GENERAL ORDER NO. 112

PUBLIC UTILITIES COMMISSION

OF THE

STATE OF CALIFORNIA

GENERAL ORDER NO. 112

RULES GOVERNING DESIGN, (CONSTRUCTION) TESTING, MAINTENANCE AND OPERATION OF UTILITY GAS TRANSMISSION AND DISTRIBUTION PIPING SYSTEMS.

PUBLIC UTILITIES COMMISSION

OF THE

STATE OF CALIFORNIA

Adopted December 28, 1960, Effective July 1, 1961
Decision No. 61269 Case No. 6352

THIS DOCUMENT IS AN INTEGRATION OF THE CALIFORNIA PUBLIC UTILITY COMMISSION'S GENERAL ORDER AND A PORTION OF THE AMERICAN STANDARD CODE FOR PRESSURE PIPING ASA B 31.8 - 1958 ADOPTED IN REFERENCE IN G.O. 112.

Portions Extracted from American Standard Gas Transmission and Distribution Piping Systems (ASA B31.8-1958) - Section 8 of American Code for Pressure Piping, with the permission of the publisher, The American Society of Mechanical Engineers, 29 West 39th Street, New York 18, New York. Modifications, Amendments, or Revisions of ASA Code B31.8-1958 Specifically required by General Order No. 112 are underlined.

All material in the ASA Code specifically in conflict with General Order No. 112 has been deleted. Material quoted directly from General Order No. 112 is underlined. The ASA chapters and topic sequences have been preserved where possible to simplify reference between this document and the ASA Code. Where General Order No 112 applies to an ASA topic, the Order's paragraph number is shown beside the ASA number.

This document has been prepared by public utility gas companies in the State of California to simplify reading and application of the General Order.

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GENERAL PROVISIONS AND DEFINITIONS

101 TITLE

101.1 This General Order shall be known as the "Rules Governing Design, Construction, Testing, Maintenance and Operation of Utility Gas Transmission and Distribution Piping Systems", and will be referred to herein as "these rules".

102 PURPOSE

102.1 The purpose of these rules is to establish minimum requirements for the design, construction, quality of materials, location, testing, operation and maintenance of facilities used in the transmission and distribution of gas, to safeguard life or limb, health, property and public welfare and to provide that adequate service will be maintained by gas utilities operating under the jurisdiction of the Commission.

102.2 These rules are concerned with safety of the general public and employees' safety to the extent they are affected by basic design, quality of the materials and workmanship, and requirements for testing and maintenance of gas transmission and distribution facilities.

804 SCOPE AND INTENT

103 SCOPE

103.1 These rules shall apply to the design, construction, installation, inspection, testing, and the safety aspects of operation and maintenance of gas transmission and distribution systems, including gas pipelines, gas compressor stations, gas metering and regulating stations, gas mains and gas services up to the outlet of the customer's meter set assembly.
(See Figure 804-A in Appendix.)

104 INTENT

104.1 The requirements of these rules are adequate for safety under conditions normally encountered in the gas industry. Requirements for abnormal or unusual conditions are not specifically provided for, nor are all details of engineering and construction prescribed. It is intended that all work performed within the scope of these rules shall meet or exceed the safety standards expressed or implied herein.

104.2 Existing industrial safety regulations pertaining to work areas, safety devices, and safe work practices are not intended to be supplanted by these rules.

104.3 It is not intended that these rules be applied retroactively to existing installations insofar as design, fabrication, installation, established operating pressure, and testing are concerned. It is intended, however, that the provisions of these rules shall be applicable to the operation, maintenance, and up-rating of existing installations.

104.4 Compliance with these rules is not intended to relieve a utility from any statutory requirements.

104.5 The establishment of these rules shall not impose upon utilities, and they shall not be subject to any civil liability for damages, which liability would not exist at law if these rules had not been adopted.

105 PRECEDENCE

105.1 These rules shall take precedence over all orders, general or special, heretofore made by the Commission, insofar as said orders may be inconsistent with these rules.

105.2 These rules shall take precedence over all rules filed or to be filed by gas utilities insofar as inconsistent therewith. Rules of utilities now on file and inconsistent with the rules herein established shall be properly revised and refiled within sixty days from the effective date of this order.

106 MODIFICATION

106.1 If hardship results from application of any rule herein prescribed because of special facts, application may be made to the Commission to deviate from the General Order. Each request for deviation shall be accompanied by a full and complete justification for such requested deviation, together with a proposed alternate rule which will be applicable to the conditions requiring the deviation.

107 COMPLIANCE WITH ASA CODE

107.1 Gas transmission and distribution facilities shall be constructed and operated in compliance with the provisions of Section 8 of the American Standard Code for Pressure Piping, known as the American Standard Code for Gas Transmission and Distribution Piping Systems, ASA B 31.8 - 1958, and in compliance with the further requirements of the additional rules herein prescribed.

107.2 Where there is any conflict between the provisions of ASA B 31.8 - 1958 and any rule specifically set forth herein, the latter shall govern, and ASA B 31.8 - 1958 shall be deemed to have been modified, amended, or revised to comply with the provisions of Chapter II of this Order.

107.3 For the purpose of complying with the rules herein adopted and prescribed, gas companies shall be governed by the provisions of ASA B 31.8 - 1958 and any other codes, standards or specifications contained therein, insofar as any such codes are herein made applicable, which were in effect on January 1, 1959, and shall not be governed by any deletions, additions, revisions, or amendments thereof, made after said date, unless and until said deletions, additions, revisions, and amendments have been authorized by the Commission.

107.4 Anything contained in ASA B 31.8 - 1958 to the contrary notwithstanding, there shall be no deviation from this General Order except after authorization by the Commission.

805 UNITS AND DEFINITIONS

201 DEFINITIONS

201.1 COMMISSION shall mean the Public Utilities Commission of the State of California.

201.2 UTILITY shall mean any person, firm or corporation engaged as a public utility in transmitting natural gas, hydrocarbon gas, or any mixture of gases for domestic, commercial, industrial or other purposes.

805.01 INDEX OF DEFINITIONS

805.1 Pressure Terms.

Pressure unless otherwise stated is expressed in pounds per square inch above atmospheric pressure, i.e., gauge pressure. (Abbreviation—psig)

805.11 *Design pressure* is the maximum operating pressure permitted by this code, as determined by the design procedures applicable to the materials and locations involved.

805.12 *Maximum allowable test pressure* is the maximum internal fluid pressure permitted by this code for testing for the materials and locations involved.

805.13 *Maximum actual operating pressure* is the maximum operating pressure existing in a piping system during a normal annual operating cycle.

805.14 *Maximum allowable operating pressure* is the maximum pressure at which a gas system may be operated in accordance with the provisions of this code.

805.15 *Standard service pressure* is the gas pressure which a utility undertakes to maintain on its domestic customers' meters. This is sometimes called the normal utilization pressure.

805.2 Pressure Control.

805.21 *Overpressure protection* is provided by a device or equipment installed for the purpose of preventing the pressure in a pressure vessel, a pipeline or distribution system from exceeding a predetermined value. This protection may be obtained by installing a pressure relief station or a pressure limiting station.

805.211 *Pressure relief station* consists of equipment installed to vent gas from a system being protected in order to prevent the gas pressure from exceeding a predetermined limit. The gas may be vented into the atmosphere or into a lower pressure system capable of safely absorbing the gas being discharged. Included in the stations are piping and auxiliary devices, such as valves, control instruments, control lines, the enclosure and ventilating equipment installed in accordance with the pertinent requirements of this code.

805.212 *Pressure limiting station* consists of equipment which under abnormal conditions will act to reduce, restrict or shut off the supply of gas flowing into a system in order to prevent the gas pressure from exceeding a predetermined value. While normal pressure conditions prevail, the pressure limiting station may exercise some degree of control of the flow of the gas or may remain in the wide open position. Included in the station are piping and auxiliary devices such as valves, control instruments, control lines, the enclosure and ventilating equipment installed in accordance with the pertinent requirements of this code.

805.22 *Pressure regulating station* consists of equipment installed for the purpose of automatically reducing and regulating the pressure in the downstream pipeline or main to which it is connected. Included are piping and auxiliary devices such as valves, control instruments, control lines, the enclosure and ventilating equipment.

805.23 *Service regulator* is a regulator installed on a gas service to control the pressure of the gas delivered to the customer.

805.24 *Monitoring regulator* is a pressure regulator set in series with another pressure regulator for the purpose of automatically taking over in an emergency the control of the pressure downstream of the station in case that pressure tends to exceed a set maximum.

805.3 **Stress** is the resultant internal force that resists change in the size or shape of a body acted on by external forces. In this code "stress" is often used as being synonymous with unit stress which is the stress per unit area (psi).

805.31 *Operating stress* is the stress in a pipe or structural member under normal operating conditions.

805.32 *Hoop stress* is the stress in a pipe wall, acting circumferentially in a plane perpendicular to the longitudinal axis of the pipe and produced by the pressure of the fluid in the pipe.

805.33 *Maximum allowable hoop stress* is the maximum hoop stress permitted by this code for the design of a piping system. It depends upon the material used, the location of the pipe, and the operating conditions.

805.34 *Secondary stress* is stress created in the pipe wall by loads other than internal fluid pressure. For example, backfill loads, traffic loads, beam action in a span, loads at supports and at connections to the pipe.

805.35 *Nominal wall thickness* (t) is the wall thickness computed by the design equation in 841.1. Under this code pipe may be ordered to this computed wall thickness without adding an allowance to compensate for the underthickness tolerances permitted in approved specifications.

805.4 **Temperatures** are expressed in degrees Fahrenheit (°F) unless otherwise stated.

805.41 *Ambient temperature* is the temperature of the surrounding medium, usually used to refer to the temperature of the air in which a structure is situated or a device operates.

805.42 *Ground temperature* is the temperature of the earth at pipe depth.

805.43 *Cold-springing* where used in the code is the fabrication of piping to an actual length shorter than its nominal length; and forcing it into position, so that it is stressed in the erected condition; thus compensating partially for the effects produced by the expansion due to an increase in temperature. Cold spring factor is the ratio of the amount of cold spring provided, to the total computed temperature expansion.

805.5 Welding, Strength of Materials, and Metallurgical Terms.

805.51 *Welding Nomenclature.* Types of welds and names of welded joints are used herein according to their common usage as defined in the American Welding Society Publication "Standard Welding Terms and Their Definitions" (AWS A3.0), or as specifically defined as follows:

A. *Electric-Resistance-Welded Pipe:* Pipe produced in individual lengths, or in continuous lengths from coiled skelp and subsequently cut into individual lengths, having a longitudinal butt joint wherein coalescence is produced by the heat obtained from resistance of the pipe to the flow of electric current in a circuit of which the pipe is a part, and by the application of pressure.

Typical specifications: ASTM A 53
ASTM A 135
API 5L
API 5 LX

B. *Furnace Lap-Welded Pipe:* Pipe having a longitudinal lap joint made by the forge welding process wherein coalescence is produced by heating the preformed tube to welding temperature and passing it over a mandrel located between two welding rolls which compress and weld the overlapping edges.

Typical specifications: ASTM A 53
API 5L

C. *Furnace Butt-Welded Pipe:*

(1) *Bell-Welded:* Furnace-welded pipe produced in individual lengths from cut-length skelp, having its longitudinal butt joint forge welded by the mechanical pressure developed in drawing the furnace-heated skelp through a cone-shaped die (commonly known as a "welding bell") which serves as a combined forming and welding die.

Typical specifications: ASTM A 53
API 5L

(2) *Continuous-Welded:* Furnace-welded pipe produced in continuous lengths from coiled skelp and subsequently cut into individual lengths, having its longitudinal butt joint forge welded by the mechanical pressure developed in rolling the hot-formed skelp through a set of round pass welding rolls.

Typical specifications: ASTM A 53
API 5L

D. *Electric-Fusion-Welded Pipe:* Pipe having a longitudinal butt joint wherein coalescence is produced in the preformed tube by manual or automatic electric-arc welding. The weld may be single or double and may be made with or without the use of filler metal.

