure - 25 p.s.i.
Drilling same as 125 lb. Std.



Forged and Rolled Steel — Material A.S.T.M. A 181-I

Pipe Size	Outside Diameter	Thickness	Inside Diameter	Length of Hub	Outside Diameter of Hub	Drilling Template			Approx. Weight Each Pounds
						Number of Bolts	Diameter and Length of Bolts	Diameter of Bolt Circle	
Inches	A	T	B	L	E				
6	11	9/16	6.72	1 1/4	7 9/16	8	3/4 x 2 1/4	9 1/2	13
8	13 1/2	9/16	8.72	1 1/4	9 11/16	8	3/4 x 2 1/4	11 3/4	18
10	16	11/16	10.88	1 1/4	12	12	7/8 x 2 1/2	14 1/4	26
12	19	11/16	12.88	1 1/4	14 3/8	12	7/8 x 2 1/2	17	42
14	21	3/4	14.14	1 1/4	15 3/4	12	1 x 2 3/4	18 3/4	44
16	23 1/2	3/4	16.16	1 1/4	18	16	1 x 2 3/4	21 1/4	58
18	25	3/4	18.18	1 1/4	19 7/8	16	1 1/8 x 3	22 3/4	59
20	27 1/2	3/4	20.20	1 1/4	22	20	1 1/8 x 3	25	69
22	29 1/2	1	22.22	1 3/4	24 1/4	20	1 1/4 x 3 1/2	27 1/4	76
24	32	1	24.25	1 3/4	26 1/8	20	1 1/4 x 3 1/2	29 1/2	113
26	34 1/4	1	26.25	1 3/4	28 1/2	24	1 1/4 x 3 1/2	31 3/4	126
28	36 1/2	1	28.25	1 3/4	30 1/2	28	1 1/4 x 3 1/2	34	139
30	38 3/4	1	30.25	1 3/4	32 1/2	28	1 1/4 x 3 1/2	36	152
32	41 3/4	1 1/8	32.25	1 3/4	34 3/4	28	1 1/2 x 4	38 1/2	206
34	43 3/4	1 1/8	34.25	1 3/4	36 3/4	32	1 1/2 x 4	40 1/2	217
36	46	1 1/8	As	1 3/4	38 3/4	32	1 1/2 x 4	42 3/4	234
38	48 3/4	1 1/8		1 3/4	40 3/4	32	1 1/2 x 4	45 1/4	264
40	50 3/4	1 1/8		1 3/4	43	36	1 1/2 x 4	47 1/4	280
42	53	1 1/4		1 3/4	45	36	1 1/2 x 4 1/4	49 1/2	328
44	55 1/4	1 1/4		2 1/4	47	40	1 1/2 x 4 1/4	51 3/4	349
46	57 1/4	1 1/4	Specified	2 1/4	49	40	1 1/2 x 4 1/4	53 3/4	363
48	59 1/2	1 3/8		2 1/2	51	44	1 1/2 x 4 1/2	56	426
50	61 3/4	1 3/8		2 1/2	53	44	1 3/4 x 4 3/4	58 1/4	451
52	64	1 3/8	by	2 1/2	55	44	1 3/4 x 4 3/4	60 1/2	477
54	66 1/4	1 3/8		2 1/2	57	44	1 3/4 x 4 3/4	62 3/4	504
60	73	1 1/2		2 3/4	63	52	1 3/4 x 5	69 1/4	643
66	80	1 1/2		2 3/4	69	52	1 3/4 x 5	76	754
72	86 1/2	1 1/2	Purchaser	2 3/4	75	60	1 3/4 x 5	82 1/2	846

* Flat faced - designed for use with full face gasket or asbestos sheet gasket extending to the bolt holes.

FIGURE 804-A

DIAGRAM SHOWING SCOPE OF SECTION 8 OF ASA B31.1

Facilities indicated by Solid Lines are within the Scope of Section 8 of ASA B31.1