Typical specifications:

ASTM A 134, ASTM A 139 — Single or double weld is permitted with or without the use of filler metal

ASTM A 155—Requires both inside and outside welds and the use of filler metal

Spiral-welded pipe is also made by the electric-fusion-welded process with either a butt joint, a lap joint or a lock-seam joint.

Typical specifications:

ASTM A 134, ASTM A 139 — Butt joint

ASTM A 211—Butt joint or lap joint or lock-seam joint

E. *Electric-Flash-Welded Pipe:* Pipe having a longitudinal butt joint wherein coalescence is produced, simultaneously over the entire area of abutting surfaces, by the heat obtained from resistance to the flow of electric current between the two surfaces, and by the application of pressure after heating is substantially completed. Flashing and upsetting are accompanied by expulsion of metal from the joint.

Typical specifications: API 5L
API 5LX

F. *Double Submerged-Arc-Welded Pipe:* Pipe having a longitudinal butt joint produced by at least two passes, one of which is on the inside of the pipe. Coalescence is produced by heating with an electric arc or arcs between the bare metal electrode or electrodes and the work. The welding is shielded by a blanket of granular, fusible material on the work. Pressure is not used and filler metal for the inside and outside welds is obtained from the electrode or electrodes.

Typical specifications: ASTM A 381
API 5LX

805.52 *Yield strength* is the strength at which a material exhibits a specified limiting permanent set, or produces a specified total elongation under load. The specified limiting set or elongation is usually expressed as a percentage of gauge length, and its values are specified in the various material specifications acceptable under this code.

805.53 *Tensile strength* is the highest unit tensile stress (referred to the original cross-section) a material can sustain before failure (psi).

805.54 *Specified minimum yield strength* is the minimum yield strength prescribed by the specification under which pipe is purchased from the manufacturer (psi).

805.55 *Specified minimum tensile strength* is the minimum tensile strength prescribed by the specification under which pipe is purchased from the manufacturer (psi).

805.56 *Specified minimum elongation* is the minimum elongation (expressed in per cent of the gauge

length) in the tensile test specimen, prescribed by the specifications under which the material is purchased from the manufacturer.

805.57 *Alloy steel.*[1] By common custom steel is considered to be alloy steel when the maximum of the range given for the content of alloying elements exceeds one or more of the following limits:

manganese	1.65%
silicon	.60%
copper	.60%

or in which a definite range or a definite minimum quantity of any of the following elements is specified or required within the limits of the recognized field of constructional alloy steels:

aluminum	molybdenum
boron	nickel
chromium up to 3.99%	titanium
cobalt	tungsten
columbium	vanadium
zirconium	

or any other alloying element added to obtain a desired alloying effect.

805.58 *Carbon steel.*[2] By common custom steel is considered to be carbon steel when no minimum content is specified or required for aluminum, boron, chromium, cobalt, columbium, molybdenum, nickel, titanium, tungsten, vanadium or zirconium, or any other element added to obtain a desired alloying effect; when the specified minimum for copper does not exceed 0.40%; or when the maximum content specified for any of the following elements does not exceed the percentages noted: manganese 1.65, silicon 0.60, copper 0.60.

In all carbon steels small quantities of certain residual elements, unavoidably retained from raw materials, are sometimes found which are not specified or required, such as copper, nickel, molybdenum, chromium, etc. These elements are considered as incidental and are not normally determined or reported.

805.6 Pipe and Piping Terms.

805.61 *Pipe* is a tubular product made as a production item for sale as such. Cylinders formed from plate in the course of the fabrication of auxiliary equipment are not pipe as defined here.

805.62 *Pipeline or transmission line* is a pipe installed for the purpose of transmitting gas from a source or sources of supply to one or more distribution centers or to one or more large volume customers or a pipe installed to interconnect sources of supply. In typical cases pipelines differ from gas mains in that they operate at higher pressures, they are longer, and the distance between connections is greater.

805.63 *Gas main or distribution main* is a pipe installed in a community to convey gas to individual services or other mains.

805.64 *Gas service* is the pipe that runs between a main or a pipeline and a customer's meter.

805.65 *Low-pressure distribution system* is a gas distribution piping system in which the gas pressure in the mains and services is substantially the same as that delivered to the customer's appliances. In such a system a service regulator is not required on the individual services.

805.66 *High-pressure distribution system* is a gas distribution piping system which operates at a pressure higher than the standard service pressure delivered to the customer. In such a system a service regulator is required on each service to control the pressure delivered to the customer.

805.67 *Length* is a piece of pipe of the length delivered from the mill. Each piece is called a length regardless of its actual dimension. This is sometimes called "joint" but "length" is preferred.

805.68 *Cold expanded pipe* is seamless or welded pipe which is formed and then expanded in the pipe mill while cold so that the circumference is permanently increased by at least 0.50%.

805.69 *Gas storage line* is a pipeline used for conveying gas between a compressor station and a gas well used for storing gas underground.

805.691 *Instrument piping* is all piping, valves, and fittings used to connect instruments to main piping, to other instruments and apparatus, or to measuring equipment.

805.692 *Control piping* is all piping, valves, and fittings used to interconnect air, gas, or hydraulically operated control apparatus or instrument transmitters and receivers.

805.693 *Sample piping* is all piping, valves, and fittings used for the collection of samples of gas, steam, water, or oil.

805.7 Miscellaneous Terms.

[1] From Steel Products Manual, Section 7, American Iron and Steel Institute, January 1952, pp. 6 and 7.

[2] From Steel Products Manual, Section 6, American Iron and Steel Institute, August 1952, pp. 5 and 6.

805.71 *Private rights-of-way* as used in this code are rights-of-way that are not located on roads, streets or highways used by the public, or on railroad rights-of-way.

805.72 *Operating company* as used herein is the individual, partnership, corporation, public agency, or other entity that operates the gas transmission or distribution facilities.

805.73 *Proprietary items* are items made and marketed by a company having the exclusive right to manufacture and sell them.

805.74 *Location class* is a geographic area classified according to its approximate population density and its other characteristics that are considered when prescribing types of construction and methods of testing pipelines and mains to be located in the area.

805.75 *Construction type* is a construction specification for pipelines and mains that fixes the stress levels. (See Table 841.02)

805.76 *One mile population density index* is a number roughly proportional to population density, applicable to a specific 1 mile length of pipeline or main and used in some cases to determine design and/or test requirements. See 841.001.

805.77 *Ten mile population density index* is a number roughly proportional to population density, applicable to a specific 10 mile length of pipeline or main and used in some cases to determine design and/or test requirements. See 841.001.

805.78 *Gas* as used in this code is any gas or mixture of gases suitable for domestic or industrial fuel and transmitted or distributed to the user through a piping system. The common types are natural gas, manufactured gas, and liquefied petroleum gas distributed as a vapor with or without the admixture of air.

805.8 Miscellaneous Facilities.

805.81 *Customer's meter* is a meter which measures gas delivered to a customer for consumption on his premises.

805.82 *Service shut-off* is a valve or cock readily accessible and operable by the customer, located in a service pipe between the gas main and the meter.

805.821 *Curb shut-off* is a buried valve or cock installed in a service pipe at or near the property line and accessible through a valve box and cover and operable by a removable key.

805.83 *Pipe container* is a gas-tight structure assembled in a shop or in the field from pipe and end closures.

805.84 *Pipe-type holder* is any pipe-container or group of interconnected pipe-containers installed at one location, and used for the sole purpose of storing gas.

805.85 *Bottle* as used in this code is a gas-tight structure completely fabricated from pipe with integral drawn, forged, or spun end closures and tested in the manufacturer's plant.

805.86 *Bottle-type holder* is any bottle or group of interconnected bottles installed in one location, and used for the sole purpose of storing gas.

805.87 *Stop valve* is a valve installed for the purpose of stopping the flow of fluid in a pipe.

805.88 *Hot taps* are branch piping connections made to operating pipelines or mains or other facilities while they are in operation. The connection of the branch piping to the operating line and the tapping of the operating line is done while it is under gas pressure.

805.9 Leakage Investigation Terms.

805.91 *Leakage surveys* are systematic surveys made for the purpose of locating leaks in a gas piping system. Three types of surveys are referred to in this code and defined below. The significant difference between the three is the manner in which the presence of a leak is first detected. They all involve verification of the presence of a leak and its location, as for example, by the driving or boring of test holes in the vicinity of the leak and testing the atmosphere in these holes with a combustible gas detector or other suitable device.

805.92 *Vegetation surveys* are leakage surveys made for the purpose of finding leaks in underground gas piping by observing vegetation.

805.93 *Gas detector surveys* are leakage surveys made by testing with a combustible gas detector the atmosphere in water meter boxes, street vaults of all types, cracks in pavements and other available locations where access to the soil under pavement is provided.

805.94 *Bar test surveys* are leakage surveys made by driving or boring holes at regular intervals along the route of an underground gas pipe and testing the atmosphere in the holes with a combustible gas detector or other suitable device.

806 STANDARDS AND SPECIFICATIONS.

806.1 Standards and specifications specifically incorporated by reference into this code and the names and addresses of the sponsoring organizations are shown in Appendixes A and B. It is not considered practicable to refer to a specific edition of each of the standards and specifications in the individual code paragraphs. Instead, the specific edition references are included in Appendixes A and B which will be revised at short intervals as needed.

806.2 Use of Standards and Specifications Incorporated by Reference.

Some standards and specifications cited in Appendices A and B are supplemented by specific requirements elsewhere in this code. Users of this code are advised against attempting direct application of any of these standards without carefully observing the code's reference to that standard.

807 STANDARD DIMENSIONS. Adherence to American Standard dimensions is strongly recommended wherever practicable. However, paragraphs or notations specifying these and other dimensional standards in this code shall not be mandatory, provided that other designs of at least equal strength and tightness and capable of withstanding the same test requirements are substituted.

CHAPTER I

MATERIALS AND EQUIPMENT

810 MATERIALS AND EQUIPMENT.

810.1 It is intended that all materials and equipment that will become a permanent part of any piping system constructed under this code shall be suitable and safe for the conditions under which they are used. All such materials and equipment shall be qualified for the conditions of their use by compliance with certain specifications, standards, and special requirements of this code or otherwise as provided herein.

811 QUALIFICATION OF MATERIALS AND EQUIPMENT.

811.1 Materials and equipment fall into five categories insofar as methods of qualification for use under this code are concerned:

(a) Items which conform to standards or specifications listed in this code.

(b) Items that are important from a safety standpoint, of a type for which standards or specifications are listed in this code, but the specific item in question does not conform to a listed standard. Example: Pipe manufactured to a specification not listed in the code.

(c) Items of a type for which standards or specifications are listed in this code but which do not conform to the standards and are relatively unimportant from a safety standpoint because of their small size or because of the conditions under which they are to be used.

(d) Items of a type for which no standard or specification is listed in this code: Example: Gas compressor.

(e) Unidentified or used pipe.

811.2 Prescribed procedures for qualifying each of these five categories are given in the following paragraphs:

811.21 Items which conform to standards or specifications listed in this code (811.1[a]) may be used for appropriate applications, as prescribed and limited by this code, without further qualification.

811.22 Important items of a type for which standards or specifications are listed in this code, such as pipe, valves and flanges, but which do not conform to standards or specifications listed in this code (811.1 (b)), shall be qualified as described in 811.221 or 811.222.

811.221 By petitioning the Code Committee for approval. If possible, the material shall be identified with a comparable material, and it should be stated that the material will comply with that specification except as noted. Complete information as to chemical composition and physical properties shall be supplied to the Code Committee, and their approval shall be obtained before this material may be used.

811.222 Materials conforming to specifications which do not vary materially from a listed specification and which meet the minimum requirements of this code with respect to quality of materials and workmanship may be used. This paragraph shall not be construed to permit deviations which would tend to adversely affect weldability or ductility. If the deviations tend to reduce strength, full allowance for the reduction shall be provided for in the design.

811.23 Relatively unimportant items which do not conform to listed standards or specifications (811.1[c]) may be used provided that:

(a) They are tested or investigated and found suitable for the proposed service, and

(b) They are used at unit stresses not greater than 50% of those allowed by this code for comparable materials, and

(c) Their use is not specifically prohibited by the code.

811.24 Items of a type for which no standards or specifications are listed in this code (811.1 (d)) may be qualified by the user by investigation and tests (if needed) that demonstrate that the item of material or equipment is suitable and safe for the proposed service, and provided further that the item is recommended for that service from the standpoint of safety, by the manufacturer. Examples: Gas compressors, pressure relief devices.

811.25 Reuse of pipe in existing line. Removal of a portion of an operating line, and reuse of the pipe in

the same line, or in a line operating at the same, or lower pressure, is permitted, subject only to the restrictions of paragraphs A, F and I in 811.27.

811.26 Used pipe, unidentified new pipe, and pipe purchased under Specification ASTM A 120 may be used for low-stress level service (hoop stress less than 6,000 psi) where no close coiling or bending is to be done, provided careful visual examination indicates that it is in good condition, free from split seams or other defects that would cause leakage, and provided further that, if the pipe is to be welded and is of unknown specification or ASTM Specification A 120, it shall satisfactorily pass weldability tests prescribed in 811.27 E.

811.27 Used pipe, unidentified new pipe, and pipe purchased under Specification ASTM A 120 may be qualified for use at stress levels above 6,000 psi or for service involving close coiling or bending by the procedures and within the limits outlined in the table below.

The letters in the table refer to the corresponding paragraphs following:

	New or Used Pipe Unknown or ASTM A-120 Specification	Used Pipe Known Specification (ASTM A-120 excluded)
Inspection	A	A
Bending Properties	B	
Thickness	C	C
Joint Efficiency	D	D
Weldability	E	
Defects	F	F
Yield Strength	G	
S Value (841.1)	H	
Test	I	I

A. *Inspection.* All pipe shall be cleaned inside and outside, if necessary, to permit good inspection, and shall be visually inspected to insure that it is reasonably round and straight, and to discover any defects which might impair its strength or tightness.

B. *Bending Properties.* For pipe 2 inches and under in nominal diameter, a sufficient length of pipe shall be bent cold through 90 deg around a cylindrical mandrel, the diameter of which is twelve times the nominal diameter of the pipe, without developing cracks at any portion and without opening the weld.

For pipe larger than 2 inches in diameter, flattening tests as prescribed in ASTM A 53 shall be made. The pipe shall meet the requirements in this test except that the number of tests required to determine flattening properties shall be the same as required in Paragraph G below to determine yield strength. See Appendix G.

C. *Determination of Wall Thickness.* Unless the nominal wall thickness is known with certainty, it shall be determined by measuring the thickness at quarter points on one end of each piece of pipe. If the lot of pipe is known to be of uniform grade, size and nominal thickness measurement shall be made on not less than 10% of the individual lengths, but not less than 10 lengths; thickness of the other lengths may be verified by applying a gage set to the minimum thickness. Following such measurement, the nominal wall thickness shall be taken as the next commercial wall thickness below the average of all the measurements taken, but in no case greater than 1.14 times the least measured thickness for all pipe under 20-inches OD, and no greater than 1.11 times the least measured thickness for all pipe 20-inches OD and larger.

D. *Joint Efficiency.* If the type of longitudinal joint can be determined with certainty, the corresponding Longitudinal Joint Factor "E" (Table 841.12) may be used. Otherwise, the factor "E" shall be taken as 0.60 for pipe 4 inches and smaller, or 0.80 for pipe over 4 inches.

E. *Weldability* shall be determined as follows: A qualified welder shall make a girth weld in the pipe. The weld shall then be tested in accordance with requirements of API Standard 1104. The qualifying weld shall be made under the most severe conditions under which welding will be permitted in the field and using the same procedure as to be used in the field. The pipe shall be considered weldable if the requirements set forth in API Standard 1104 are met. At least one such test weld shall be made for each 100 lengths of pipe in sizes over 4 inches in diameter. On sizes 4 inches and under one test will be required for each 400 lengths of pipe. If, in testing the weld, the requirements of API Standard 1104 cannot be met, the weldability may be established by making chemical tests for carbon and manganese, (see 824.23), and proceeding in accordance with the provisions of ASA B31.1—1955, Section 6, Chapter IV. The number of chemical tests shall be the same as required for circumferential weld tests, stated above.

F. *Surface Defects.* All pipe shall be examined for gouges, grooves and dents, and shall be qualified in accordance with the provisions of 841.24.

G. *Determination of Yield Strength.* When the manufacturer's specified minimum yield strength, tensile strength or elongation for the pipe is unknown, and no physical tests are made, the minimum yield strength for purposes of design shall be taken as not more than 24,000 psi. Alternately, the tensile properties may be established as follows:

Perform all tensile tests prescribed by API Standard

5LX, except that the number of such tests shall be as follows:

Number of Tensile Tests—All Sizes

Lot of	
10 lengths or less	1 Set of tests from each length
11 to 100 lengths	1 Set of tests for each 5 lengths, but not less than 10
Over 100 lengths	1 Set of tests for each 10 lengths, but not less than 20

All test specimens shall be selected at random.

If the yield-tensile ratio exceeds .85, the pipe shall not be used except as provided in 811.26.

H. *S Value.* For pipe of unknown specification, the yield strength, to be used as S in the formula of 841.1, in lieu of the specified minimum yield strength shall be 24,000 psi, or determined as follows:

Determine the average value of all yield strength tests for a uniform lot. The value of S shall then be taken as the lesser of the following:

(1) 80% of the average value of the yield strength tests.

(2) The minimum value of any yield strength test, provided, however, that in no case shall S be taken as greater than 52,000 psi.

I. *Hydrostatic Test.* New or used pipe of unknown specification and all used pipe the strength of which is impaired by corrosion or other deterioration, shall be re-tested hydrostatically either length by length in a mill type test or in the field after installation before being placed in service, and the test pressure used shall establish the maximum allowable operating pressure subject to limitations described in 841.14 (a) and (b).

812 MARKING.

812.1 All valves, fittings, flanges, bolting, pipe and tubing, shall be marked in accordance with the marking sections of the standards and specifications to which reference is made in this code, or in accordance with the requirements of MSS SP-25, Standard Marking System for Valves, Fittings, Flanges and Unions of the Manufacturers Standardization Society of the Valve and Fittings Industry.

812.2 Die stamping, if used, shall be done with dies having blunt or rounded edges to minimize stress concentrations.

813 MATERIAL SPECIFICATIONS.

813.1 Standard specifications for various materials are listed in Appendices A and B.

813.2 Cold expanded pipe shall meet the mandatory requirements of API Standard 5LX.

814 MATERIALS FOR USE IN COLD CLIMATES. Some of the materials conforming to specifications approved for use under this code may not have properties suitable for the lower portion of the temperature band covered by this code. Engineers are cautioned to give attention to the low-temperature properties of the materials used for facilities to be exposed to unusually low ground temperatures or low atmospheric temperatures.

815 EQUIPMENT SPECIFICATIONS. Except for the piping components and structural materials listed in Appendices A and B, it is not intended to include in this code complete specifications for equipment. However, certain details of design and fabrication necessarily refer to equipment such as pipe hangers, vibration dampeners, electrical facilities, engines, compressors, etc. Partial specifications for such equipment items are given herein, particularly if they affect the safety of the piping system in which they are to be installed. In other cases where the code gives no specifications for the particular equipment item, the intent is that the safety provisions of the code shall govern insofar as they are applicable, and in any case the safety of equipment installed in a piping system shall be commensurate with that of other parts of the same system.

CHAPTER II

WELDING

820 WELDING.

821 GENERAL.

821.1 This chapter concerns the arc and gas welding of pipe joints in both wrought and cast steel materials, and more specifically covers butt joints in pipe, valves, flanges and fittings, and fillet welded joints in pipe branches, slip-on flanges, socket weld fittings, etc., as applied in pipelines and connections to apparatus or equipment. When valves or equipment are furnished with welding ends suitable for welding directly into a pipeline, the design, composition, welding, and stress relief procedures must be such that no significant damage will be likely to result from the welding or stress relieving operation. This chapter does not apply to the welding of longitudinal joints in the manufacture of pipe.

821.2 These standards apply to manual shielded metal arc and gas welding, automatic submerged arc welding, and are recommended for other manual and automatic welding where applicable.

202.1 821.3 Each utility shall establish and qualify a welding procedure for sound and ductile welds. In applying these standards, the welder is required to qualify under the procedure employed. These standards establish the groupings of materials that can be welded under a procedure which has been qualified with any one of the materials included in the group. The changes in material, filler metal, process or procedure that require requalification of either welding procedure or welder are set out in 824.21 (a), (b), and (c).

821.4 The standards of quality for pipelines and mains to operate at 20% or more of the specified minimum yield strength are established under Section 829, "Standards of Acceptability" and the methods of nondestructive and destructive examination are set out.

821.5 All the welding done under the standards of this code shall be performed under a specification which at least embodies the requirements of this code. Example of such specification is API Standard 1104, "A Standard for Field Welding of Pipe Lines."

821.6 **Welding Terms.** Definitions pertaining to welding as used in this code conform to the standard definitions established by the American Welding Society and contained in AWS publication, "Standard Welding Terms and Their Definitions" --AWS A 3.0.

822 TYPES OF WELDS.

822.1 **Butt Welds.** Butt joints may be of the single Vee, double Vee, or other suitable type of groove. Joint designs shown in Figure 823-A or applicable combinations of these joint design details are recommended. See Figure 823-B for acceptable preparation for butt welding of pieces of unequal thickness.

822.2 **Fillet Welds.** Fillet welds may be concave to slightly convex. The size of a fillet weld is stated as the leg length of the largest inscribed right isosceles triangle as shown in Figure 823-C.

822.3 **Seal Welds.** Seal welding shall be done by qualified welders. Seal welding of threaded joints is permitted but the seal welds shall not be considered as contributing to the strength of joints.

823 PREPARATION FOR WELDING.

823.1 **Butt Welds.**

(a) The welding surfaces shall be clean, and free of material that may be detrimental to the weld.

(b) ***Welding Groove Details.*** End preparation as given in Figure 823-A represents present acceptable practice.

(c) *Pipe Alignment.* The ends of pipe to pipe, or pipe to fitting joints shall be aligned as accurately as practicable giving consideration to existing commercial tolerances on pipe diameters, pipe wall thickness and out of roundness. Alignment shall provide the most favorable condition for the deposition of the root bead and shall be preserved during welding of the root bead.

(d) Root opening of the joint shall be as given in the Procedure Specification employed.

823.2 **Fillet Welds.** Minimum dimensions for fillet welds used in the attachment of slip-on flanges, for socket welded joints, are shown in Figure 823-C. Similar minimum dimensions for fillet welds used in branch connections are shown in Figures 831-B and 831-C.

824 QUALIFICATION OF PROCEDURES AND WELDERS.

207 WELDER QUALIFICATION.

824.1 Requirements for Qualification of Procedures and Welders on Piping Systems Operating at Hoop Stresses of Less Than 20% of the Specified Minimum Yield Strength.

824.11 Welders whose work is limited to the application of the oxy-acetylene or manual arc welding processes on piping operating at hoop stresses of less than 20% of the specified minimum yield strength, shall be qualified under any of the references given in 824.21 or in accordance with Appendix F of this code.

824.2 Requirements for Qualification of Procedures and Welders on Pipelines to Operate at Hoop Stresses of 20% or more of the Specified Minimum Yield Strength.

824.21 Welding procedures and welders performing work under this classification must be qualified under one of the following standards:

(a) ASA B31.1-1955, Code for Pressure Piping, Section 6, Chapter IV.