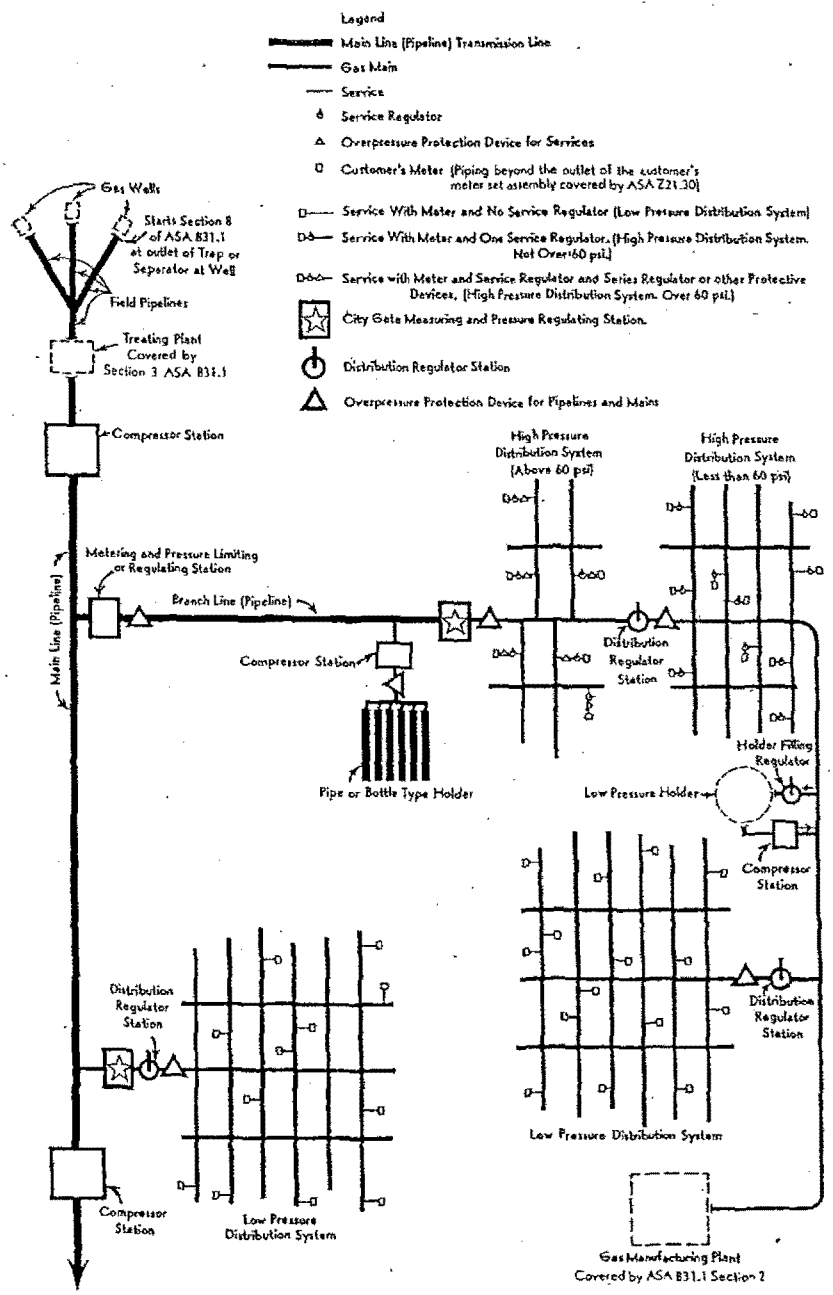


FIGURE 823-A

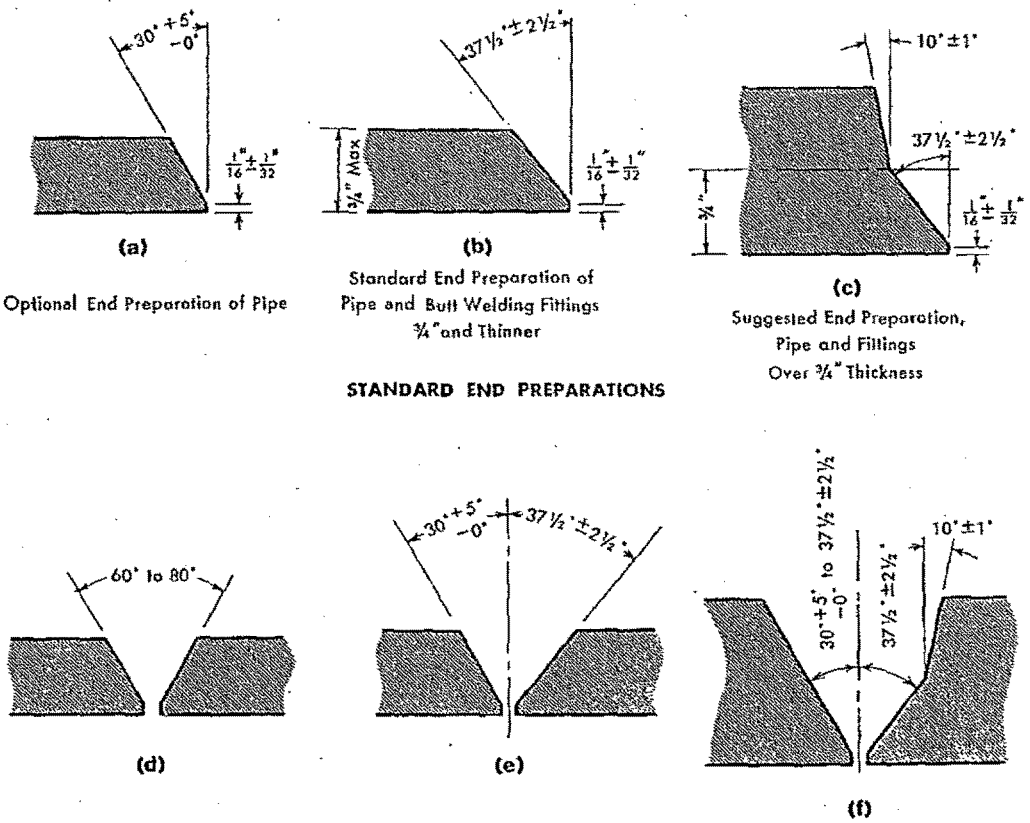
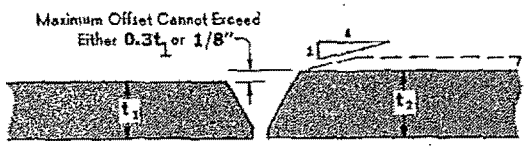


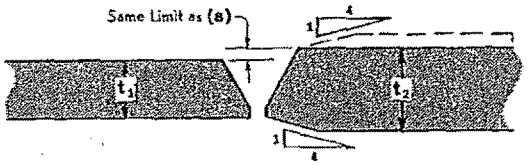
FIGURE 823-B

ACCEPTABLE WELDING END TREATMENT



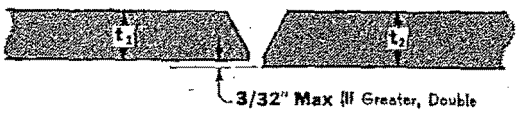
(a)

INTERNAL DIAMETERS EQUAL



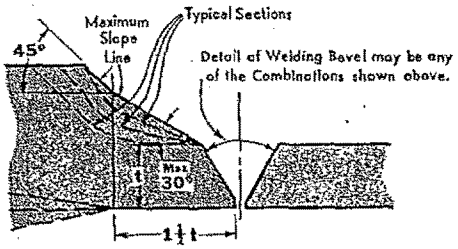
(b)

INTERNAL AND EXTERNAL DIAMETERS UNEQUAL
Internal offset exceeds 3/32"



(c)

EXTERNAL DIAMETERS EQUAL
Internal offset does not exceed 3/32"



(d)

ACCEPTABLE COMBINATIONS OF PIPE END TO BUTT WELDING FITTINGS
For reentrant angles of heavy body thicknesses (i.e. valves and fittings to pipe welding ends)

Explanatory Notes:

The sketches (a), (b), (c) and (d) are designed to illustrate the following principles governing the preparation of ends having unequal thickness.

1. If the nominal internal diameters are the same.

   (a) No special treatment is necessary unless the excess thickness exceeds 0.3 t_1 or 1/8" maximum. When this value is exceeded the heavier end shall be tapered as indicated in sketches (a) or (d) .

2. If the nominal internal diameters are unequal.

   (a) No special treatment is required if the offset does not exceed 3/32

   (b) If internal offset exceeds 3/32" the joint shall be internally beveled as shown in sketch (b) or double welded .

3. When the welding ends are of unequal inside and outside diameters the requirements 1 and 2 shall be applied.

4. Sketch (d) illustrates accepted methods of handling the reentrant angles between welding ends and heavy body thicknesses such as are encountered with valves and other fittings.