(b) ASME Boiler and Pressure Vessel Code, Section IX.

(c) API Standard 1104, "Standard for Field Welding of Pipe Lines."

824.22 When welders qualified under API Standard 1104 are employed on compressor station piping, their qualifying test shall have been based upon the guided bend test.

824.23 *Variables Requiring Separate Qualification of Welding Procedures and Welders.* The references given in 824.21 (a), (b) and (c) contain sections entitled "Essential Variables" applicable to welding procedures and also to welders. These shall be followed except that for the purposes of this code all carbon steels which have a carbon content not exceeding 0.32% by ladle analysis, and a carbon equivalent (C + 1/4 Mn) not exceeding 0.65% by ladle analysis, are considered to come under material grouping P1. Alloy steels having weldability characteristics demonstrated to be similar to these carbon steels shall be welded, pre-heated and stress relieved as prescribed herein for such carbon steels. Other alloy steels shall be welded, pre-heated, and stress relieved as prescribed in ASA B31.1 - 1955, Section 6, Chapter IV.

824.24 *Welder Requalification Requirements.* Welder requalification tests shall be required if there is some specific reason to questiona welder's ability or the welder is not engaged in a given process of welding (i.e., arc or gas) for a period of six months or more.

207.1 No welder shall be used on pipelines or mains that operate or are intended to be operated at hoop stresses of 20% or more of the specified minimum yield strength, unless qualified within the preceding year.

824.25 *Qualification Records.* Records of the tests that establish the qualification of a welding procedure shall be maintained as long as that procedure is in use. The operating company or contractor shall, during the construction involved, maintain a record of the welders qualified showing the date and results of tests.

825 WELDING PROCEDURE - GENERAL.

825.1 The welding procedure followed during the qualifying tests shall be recorded in detail, and shall be adhered to during subsequent construction.

825.2 Welding shall not be done when the quality of the completed weld would be likely to be impaired by the prevailing weather conditions including, but not limited to, airborne moisture, blowing sand, or high wind. Wind shields may be used when practicable.

826 PREHEATING.

202.1 826.1 Carbon steels having a carbon content in excess of 0.32% (ladle analysis) or a carbon equivalent (C + 1/4 Mn) in excess of 0.65% (ladle analysis) shall be preheated as prescribed in ASA B31.1 - 1955, Section 6, Chapter IV. Preheating also is required for steels having lower carbon or carbon equivalent, when conditions exist that either limit the welding technique that can be used, or that tend to adversely affect the quality of the weld.

826.2 When welding dissimilar materials having different preheating requirements, the material requiring the higher preheat shall govern.

826.3 Preheating may be accomplished by any suitable method, provided that it is uniform and that the temperature does not fall below the prescribed minimum during the actual welding operations.

826.4 The preheating temperature shall be checked by the use of temperature indicating crayons, thermocouple pyrometers or other suitable method to assure that the required preheat temperature is obtained prior to and maintained during the welding operation.

827 STRESS RELIEVING.

202.1 827.1 Carbon steels having a carbon content in excess of 0.32% (ladle analysis) or a carbon equivalent (C+ 1/4 Mn) in excess of 0.65% ladle analysis) shall be stress relieved as prescribed in ASA B31.1 - 1955, Section 6, Chapter IV. Stress relieving also is required for steels having lower carbon or carbon equivalent when adverse conditions exist which too rapidly cool the weld.

827.2 Welds in all carbon steels shall be stress relieved when the wall thickness exceeds 1 1/4 inches.

827.3 When the welded joint connects parts that are of different thicknesses but of similar materials, the thickness to be used in applying the rules in 827.1 and 827.2 shall be:

(a) The thicker of the two pipes joined.

(b) The thickness of the pipe run or header in case of branch connections, slip-on flanges or socket weld fittings.

827.4 In welds between dissimilar materials, if either material requires stress relieving, the joint shall require stress relieving.

827.5 All welding of connections and attachments shall be stress relieved when the pipe is required to be stress relieved by the rules of 827.3 with the following exceptions:

(a) Fillet and groove welds not over 1/2 inch in size (leg) that attach connections not over 2 inch pipe size.

(b) Fillet and groove welds not over 3/8 inch in groove size which attach supporting members or other non-pressure attachments.

827.6 **Stress Relieving Temperature.**

(a) Stress relieving shall be performed at a temperature of 1100 F or over for carbon steels, and 1200 F or over for ferritic alloy steels. The exact temperature range shall be stated in the procedure specification.

(b) When stress relieving a joint between dissimilar metals having different stress relieving requirements, the material requiring the higher stress temperature shall govern.

(c) The parts heated shall be brought slowly to the required temperature and held at that temperature for a period of time proportioned on the basis of at least 1 hour per inch of pipe wall thickness, but in no case less than 1/2 hour, and shall be allowed to cool slowly and uniformly.

827.7 **Methods of Stress Relieving.**

(a) Heating the complete structure as a unit.

(b) Heating a complete section containing the weld or welds to be stress relieved before attachment to other sections of work.

(c) Heating a part of the work by heating slowly a circumferential band containing the weld at the center. The width of the band which is heated to the required temperature shall be at least 2 inches greater than the width of the weld reinforcement. Care should be used to obtain a uniform temperature around the entire circumference of the pipe. The temperature shall diminish gradually outward from the ends of this band.

(d) Branches, or other welded attachments for which stress relief is required, may be locally stress relieved by heating a circumferential band around the pipe on which the branch or attachment is welded with the attachment at the middle of the band. The width of the band shall be at least 2 inches greater than the diameter of the weld joining the branch or attachment to the header. The entire band shall be brought up to the required temperature and held for the time specified.

827.8 **Equipment for Local Stress Relieving.**

(a) Stress relieving may be accomplished by: electric induction, electric resistance, fuel-fired ring burners, fuel - fired torch or other suitable

means of heating provided that a uniform temperature is obtained and maintained during the stress relieving.

(b) The stress relieving temperature shall be checked by the use of thermocouple pyrometers or other suitable equipment to be assured that the proper stress relieving cycle has been accomplished.

828 WELDING INSPECTION AND TESTS.

206 WELD INSPECTION.

202.1, 828.1 **Inspection of Welds on Piping Systems Intended to Operate at Less Than 20% of the Specified Minimum Yield Strength.** The quality of welding shall be checked visually on a sampling basis, and if there is any reason to believe that the weld is defective, it shall be removed from the line and tested in accordance with the specification or it may be subject to a non-destructive test as out-lined in 828.2.

828.2 **Inspection and Tests of Welds on Piping Systems Intended to Operate at 20% or More of the Specified Minimum Yield Strength.**

206.1 On pipelines or mains operating or intended to be operated at hoop stresses of 20% or more of the specified minimum yield strength, the quality of welding shall be checked by non-destructive testing including visual inspection or by destructive testing to determine that the welds conform to the standards of acceptability of this order.

The extent of weld inspection shall be sufficient to establish that the performance of each welder is sampled. The following minimum inspections shall be made:

100% of welds at tie-ins
100% of welds at river, highway and railroad crossings.
100% of welds at taps to pipeline.
100% of welds which contain repaired areas.
30% of welds in Class 3 and Class 4 locations.
20% of welds in Class 1 and Class 2 locations.

A record shall be made of the results of the tests and the method employed.

(a) Non-destructive testing may consist of radiographic examination, magnetic particle testing, or other acceptable methods. The trepanning method of non-destructive testing is prohibited.

(b) When radiographic examination if employed, the procedure set forth in API Standard 1104 (Standard for Field Welding of Pipe Lines) shall be followed.

(c) Completed welds which have been removed for inspection shall, to be acceptable, successfully meet the testing requirements outlined under the welder qualification procedure, and in addition, shall meet the standards of acceptability contained in 829.

829 STANDARDS OF ACCEPTABILITY OF WELDS ON PIPELINES INTENDED TO OPERATE AT 20% OR MORE OF THE SPECIFIED MINIMUM YIELD STRENGTH.

829.1 **Inadequate Penetration and Incomplete Fusion.** Any individual inadequate penetration or incomplete fusion shall not exceed 1 inch in length. In any 12-inch length of weld, the total length of inadequate penetration or incomplete fusion shall not exceed 1 inch. The total length of the inadequate penetration or incomplete fusion in any two succeeding 12-inch lengths shall not exceed 2 inches and individual defects shall be separated by at least 6 inches of sound weld metal.

829.2 **Burn - Through Areas.** Any individual burn-through area shall not exceed 1/2 inch in length. In any 12 - inch length of weld, the total length of burn-through area shall not exceed 1 inch. The total length of burn-through area in any two succeeding 12-inch lengths shall not exceed 2 inches, and individual defects shall be separated by at least 6 inches of sound weld metal.

829.3 **Elongated Slag Inclusions.** Any elongated slag inclusion shall not exceed 2 inches in length or 1/16 inch in width. In any 12 - inch length of weld, the total length of elongated slag inclusions shall not exceed 2 inches. The total length of elongated slag inclusions in any two succeeding 12 - inch lengths, shall not exceed 4 inches, and individual defects shall be separated by at least 6 inches of sound weld metal. Parallel slag lines shall be considered as individual defects if they are wider than 1/32 inch.

829.4 **Isolated Slag Inclusions.** The maximum width of any isolated slag inclusion shall not exceed 1/8 inch. In any 12-inch length of weld, the total length of isolated slag inclusions shall not exceed 1/2 inch, nor shall there be more than four isolated slag inclusions of the maximum width of 1/8 inch in this length. Any two such inclusions shall be separated by 2 inches of sound

metal. In any 24-inch length of weld, the total weld length of isolated slag inclusions shall not exceed 1 inch.

829.5 Gas Pockets. The maximum dimensions of any individual gas pocket shall not exceed 1/16 inch. Maximum distribution of gas pockets shall not exceed that shown in Figs. 7 and 8 of API Standard 1104, 5th Ed., 1958.

829.6 Cracks. No welds containing cracks, regardless of size or location shall be acceptable until such welds have been repaired in conformance with 829.9.

829.7 Accumulation of Discontinuities. Any accumulation of discontinuities having a total length of more than 2 inches in a weld length of 12 inches is unacceptable. Any accumulation of discontinuities which total more than 10% of the weld length of a joint is unacceptable.

829.8 Undercutting. Undercutting adjacent to the cover bead on the outside of the pipe shall not exceed 1/32 inch in depth and 2 inches in length. Undercutting adjacent to the root bead on the inside of the pipe shall not exceed 2 inches in length.

202.1 **829.9 Repair of Defects.**

(a) Except as provided in (g) below, defective welds shall be repaired or removed from the pipeline at the request of the company representative. The company may authorize repairs of defects in the root and filler beads, but any weld that shows evidence of repair work having been done without authorization by the company may be rejected.

(b) Minor cracks in the surface and filler beads may be repaired when so authorized by the company, but any crack penetrating the root bead or the second bead shall be cause for complete rejection of the weld. The entire weld shall then be cut from the pipe line and replaced. Minor cracks shall be defined as cracks visible in the surface bead and not over 2 inches in length.

(c) Before repairs are made, injurious defects shall be removed by chipping, grinding, or oxygen gouging to clean metal. All slag and scale shall be removed by wire brushing.

(d) It is required that all such areas be preheated before the repair weld is started.

(e) Repaired areas shall be carefully inspected and radiographed when considered necessary.

(f) No further repairs shall be allowed in repaired areas.

(g) Repairs may be made to pin holes and undercuts in the final bead without authorization, but must meet with the approval of the company.

CHAPTER III
PIPING SYSTEM COMPONENTS AND FABRICATION DETAILS

830 PIPING SYSTEM COMPONENTS AND FABRICATION DETAILS.

830.1 General.

The purpose of this chapter is to provide a set of standards for piping systems covering:

(1) Specifications for, and selection of, all items and accessories entering into the piping system, other than the pipe itself.

(2) Acceptable methods of making branch connections.

(3) Provisions to be made to care for the effects of temperature changes.

(4) Approved methods for support and anchorage of piping systems, both exposed and buried.

This chapter does not include:

(a) Pipe materials (see Chapter I).

(b) Welding procedures (see Chapter II).

(c) Design of pipe (see Chapter IV).

(d) Installation and testing of piping systems (see Chapter IV).

831 PIPING SYSTEM COMPONENTS.

All components of piping systems, including valves, flanges, fittings, headers, special assemblies, etc., shall be designed to withstand operating pressures, and other specified loadings, with unit stresses not in excess of those permitted for comparable material in pipe in the same location and type of service. Components shall be selected that are designed to withstand the field test pressure to which they will be subjected, without failure or leakage, and without impairment of their serviceability.

831.1 Valves.

831.11 Valves shall be used only in accordance with the service recommendation of the manufacturer. Valves shall conform to American Standards governing minimum wall thickness, materials and dimensions, and may be used in accordance with pressure-temperature ratings contained in the following standards:

ASA B16.5 —Steel Pipe Flanges and Flanged Fittings
API 6D —Specification for Steel Gate, Plug, and and Check Valves for Pipeline Service
MSS SP-44 —Steel Pipe Line Flanges
MSS SP-52 —Cast Iron Pipe Line Valves
ASA B16.24—Brass or Bronze Flanges and Flanged Fittings.

831.12 Screw-end valves shall be threaded according to the American Standard for Pipe Threads (ASA B2.1) or API Specification for Line Pipe (5L) or API Specification for Threads in Valves, Fittings and Flanges (6A).

831.13 Pressure-reducing devices shall conform to the requirements of this code for valves in comparable service conditions.

831.2 Flanges.

831.21 *Flange Types and Facings.*

(a) The dimensions and drilling for all line or end flanges shall conform to the following standards:

ASA B16 Series—(For Iron and Steel)
MSS SP-44 —Steel Pipe Line Flanges
Appendix H —Light-Weight Steel Flanges
ASA B16.24 —Brass or Bronze Flanges and Flanged Fittings.

Flanges cast or forged integral with pipe, fittings or valves will be permitted in sizes and for the maximum service rating covered by the Standards listed above, subject to the facing, bolting and gasketing requirements of this paragraph and 831.22 and 831.23.

(b) Screwed companion flanges which comply with the B16 group of ASA Standards will be permitted in sizes and for maximum service ratings covered by these standards.

(c) Lapped flanges will be permitted in sizes and pressure standards established in the American Standard ASA B16.5.

(d) Slip-on welding flanges will be permitted in sizes and pressure standards established in American Standard ASA B16.5 and MSS SP-44. Slip-on flanges of rectangular section may be substituted for hubbed slip-on flanges provided the thickness is increased as required to produce equivalent strength as determined by calculations made in accordance with Section VIII, Unfired Pressure Vessels, of the ASME Boiler and Pressure Vessel Code.

(e) Welding neck flanges will be permitted in sizes and pressure standards established in American Standard ASA B16.5 and MSS SP-44. The bore of the flange should correspond to the inside diameter of the pipe used. For permissible welding end treatment see Fig. 823-B.

(f) Cast iron and steel flanges shall have contact faces finished in accordance with MSS Standard Finishes for Contact Faces of Connecting-End Flanges of Ferrous Valves and Fittings, SP-6.

(g) Nonferrous flanges shall have contact faces finished in accordance with American Standard ASA B16.24.

(h) 25 psi and Class 125 cast-iron integral or screwed companion flanges may be used with a full face gasket or with a flat ring gasket extending to the inner edge of the bolt holes. When using a full-face gasket, the bolting may be of heat-treated carbon steel (ASTM A-261), or alloy steel (ASTM A-193). When using a ring gasket, the bolting shall be of carbon steel equivalent to ASTM A-307, Grade B without heat treatment other than stress relief.

(i) When bolting together two Class 250 integral or screwed companion cast-iron flanges, having $\frac{1}{16}$-inch raised faces, the bolting shall be of carbon steel equivalent to ASTM A-307 Grade B, without heat treatment other than stress relief.

(j) 150 psi steel flanges may be bolted to Class 125 cast-iron flanges. When such construction is used, the $\frac{1}{16}$-inch raised face on the steel flange shall be removed. When bolting such flanges together using a flat ring gasket extending to the inner edge of the bolt holes, the bolting shall be of carbon steel equivalent to ASTM A-307 Grade B, without heat treatment other than stress relief. When bolting such flanges together using a full face gasket, the bolting may be heat treated carbon steel (ASTM A-261) or alloy steel (ASTM A-193).

(k) 300 psi steel flanges may be bolted to Class 250 cast-iron flanges. Where such construction is used, the bolting shall be of carbon steel, equivalent to ASTM A-307 Grade B, without heat treatment other than stress relief. Good practice indicates that the raised face on the steel flange should be removed, but also in this case, bolting shall be of carbon-steel equivalent to ASTM A-307 Grade B.

831.22 *Bolting.*

(a) Bolts or bolt studs shall extend completely through the nuts. American Standard ASA B1.1 for Screw Threads, Coarse Thread Series shall govern bolt and nut threads for carbon steel bolting per ASTM A-307 Grade B, and American Standard ASA B1.4 for Screw Threads for High-Strength Bolting shall govern bolt, boltstud and nut threads for carbon steel bolting per ASTM A-261 and ASTM A-325 and alloy steel bolting per ASTM A-193 and ASTM A-354. Bolt heads shall conform to the regular square head or heavy hexagon dimensions and nuts shall conform to the heavy hexagon dimensions of American Standard for Wrench-Head Bolts and Nuts (ASA B18.2). For all flange joints where pressure exceeds 300 psi and temperatures are in excess of ordinary atmospheric temperature, alloy steel bolting material equivalent to ASTM A-193 and ASTM A-354 is recommended, but high strength carbon steel bolting material per ASTM A-261 and ASTM A-325 may be used. Carbon steel bolting per ASTM A-307 Grade B may be used for pressures 300 pounds or lower where the temperature does not exceed 450 F. Alloy steel bolting material (ASTM A-193 and ASTM A-354) shall be used for insulating flanges, and for flanged piping in compressor stations, where flanges require a rating exceeding 300 pounds according to ASA B16.5 Nuts shall be in accordance with ASTM Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure and High Temperature Service, ASTM A-194. Nuts cut from bar stock in such a manner that their axis will be parallel to the direction of rolling of the bar may be used in all sizes for joints in which one or both flanges are cast iron and for joints with steel flanges where the pressure does not exceed 250 psi; they shall not be used for joints in which both flanges are steel and the pressure exceeds 250 psi, except for nut sizes ½ inch and smaller, which are permissible in any case.

(b) ⅛ inch undersize bolting may be used on insulating flanges provided that alloy steel bolting material (ASTM A-193 and ASTM A-354) is used.

831.23 *Gaskets.*

(a) Material for gaskets shall be capable of withstanding the maximum pressure and of maintaining its physical and chemical properties, at any temperature to which it might reasonably be subjected in service.

(b) Gaskets used under pressure and at temperatures above 250 F shall be of non-combustible ma-

terial. Metallic gaskets shall not be used with 150 lb standard or lighter flanges.

(c) Asbestos composition gaskets may be used as permitted in the American Standard for Steel Pipe Flanges and Flanged Fittings (ASA B16.5). This type of gasket may be used with any of the various flange facings except small male and female, or small tongue and groove.

(d) The use of metal or metal-jacketed asbestos gaskets (either plain or corrugated) is not limited as to pressure provided that the gasket material is suitable for the service temperature. These types of gaskets are recommended for use with the small male and female or the small tongue and groove facings. They may also be used with steel flanges with any of the following facings: lapped, large male and female, large tongue and groove, or raised face.

(e) Full-face gaskets shall be used with all bronze flanges, and may be used with 25 psi or Class 125 cast iron flanges. Flat ring gaskets with an outside diameter extending to the inside of the bolt holes may be used with cast iron flanges, with raised face steel flanges, or with lapped steel flanges.

(f) In order to secure higher unit compression on the gasket, metallic gaskets of a width less than the full male face of the flange may be used with raised face, lapped or large male and female facings. Width of gasket for small male and female or for tongue and groove joints shall be equal to the width of the male face or tongue.

(g) Rings for ring joints shall be of dimensions established in ASA B16.20. The material for these rings shall be suitable for the service conditions encountered and shall be softer than the flanges.

(h) The insulating material shall be suitable for the temperature, moisture and other conditions where it will be used.

831.3 Fittings Other Than Valves and Flanges.

831.31 *Standard Fittings.*

(a) The minimum metal thickness of flanged or screwed fittings shall not be less than specified for the pressures and temperatures in the applicable American Standards or the MSS Standard Practice.

(b) Steel butt-welding fittings (not flanged) shall comply with the American Standard for Steel Butt-Welding Fittings (ASA B16.9) and shall have pressure and temperature ratings based on stresses for pipe of the same or equivalent material. To insure adequacy of fitting design, the actual bursting strength of fittings shall at least equal the computed bursting strength of pipe of the designated material and wall thickness. Mill hydrostatic testing of factory made steel butt-welding fittings is not required, but all such fittings shall be capable of withstanding a field test pressure equal to the test pressure established by the manufacturer, without failure or leakage, and without impairment of their serviceability.

(c) Steel socket-welding fittings shall comply with American Standard for Steel Socket-Welding Fittings (ASA B16.11).

831.32 *Special Fittings.* When special cast, forged, wrought, or welded fittings are required to dimensions differing from those of regular shapes specified in the applicable ASA and MSS Standards, the provisions of 807 shall apply.

831.33 *Branch Connections.*

(a) Welded branch connections on steel pipe must meet the design requirements of 831.4 and 831.5.

(b) Threaded taps in cast iron pipe are permitted, without reinforcement, to a size not more than 25% of the nominal diameter of the pipe, except that 1¼ inch taps are permitted in 4 inch pipe. Larger taps shall be covered by a reinforcing sleeve.

(c) Mechanical fittings may be used for making hot taps on pipelines and mains; provided they are designed for the operating pressure of the pipeline or main, and are suitable for the purpose.

831.34 *Special Components Fabricated by Welding.*

(a) This section covers piping system components other than assemblies consisting of standard pipe and fittings joined by circumferential welds.

(b) All welding shall be performed using procedures and operators that are qualified in accordance with the requirements of 824.

(c) Branch connections shall meet the design requirements of 831.4 and 831.5.

(d) The design of other components shall be in accordance with recognized engineering practice and applicable requirements of this code. When the strength of such components cannot be computed or determined with reasonable accuracy under the provisions of this code, the allowable working pressure shall be established as prescribed by Par. UG-101, Section VIII, ASME Boiler and Pressure Vessel Code.

(e) Prefabricated units, other than regularly manufactured butt-welding fittings, which employ plate and longitudinal seams as contrasted with pipe that has been produced and tested under one of the specifications listed in this code, shall be designed, constructed and tested under requirements of the ASME Boiler and Pressure Vessel Code. It is not intended to apply ASME Code requirements to such partial assemblies as split rings or collars or other field welded details.

(f) Orange-peel bull plugs and orange-peel swages are prohibited on systems operating at stress levels of

20% or more of the specified minimum yield strength of the pipe material. Fish tails and flat closures are permitted for 3 inch diameter pipe and smaller, operating at less than 100 psi. Fish tails on pipe larger than 3 inch diameter are prohibited. Flat closures larger than 3 inch diameter shall be designed according to Section VIII, Unfired Pressure Vessels, of the ASME Boiler and Pressure Vessel Code.

(g) Every prefabricated unit produced under this section of the code shall successfully withstand a pressure test without failure, leakage, distress or distortion other than elastic distortion, at a pressure equal to the test pressure of the system in which it is installed, either before installation or during the system test. When such units are to be installed in existing systems, they shall be pressure tested before installation, if feasible; otherwise, they shall withstand a leak test at the operating pressure of the line.