FIGURE 823-C

RECOMMENDED ATTACHMENT DETAILS OF FLANGES

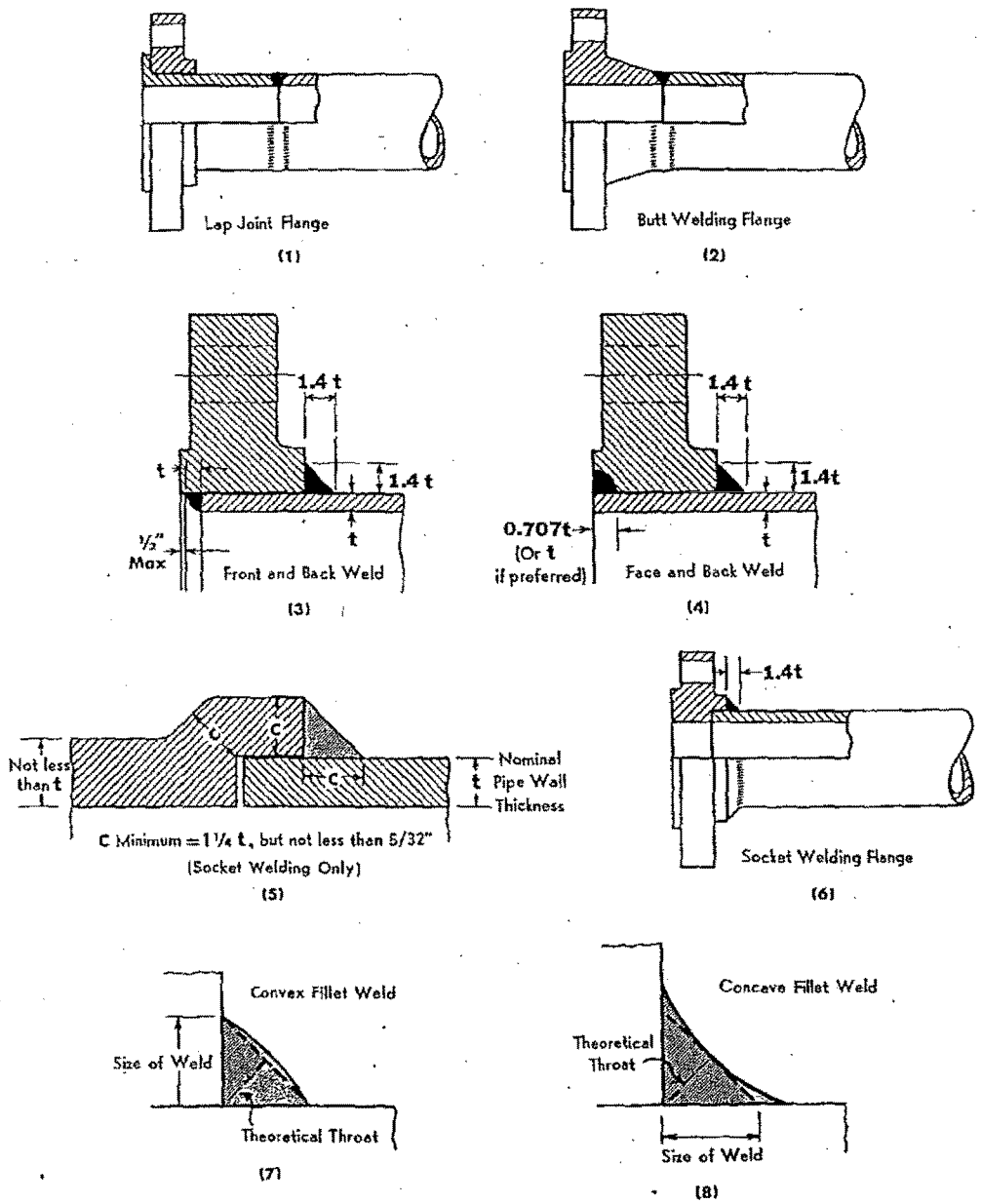
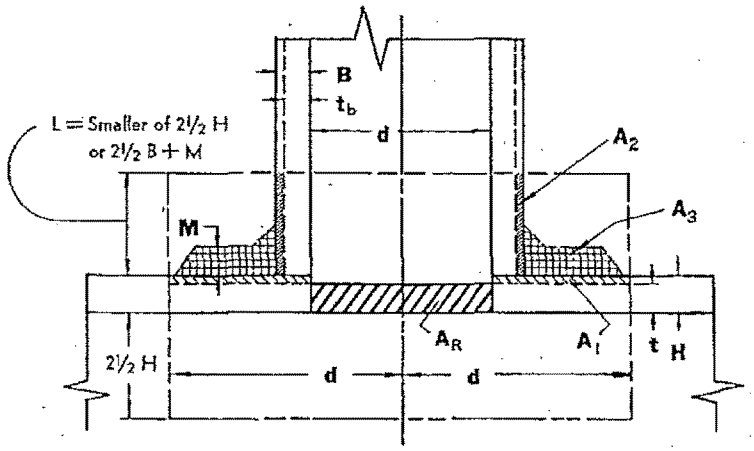


FIGURE 831-A



REINFORCEMENT OF BRANCH CONNECTIONS

"Area of Reinforcement" Enclosed by ——— – – ——— Lines.

Reinforcement Area Required $A_R = (d)(t)$

Area Available as Reinforcement = $A_1 + A_2 + A_3$

$A_1 = (H - t)(d)$

$A_2 = 2(B - t_b)L$

A_3 = Summation of Area of All Added Reinforcement, Including Weld Areas which Lie within the "Area of Reinforcement."

$A_1 + A_2 + A_3$ must be equal to or greater than A_R

Where:

H = Nominal Wall Thickness of Header

B = Nominal Wall Thickness of Branch

t_b = Required Nominal Wall Thickness of the Branch
(Under the appropriate section of the code)

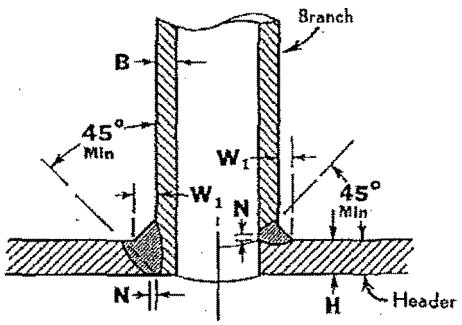
t = Required Nominal Wall Thickness of the Header
(Under the appropriate section of the code)

d = The Length of the Finished Opening in the Header Wall
(Measured parallel to the Axis of the Header)

M = Actual (by measurement) or Nominal Thickness of Added Reinforcement

FIGURE 831-B

WELDING DETAILS FOR OPENINGS WITHOUT REINFORCEMENT OTHER THAN THAT IN HEADER AND BRANCH WALLS



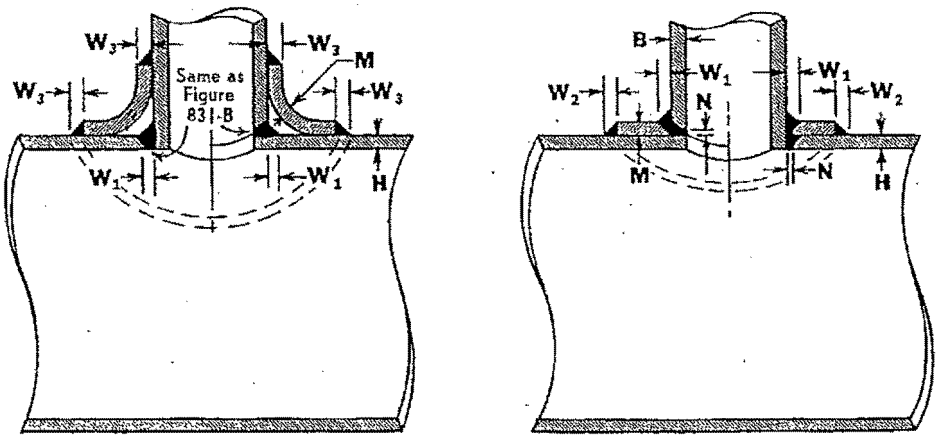
When a Welding Saddle is used it shall be inserted over this type of connection

$$W_1 = \frac{3}{8} B \quad \text{but not less than } \frac{1}{4}"$$

$$N = \frac{1}{16}" \text{ (minimum)}, \ \frac{1}{8}" \text{ (maximum)}, \ \text{(Unless Back Welded or Backing Strip is used)}$$

FIGURE 831-C

WELDING DETAILS FOR OPENINGS WITH LOCALIZED TYPE REINFORCEMENT



SADDLE PAD

W_1 (minimum) $= \frac{3}{8}$ B but not less than $\frac{1}{4}$"

W_2 (minimum) $= \frac{1}{2}$ M but not less than $\frac{1}{4}$"