831.4 Reinforcement of Welded Branch Connections.

831.41 *General Requirements.* All welded branch connections shall meet the following requirements:

(a) When branch connections are made to pipe in the form of a single connection or in a header or manifold as a series of connections, the design must be adequate to control the stress levels in the pipe within safe limits. The construction shall take cognizance of the stresses in the remaining pipe wall due to the opening in the pipe or header, the shear stresses produced by the pressure acting on the area of the branch opening, and any external loadings due to thermal movement, weight, vibration, etc. The following paragraphs provide design rules for the usual combinations of the above loads, except excessive external loads.

(b) The reinforcement required in the crotch section of a welded branch connection shall be determined by the rule that the metal area available for reinforcement shall be equal to or greater than the required area as defined in this paragraph and in Figure 831-A in the Appendix.

(c) The required cross-sectional area A_R is defined as the product of d times t:

$$A_R = d \times t$$

where, d = the length of the finished opening in the header wall measured parallel to the axis of the run.

t = the nominal header wall thickness required by Section 841.1 of this code for the design pressure and temperature.

When the pipe wall thickness includes an allowance for corrosion or erosion, all dimensions used shall be those that will result after the anticipated corrosion or erosion has taken place.

(d) The area available for reinforcement shall be the sum of:

(1) The cross sectional area resulting from any excess thickness available in the header thickness (over the minimum required for the header as defined in 831.41 [c] above) and which lies within the reinforcement area as defined in 831.41 (e) below.

(2) The cross-sectional area resulting from any excess thickness available in the branch wall thickness over the minimum thickness required for the branch and which lies within the reinforcement area as defined in 831.41 (e) below.

(3) The cross-sectional area of all added reinforcing metal including weld metal, which is welded to the header wall and lies within the reinforcement area as defined in 831.41 (e) below.

(e) The area of reinforcement is shown in Figure 831-A in the Appendix and is defined as a rectangle whose length shall extend a distance "d" on each side of the transverse centerline of the finished opening and whose width shall extend a distance of 2½ times the header wall thickness on each side of the surface of the header wall, except that in no case shall it extend more than 2½ times the thickness of the branch wall from the outside surface of the header or of the reinforcement, if any.

(f) The material of any added reinforcement shall have an allowable working stress at least equal to that of the header wall, except that material of lower allowable stress may be used if the area is increased in direct ratio of the allowable stresses for header and reinforcement material respectively.

(g) The material used for ring or saddle reinforcement may be of specifications differing from those of the pipe, provided the cross-sectional area is made in correct proportion to the relative strength of the pipe and reinforcement materials at the operating temperatures and provided it has welding qualities comparable to those of the pipe. No credit shall be taken for the additional strength of material having a higher strength than that of the part to be reinforced.

(h) When rings or saddles are used which cover the weld between branch and header, a vent hole shall be provided in the ring or saddle to reveal leakage in the weld between branch and header and to provide venting during welding and heat treating operations. Vent holes should be plugged during service to prevent crevice corrosion between pipe and reinforcing member, but no plugging material should be used that would be capable of sustaining pressure within the crevice.

(i) The use of ribs or gussets shall not be considered as contributing to reinforcement of the branch connection. This does not prohibit the use of ribs or

gussets for purposes other than reinforcement, such as stiffening.

(j) The branch shall be attached by a weld for the full thickness of the branch or header wall plus a fillet weld "W_1," as shown in Figures 831-B and 831-C in the Appendix. The use of concave fillet welds is to be preferred to further minimize corner stress concentration. Ring or saddle reinforcement (Figure 831-C) shall be attached as shown by the figure. When a full fillet is not used it is recommended that the edge of the reinforcement be relieved or chamfered at approximately 45° to merge with the edge of the fillet.

(k) Reinforcement rings and saddles shall be accurately fitted to the parts to which they are attached. Figures 831-C and 831-D illustrate some acceptable forms of reinforcement.

(l) Branch connections attached at an angle less than 85° to the run become progressively weaker as the angle becomes less. Any such design must be given individual study and sufficient reinforcement must be provided to compensate for the inherent weakness of such construction. The use of encircling ribs to support the flat or re-entering surfaces is permissible, and may be included in the strength calculations. The designer is cautioned that stress concentrations near the ends of partial ribs, straps or gussets may defeat their reinforcing value.

831.42 *Special Requirements.* In addition to the requirements of 831.41, branch connections must meet the special requirements given in the following Table 831.421.

A. Smoothly contoured wrought steel tees of proven design are preferred. When tees cannot be used, the reinforcing member shall extend around the circumference of the header. Pads, partial saddles, or other types of localized reinforcement are prohibited.

B. Smoothly contoured tees of proven design are preferred. When tees are not used, the reinforcing member should be of the complete encirclement type but may be of the pad type, saddle type, or a welding outlet fitting.

TABLE 831.421

Reinforcement of Welded Branch Connections Special Requirements

Ratio of Design Hoop Stress to Minimum Specified Yield Strength in the Header	Ratio of Nominal Branch Diameter to Nominal Header Diameter		
	Less than 25%	25 to 50%	50% and more
Less than 20%	G	G	H
20 to 50 %	I D	I	I H
50% and more	C D E	B E	A E F

C. The reinforcement member may be of the complete encirclement type, pad type, saddle type, or welding outlet fitting type. The edges of reinforcement members should be tapered to the header thickness. It is recommended that legs of fillet welds joining the reinforcing member and header do not exceed the thickness of the header.

D. Reinforcement calculations are not required for openings 2 inch and smaller in diameter; however, care should be taken to provide suitable protection against vibrations and other external forces to which these small openings are frequently subjected.

E. All welds joining the header, branch and reinforcing member shall be equivalent to those shown in Figures 831-B and 831-C.

F. The inside edges of the finished opening shall, whenever possible, be rounded to a $\frac{1}{8}$ inch radius. If the encircling member is thicker than the header and is welded to the header, the ends shall be tapered down to the header thickness and continuous fillet welds made.

G. Reinforcement of openings is not mandatory, however, reinforcement may be required for special cases involving pressures over 100 psi, thin wall pipe or severe external loads.

H. If a reinforcement member is required, and the branch diameter is such that a localized type of reinforcement member would extend around more than half the circumference of the header, then a complete encirclement type of reinforcement member shall be used, regardless of the design hoop stress; or a smoothly contoured wrought steel tee of proven design may be used.

I. The reinforcement may be of any type meeting the requirements of 831.41.

831.5 Reinforcement of Multiple Openings.

831.51 When two or more adjacent branches are spaced at less than two times their average diameter (so that their effective areas of reinforcement overlap) the group of openings shall be reinforced in accordance with 831.4. The reinforcing metal shall be added as a combined reinforcement, the strength of which shall equal the combined strengths of the reinforcements that would be required for the separate openings. In no case shall any portion of a cross-section be considered to apply to more than one opening, or be evaluated more than once in a combined area.

831.52 When more than two adjacent openings are to be provided with a combined reinforcement, the minimum distance between centers of any two of these openings shall preferably be at least 1½ times their average diameter, and the area of reinforcement between them shall be at least equal to 50% of the total required for these two openings on the cross-section being considered.

831.53 When two adjacent openings as considered under 831.52 have the distance between centers less than 1⅓ times their average diameter, no credit for reinforcement shall be given for any of the metal between these two openings.

831.54 Any number of closely spaced adjacent openings, in any arrangement may be reinforced as if the group were treated as one assumed opening of a diameter enclosing all such openings.

832 EXPANSION AND FLEXIBILITY.

832.1 This section is applicable to above ground piping only and covers all classes of materials permitted by this code up to temperatures no greater than 450 F.

832.2 Amount of Expansion. The thermal expansion of the more common materials used for piping shall be determined from Table 832.21. The expansion to be considered is the difference between the expansion for the maximum expected operating temperature and that for the expected average erection temperature. For materials not included in this table, or for precise calculations, reference shall be made to authoritative source data, such as publications of the National Bureau of Standards.

TABLE 832.21

Thermal Expansion of Piping Materials
Carbon and Low Alloy
High Tensile Steel
and Wrought Iron

Temperature Degree F	Total expansion in inches per 100 feet above 32 F
32	0.
60	0.2
100	0.5
125	0.7
150	0.9
175	1.1
200	1.3
225	1.5
250	1.7
300	2.2
350	2.6
400	3.0
450	3.5

832.3 Flexibility Requirements.

832.31 Piping systems shall be designed to have sufficient flexibility to prevent thermal expansion or contraction from causing excessive stresses in the piping material, excessive bending or unsual loads at joints, or undesirable forces or moments at points of connection to equipment or at anchorage or guide points. Formal calculations shall be required only where reasonable doubt exists as to the adequate flexibility of the system.

832.32 Flexibility shall be provided by the use of bends, loops, or offsets; or provision shall be made to absorb thermal changes by the use of expansion joints or couplings of the slip joint type or expansion joints of the bellows type. If expansion joints are used, anchors or ties of sufficient strength and rigidity shall be installed to provide for end forces due to fluid pressure and other causes.

832.33 In calculating the flexibility of a piping system the system shall be treated as a whole. The significance of all parts of the line and all restraints, such as solid supports or guides, shall be considered.

832.34 Calculations shall take into account stress intensification factors found to exist in components other than plain straight pipe. Credit may be taken for the extra flexibility of such components. In the absence of more directly applicable data, the flexibility factors and stress intensification factors shown in Table 1, Appendix D may be used.

832.35 Properties of pipe and fittings for these calculations shall be based on nominal dimensions, and the joint Factor E (841.12) shall be taken as 1.00.

832.36 The total range in temperature shall be used in all expansion calculations, whether piping is cold-sprung or not. In addition to the expansion of the line itself, the linear and angular movements of the equipment to which it is attached shall be considered.

832.37 *Cold-springing.* In order to modify the effect of expansion and contraction, runs of pipe may be cold sprung. Cold spring may be taken into account in the calculations of the reactions as shown in 833.5 provided an effective method of obtaining the designed cold spring is specified and used.

832.38 Flexibility calculations shall be based on the modulus of elasticity E_c at ambient temperature.

833 COMBINED STRESS CALCULATIONS.

833.1 Using the above assumptions, the stresses and reactions due to expansion shall be investigated at all significant points.

833.2 The expansion stresses shall be combined in accordance with the following formula:

$$S_E = \sqrt{S_b^2 + 4S_t^2}$$

Where:

$S_b = i M_b/Z$ = Resultant bending stress, psi.
$S_t = M_t/2Z$ = Torsional stress, psi
M_b = Resultant bending moment, lb in.
M_t = Torsional moment, lb in.
Z = Section modulus of pipe, in.^{3}
i = Stress intensification factor.

833.3 The maximum computed expansion stress range, S_E, shall not exceed $0.72S$, where S is the specified minimum yield strength, psi; subject to the further limitation of 833.4.

833.4 The total of the following shall not exceed the specified minimum yield strength, S:

(a) The combined stress due to expansion, S_E
(b) The longitudinal pressure stress
(c) The longitudinal bending stress due to external loads, such as weight of pipe and contents, wind, etc.

The sum of (b) and (c) shall not exceed 75% of the allowable stress in the hot condition ($S \times F \times T$, Section 841.1).

833.5 The reactions R' shall be obtained as follows from the reactions R derived from the flexibility calculations:

$R' = (1 - \frac{2}{3} C_s R)$ When C_s is less than 0.6
$R' = C_s R$, When C_s is between 0.6 and 1.0

Where:

C_s = The cold spring factor varying from zero for no cold spring to one for 100 percent cold spring.
R = Range of reactions corresponding to the full expansion range based on E_c.
E_c = The modulus of elasticity in the cold condition.

R' is maximum reaction for the line after cold-springing. The reactions so computed shall not exceed limits which the attached equipment or anchorage is designed to sustain.

834 SUPPORTS AND ANCHORAGE FOR EXPOSED PIPING.

834.1 General. Piping and equipment shall be supported in a substantial and workmanlike manner, so as to prevent or damp out excessive vibration, and shall be anchored sufficiently to prevent undue strains on connected equipment.