W_3 (minimum) $=$ M but not greater than H

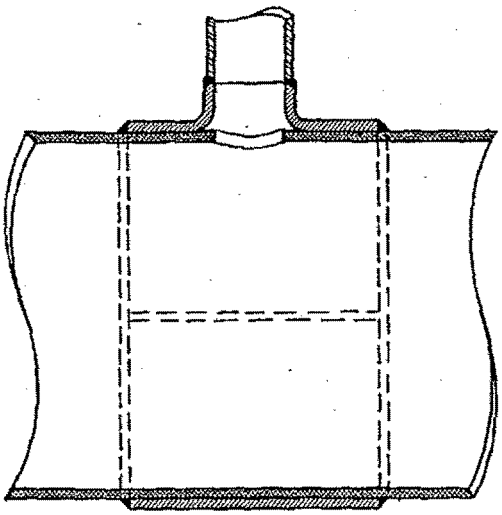
N $= \frac{1}{16}$" (minimum), $\frac{1}{8}$" (maximum), (Unless Back Welded or Backing Strip is used)

All Welds to have equal Leg Dimensions and a Minimum Throat $=$ .707 X Leg Dimension.

NOTE: If M is thicker than H the Reinforcing Member shall be tapered down to the Header Wall thickness.

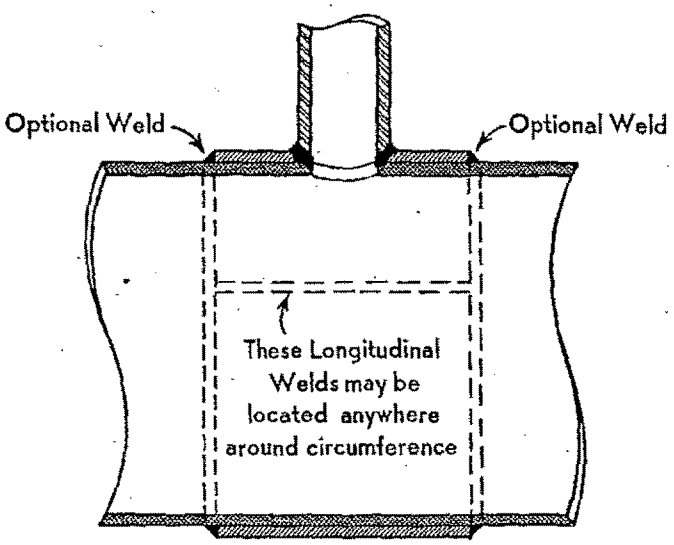
FIGURE 831-D

WELDING DETAILS FOR OPENINGS WITH COMPLETE ENCIRCLEMENT TYPES OF REINFORCEMENT

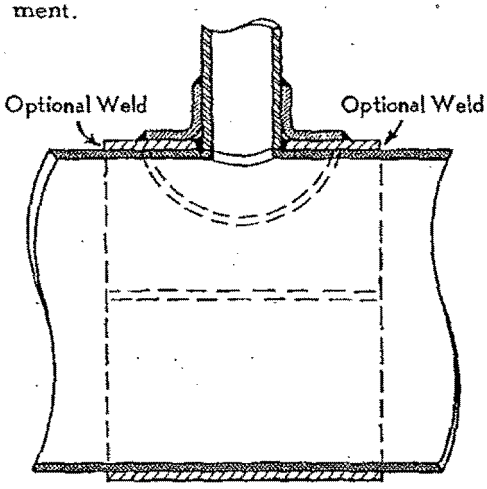


TEE TYPE

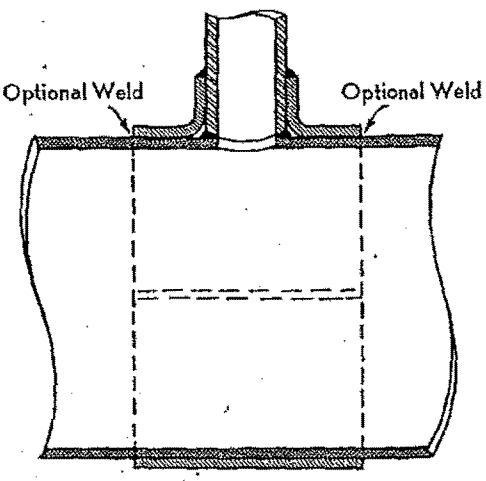
Note: Since fluid pressure is exerted on both sides of pipe metal under tee, the pipe metal does not provide reinforcement.



SLEEVE TYPE



SADDLE AND SLEEVE TYPE



SADDLE TYPE

INDEX

For Index of Definitions see 805.01

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