834.2 Provision for Expansion. Supports, hangers and anchors should be so installed as not to interfere with the free expansion and contraction of the piping between anchors. Suitable spring hangers, sway bracing, etc., shall be provided where necessary.

834.3 Materials, Design and Installation. All permanent hangers, supports, and anchors shall be fabricated from durable incombustible materials, and designed and installed in accordance with the good engineering practice for the service conditions involved. All parts of the supporting equipment shall be designed and installed so that they will not be disengaged by movement of the supported piping.

834.4 Forces on Pipe Joints.

(a) All exposed pipe joints shall be able to sustain the maximum end force due to the internal pressure, i.e., the design pressure (psi) times the internal area of the pipe (sq in.); as well as any additional forces due to temperature expansion or contraction, or to the weight of pipe and contents.

(b) If compression or sleeve-type couplings are used in exposed piping, provision shall be made to sustain the longitudinal forces noted in 834.4 (a). If such provision is not made in the manufacture of the coupling, suitable bracing or strapping shall be provided; but such design must not interfere with the normal performance of the coupling nor with its proper maintenance. Attachments must meet the requirements of 834.5.

834.5 Attachment of Supports or Anchors.

(a) If the pipe is designed to operate at a hoop stress of less than 50% of the specified minimum yield strength, structural supports or anchors may be welded directly to the pipe. Proportioning and welding strength requirements of such attachments shall conform to standard structural practice.

(b) If the pipe is designed to operate at a hoop stress of 50% or more of the specified minimum yield strength, support of the pipe shall be furnished by a member which completely encircles it. Where it is necessary to provide positive attachment, as at an anchor, the pipe may be welded to the encircling member only; the support shall be attached to the encircling member, and not to the pipe. The connection of the

pipe to the encircling member shall be by continuous, rather than intermittent, welds.

835 ANCHORAGE FOR BURIED PIPING.

835.1 General. Bends or offsets in buried pipe cause longitudinal forces, which must be resisted by anchorage at the bend, by restraint due to friction of the soil, or by longitudinal stresses in the pipe.

835.2 Anchorage at Bends. If the pipe is anchored by bearing at the bend, care shall be taken to distribute the load on the soil so that the bearing pressure is within safe limits for the soil involved.

835.3 Restraint Due to Soil Friction. Where there is doubt as to the adequacy of anchorage by soil friction, calculations should be made.

835.4 Forces on Pipe Joints. If anchorage is not provided at the bend (835.2), pipe joints which are close to the points of thrust origin shall be designed to sustain the longitudinal pullout force. If such provision is not made in the manufacture of the joint, suitable bracing or strapping shall be provided, unless calculations show the joint to be safe.

835.5 Supports for Buried Piping. In pipelines, especially those which are highly stressed from internal pressure, uniform and adequate support of the pipe in the trench is essential. Unequal settlements may produce added bending stresses in the pipe. Lateral thrusts at branch connections may greatly increase the stresses in the branch connection itself, unless the fill is thoroughly consolidated or other provisions made to resist the thrust.

835.51 When openings are made in a consolidated backfill to connect new branches to an existing line, care must be taken to provide firm foundation for both the header and the branch, to prevent both vertical and lateral movements.

835.6 Interconnection of Underground Lines. Underground lines are subjected to longitudinal stresses due to changes in pressure and temperature. For long lines, the friction of the earth will prevent changes in length from these stresses, except for several hundred feet adjacent to bends or ends. At these locations the movement, if unrestrained, may be of considerable magnitude. If connections are made at such a location to a relatively unyielding line, or other fixed object, it is essential that the interconnection shall have ample flexibility to care for possible movement, or that the line shall be provided with an anchor sufficient to develop the forces necessary to limit the movement.

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 Indexes.*

(a) Two population density indexes, 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 indexes 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 indexes for the pipeline.

(c) To determine the ten-mile density indexes for any given ten-mile length of pipeline, proceed as follows: Add the one-mile density indexes 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.

210 **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.

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 [2] 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 con-

[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.

[2] 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.

struction 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.

210.1 The provisions of ASA B 31.8-1958 specifying standards of construction for pipelines in Class 3 and Class 4 locations shall be applicable to construction inside the incorporated areas of municipalities regardless of any provisions of said ASA B31.8-1958 permitting lower standards for pipelines within incorporated areas depending upon the concentration of development therein.

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 location 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. Location 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 roads 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 and Class 2 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 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 location 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 Class	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 Arc Welded	.80
ASTM A135	Electric Resistance Welded	1.00
ASTM A139	Electric Fusion Welded	.80
ASTM A155	Electric Fusion Arc Welded	1.00
ASTM A381	Double Submerged-Arc-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

Note.—Definitions for the various classes of welded pipe are given in Paragraph 805.51.

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.

(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.

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	
⅛″	Threaded or Plain End	0.068	0.068	0.095	Threaded or Plain End
¼″		0.088	0.088	0.119	
⅜″		0.091	0.091	0.126	
½″		0.109	0.109	0.147	
¾″		0.113	0.113	0.154	
1″		0.133	0.133	0.179	
1¼″		0.140	0.140	0.191	
1½″		0.145	0.145	0.200	
2″		0.154	0.154	0.218	
2½″	Plain End Only	0.103	*0.125	0.203	Plain End Only
3″		0.104	*0.125	0.216	
3½″		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: 2½″ to 0.203, 3″ to 0.216, 3½″ 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.

841.142 *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 crossing, the pipelines and mains shall be reasonably protected by distance or barricades from accidental damage by vehicular traffic or other causes.

203 COVER REQUIREMENTS

203.1 Buried pipelines and mains operating or intended to be operated at hoop stresses of 20% or more of the specified minimum yield strength shall be installed with a minimum cover of 30" in Class 3 and Class 4 locations.

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 water 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 water 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 recommended 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.**

202.1 841.21 *Construction Specifications.* All construction work performed on piping systems in accordance with the requirements of this code shall be done under construction specifications. The construction specifications shall cover all phases of the work and shall 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.

202.1 841.222 The installation inspection provisions for pipelines and other facilities to operate at hoop stresses of 20% or more of the specified minimum yield strength shall be adequate either to make possible the following inspections at sufficiently frequent invervals or to do other things that will assure good 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.

202.1 841.23 *Bends, Elbows, and Miters in Steel Pipelines and Mains.* Changes in direction shall 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.

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

205 PIPE BENDS

205.1 Pipe bends shall not be made within 1-1/2 pipe diameters of a circumferential weld on piping systems that operate or are intended to be operated at hoop stresses of 20% or more of the specified minimum yield strength.

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).

204 MITER JOINTS AND WRINKLE BENDS

204.1 Mitered joints at an angle greater than 3°, and wrinkle bends shall not be permitted on pipelines or mains operating or intended to be operated at hoop stresses of 20% or more of the specified minimum yield strength.

841.234 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

204.1 841.236 Mitered bends are permitted subject to the following limitations:

(a) Mitered joints at an angle greater than 3°, and wrinkle bends shall not be permitted on pipelines or mains operating or intended to be operated at hoop stresses of 20% or more of the specified minimum yield strength.

(b) In systems intended to operate at 10% but less than 20% 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.

202.1 841.241 *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 required.

(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 shall 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 Electrical test leads may be attached directly on to the pipe by the thermite welding process using aluminum powder and copper oxide provided the charge is limited to #15 (15 gram) cartridges and the size of electrical conductor restricted to #6 AWG or smaller. Where the application involves the attachment of a larger wire, use a multi-strand conductor and rearrange the strands into groups no larger that #6 AWG and attach each group to the pipe separately, using a #15 (15 gram) cartridge of powder. Attaching electrical test leads directly onto the pipe by other methods of brazing 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.*

202.1 841.271 *Handling, Hauling and Stringing.* Care shall 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 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.

202.1 841.273 *Backfilling.*

(a) Backfilling shall 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 shall 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

[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.

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.

202.1 841.283 No welding or acetylene cutting shall 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.

202.1 841.284 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 required:

(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.

202.1 841.285 *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 shall 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 shall be introduced to prevent the formation of an explosive mixture of 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.

209 STRENGTH TESTING
(See 209.1, 11, 12, 13, 14, 15)

209.1 The requirements set forth in this section shall apply only to pipelines and mains operating or intended to be operated at hoop stresses of 20% or more of the specified minimum yield strength.

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.

209.15 At the tie-in connections where it is impractical to test for strength, all welds shall be inspected for quality at least equal to that of the strength tested portions of the pipeline.

841.4 TEST REQUIREMENTS.

209.1 841.411 All pipelines and mains to be operated at a hoop stress of 20% 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.

209.11 841.412 (a) Minimum test pressure in Class 1 and Class 2 locations shall be 1.25 times maximum operating pressure or 90% of the mill test pressure, whichever is the lesser. See 841.5.

209.11 841.412 (b) See 209.11 841.412 (a).

209.12 841.412 (c) Minimum test pressure in Class 3 and Class 4 locations shall be 1.50 times maximum operating pressure or 90% of the mill test pressure whichever is the lesser.

(The test requirements given in 209.11 841.412 (a) and (b) and 209.12 841.412 (b) above and permissible test fluid data are summarized in 209-Table 841.412 (d).)

209 - TABLE 841.412 (d)

Test Requirements for Pipelines and Mains to Operate at Hoop Stresses of 20% or More of the Specified Minimum Yield Strength of the Pipe

1	2	3	4	5
		Prescribed Test Pressure		Maximum Allowable Operating Pressure, the lesser of
Location Class	Permissible Test Fluid	Minimum	Maximum	
1	Water	1.25 x m.o.p. or 90%	None	t.p. ÷ 1.25 or
	Air	1.25 x m.o.p. of mill	1.1 x d.p.	
	Gas	1.25 x m.o.p. test press. whichever is the lesser	1.1 x d.p.	t.p. ÷ 1.125* or d.p.
2	Water	1.25 x m.o.p. or 90% of mill test press. whichever is the lesser	None	t.p. ÷ 1.25 or d.p.
	Air	1.25 x m.o.p.	1.25 x d.p.	
3	Water	1.50 x m.o.p. or 90% of mill test pressure whichever is the lesser	None	t.p. ÷ 1.50 or d.p.
4	Water	1.50 x m.o.p. or 90% of mill test pressure whichever is the lesser	None	t.p. ÷ 1.50 or d.p.

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

d.p. = design pressure
t.p. = test pressure

*Where test pressure depends on mill test pressure (see 209.11)

Note.--This table brings out the relationship 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.

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

(a) The ground temperature at pipe depth is 32F 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.

209.13 Where water is utilized as the test fluid, adequate provisions shall be made for disposal of the water and steps shall be taken to guard against contamination of local water supply.

209.14 Test pressure shall be maintained until the pressure has stabilized in all portions of the test sections. In no event shall the test at maximum pressure be less than one hour.

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 20% 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 20% 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 of 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 42.)
Table 842.142
(See Table on page 43.)

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 resilient 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.

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.

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 Laying Condition				5 FEET OF COVER Laying Condition				8 FEET OF COVER 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 Laying Condition				5 FEET OF COVER Laying Condition				8 FEET OF COVER 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 [illegible]

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 equipment and wiring installed in gas transmission and distribution compressor stations shall conform to the requirements of the National Electrical Code, ASA C1—1956, insofar as the equipment commercially available permits.

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 electrical 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 al-

lowable 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* (general provisions applicable to all gas piping).

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 after installation in accordance with the provisions of Paragraph 841.4 for pipe lines and mains in location Class 3, 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* (specific provisions applicable to fuel gas piping only).

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 ASA B 31.1 - 1955 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 tanks. 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 compressor 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 ASA B 31.1 - 1955 Code for Pressure Piping.

843.55 ***Water Piping.*** All water piping within gas compressing stations shall be constructed in accordance with Section 1 of ASA B 31.1 - 1955 Code for Pressure Piping.

843.56 ***Steam Piping.*** All steam piping within gas compressing stations shall be constructed in accordance with Section 1 of ASA B 31.1 - 1955 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 ASA B 31.1 - 1955 Code for Pressure Piping.

211 844 PIPE - TYPE AND BOTTLE - TYPE HOLDERS

211.1 Section 844 of the American Standard Code for Gas Transmission and Distribution Piping Systems (ASA B 31.8 - 1958) is herewith amended in its entirety to conform to General Order no. 94-A of the Commission.

845 CONTROL AND LIMITING OF GAS PRESSURE

845.1 Basic Requirement for Protection Against Accidental Overpressuring. 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. Special provisions for service regulators are set forth under paragraph 845.5.

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 include:

(a) Spring-loaded relief valves of types meeting the provisions of the ASME Unfired Pressure Vessel Code.

(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:

Class No. Location		Pressure
SEE 209.11 Page 38	1	Test Pressure* / 1.125 or Test Pressure / 1.25
	2	Test Pressure / 1.25
	3	Test Pressure[1] / 1.50
SEE 209.12 Page 38	4	Test Pressure[1] / 1.50

*Where Test Pressure Depends on Mill Test Pressure.

[1]Other factors than 1.5 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 be 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 condi-

tions, 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 include:

(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 845.53.

(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 include:

(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).

212 **845.43** *Maximum Allowable Operating Pressure for Low Pressure Distribution Systems.*

212.1 Section 845.43 of the American Standard Code for Gas Transmission and Distribution Piping Systems (ASA B 31.8 - 1958) is herewith amended in its entirety to conform to General Order No. 58-A of the Commission.

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, Small Commercial and Small Industrial Customers from High Pressure Distribution Systems.

Note: When the pressure of the gas and the demand by the customer are greater than that which is applicable under the provisions of 845.5, the requirements for control and limiting of the pressure of gas delivered 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 unsafe 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, to the maximum safe value, the pressure of 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 in no case shall 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 secondary 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, with the relief valve set to open so that the pressure of gas going to the customer shall not exceed 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. Where required to protect devices, the discharge stacks, or vents, shall be protected with rain caps to preclude the entry of water.

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. In-

struct 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 Stations.

845.71 Each pressure relief station or pressure limiting station or group of such stations installed to protect a piping system or pressure vessel 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 produces a hoop stress of 75% of the specified minimum yield strength, whichever is the lower, or in a low pressure distribution system, a pressure which would cause the unsafe operation of any connected and properly adjusted gas burning equipment.

845.72 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 equipment 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 846.33.

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 back-pressure 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

(1) The utilization equipment might induce a back-pressure.

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

(3) Liquefied petroleum gas or other supplementary gas is used as standby and might flow back into the meter. A threeway 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 into the main or to drips 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 831.1.

(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.

213, 847.13 *Location of Service Shut-offs.*

213.1 Section 847.13 of the American Standard Code for Gas Transmission and Distribution Piping Systems (ASA B 31.8 - 1958) is herewith amended in its entirety to conform to General Order No. 58-A of the Commission.

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.

(g) An underground copper service, 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) A copper service installed underground under buildings shall be encased in a conduit designed to prevent gas leaking from the service and getting into the building. When joints are used, they shall be of the brazed or soldered type in accordance with 847.44.

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.

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) Conections 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 mentioned 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

[1] See 847.12 and 847.13 for valves in services.

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. The box or enclosure shall be installed in a manner to avoid transmitting external loads to the main.

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) Vaults and pits shall be designed and constructed in accordance with good structural engineering practice to meet the loads which may be imposed upon them.

(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) Pipe 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—1956.

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.

202.1 850.4 **Essential Features of the Plan.** The plan prescribed in 850.3 (a) above shall include:

(a) Detailed plans and instructions to employees covering operating and maintenance procedures for gas facilities during normal operation 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

202.1 850.1 **Pipeline Patrolling.** Each operating company shall 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 shall be inspected with greater frequency and more closely than pipelines in open country.

202.1 851.2 **External Corrosion of Pipelines.** Periodic inspections and tests shall 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 shall be made to determine if protection is needed or if installed protection is adequate.

202.1 851.3 **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 shall 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 shall be carefully inspected for evidence of internal corrosion.

202.1 851.4 **Corrosion Records.** Records shall 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 shall be stated.

202.1 851.5 **Pipeline Leak Records.** Records shall be made covering all leaks discovered and repairs made. All pipeline breaks shall be reported in detail. These records along with leakage survey records, line patrol records and other records relating to routine or unusual inspections shall 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.

214 852.3 **Abandoning of Distribution Facilities.**

214.1 Section 852.3 of the American Standard Code for Gas Transmission and Distribution Piping Systems (ASA B 31.8 - 1958) is herewith amended in its entirety to conform to General Order No. 58-A of the Commission.

853 COMPRESSOR STATION MAINTENANCE

853.1 **Compressors and Prime Movers.** The starting, operating and shutdown 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 shutdown 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 replacement 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.

215 PROCEDURES FOR MAINTAINING PIPE-TYPE HOLDERS IN SAFE OPERATING CONDITION.

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

215.1, Section 854 of the American Standard Code for Gas Transmission and Distribution Piping Systems (ASA B 31.8 - 1958) is herewith amended in its entirety to conform to General Order No. 94-A of the Commission.

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

RECORDS

301 GENERAL

301.1 The responsibility for the maintenance of necessary records to establish that compliance with these rules has been accomplished rests with the utility. Such records shall be available for inspection at all times by the Commission or the Commission Staff.

302 SPECIFICATIONS

302.1 Specifications for material and equipment, installation, testing and fabrication shall be maintained by the utility.

303 OPERATING AND MAINTENANCE PROCEDURES

303.1 Plans covering operating and maintenance procedures, including maximum actual operating pressure to which the line is intended to be subjected, shall be maintained by the utility.

303.2 No pipeline shall be operated in excess of the maximum actual operating pressure recorded by the company in accordance with this section.

CHAPTER VII

REPORTS

401 GENERAL

401.1 In order that the Commission may be informed concerning the operation and status of the more important facilities of the utilities, the following information shall be filed with the Commission.

401.2 **Proposed Installation.** At least 30 days prior to the construction of a pipeline intended to be operated at hoop stresses of 20% or more of the specified minimum yield strength of the pipe used, a report shall be filed with the Commission setting forth the proposed route and general specifications for such pipeline. The specifications shall include but not be limited to the following items:

(a) Description and purpose of the proposed pipeline.

(b) Specifications covering the pipe selected for installation.

(c) Maximum allowable operating pressure for which the line is being constructed.

(d) Fluid and pressure to be used during prove strength testing.

401.3 **Reconstruction.** At least 30 days prior to major reconstruction of a pipeline operating or intended to be operated at hoop stresses of 20% or more of the specified minimum yield strength of the pipe used, a report shall be filed with the Commission setting forth the reasons for the general specifications covering such reconstruction. The specifications shall include but not be limited to the following items:

(a) Description and reason for the proposed reconstruction.

(b) Specifications covering the pipe selected for installation.

(c) Maximum allowable operating pressure for which the line is being constructed.

(d) Fluid and pressure to be used during prove strength testing.

401.4 **Change in Maximum Allowable Operating Pressure.** Not later than 30 days subsequent to an increase or decrease in the maximum allowable operating pressure of a pipeline, a report shall be filed with the Commission giving the new maximum allowable operating pressure, the reasons for such change, and, if increased, the steps taken to determine the capability of the pipeline to withstand such an increase.

402 PROCEDURE FOR KEEPING GENERAL ORDER UP TO DATE

402.1 For the purpose of keeping the provisions, rules, standards, and specifications of this general order up to date, the gas utilities subject to these rules, either individually or collectively, shall file annually on or before June 30, a report setting forth such recommended changes in rules, standards, or specifications as they deem necessary to keep this general order up to date in keeping with the purpose, scope, and intent thereof, or stating that no changes are deemed to be necessary. Gas utilities recommending changes shall, either collectively or otherwise, file appropriate formal applications seeking Commission approval for such changes. However, nothing herein shall preclude other interested parties from initiating appropriate formal proceedings to have the Commission consider any changes they deem appropriate, or the Commission from acting upon its own motion.

CHAPTER VIII

MISCELLANEOUS

860 MISCELLANEOUS

208 861 ODORIZATION.

208.1 All combustible gases transported by utility pipeline shall have a distinctive odor of sufficient intensity so that the presence of the gas may be detected down to the concentration in air of not over 1/5 the lower limit of combustibility. Whenever necessary to maintain this level of intensity, a suitable odorant shall be added in accordance with the following specifications:

208.2 Odorants in the concentrations used shall be:

Harmless to humans
Nontoxic
Noncorrosive to steel, iron, brass, copper and leather
Nonsoluble in water to an extent greater than 2.5 parts by weight of odorant to 100 parts by weight of water.

208.3 Odorizing equipment shall be:
Designed to maintain reasonably uniform level of odor in the gas.

208.4 Each utility shall make periodic checks to determine that a proper level of odorization is maintained throughout the pipeline system.

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 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) Bonding connections between the pipeline and either the steel tower footings or the buried ground facilities or the ground-wire 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.

[1] Refer to National Board of Fire Underwriters and the National Fire Protection Association Bulletins No. 58 Storage and Handling of Liquefied Gases and No. 59 -- Liquefied Petroleum Gases at Utility Gas Plants.

CHAPTER IX

APPENDIXES

APPENDIX A

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

ASTM SPECIFICATIONS

A 7—58T
A 42—55
A 47—52
A 48—56
A 53—58T
A 56—56T
A 72—56T
A 84—55
A 95—44 **
A 105—57T
A 106—55T
A 107—58T
A 120—57T
A 125—52
A 126—42
A 129—56
A 134—54
A 135—57T
A 139—58
A 141—58
A 155—56T
A 181—58T
A 182—58T
A 193—58T
A 194—58T
A 197—47
A 211—54
A 212—57T
A 216—57T
A 217—57T
A 225—56
A 234—58T
A 242—55
A 261—56
A 283—58
A 285—57T
A 307—58T
A 325—58T
A 354—58T
A 372—58
A 377—57
A 381—58
B 21—58
B 42—58
B 43—58
B 61—52
B 62—52
B 68—58
B 75—58
B 88—58
B 132—52
B 249—58T
B 251—58T

ASA Standards

A21.1—1957
A21.3—1953
A21.7—1953
A21.9—1953
A21.10—1952
A21.11—1953
B1.1—1949
Third Edition
B1.4—1945
B2.1—1945
B16.1—1948 (R 1953)***
B16b—1944 (R 1953)***
B16b1—1931 (R 1952)***
B16b2—1931 (R 1952)***
B16.3—1951 (R 1958)***
B16.4—1949 (R 1953)***
B16.5—1957
B16.9—1951
B16.11—1946 (R 1952)***
B16.18—1950
B16.19—1951 (R 1958)***
B16.20—1956
B16.24—1953
B16.25—1955
B18.2—1955
B31.1—1955
B36.10—1950
Cl—1956
Z21.30—1954

MSS Standard Practices

SP- 6—1958
SP-25—1958
SP-44—1955
SP-46—1955
SP-47—1956
SP-48—1956
SP-52—1957

API Standards

5A, 22nd Edn. 1958
5L, 17th Edn. 1958
5LX, 8th Edn. 1958
6A, 7th Edn. 1957
6D, 7th Edn. 1956
1102, 3rd Edn. 1957
1104, 5th Edn. 1958

ASME Code

ASME Boiler and Pressure Vessel Code, 1956 and 1956 and 1957 Addenda

AWWA Standards

C100—1955
C207—1955

AWS Standard

A3.0—1949

CIPRA Standards

Cast Iron Mechanical Joint Fittings

NBFU Publications ****

Standard No. 30—1958
Standard No. 58—1958
Standard No. 59—1958
Bulletin No. 294—1956

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

** Discontinued in 1956 (replaced by additions to A 216—56T). A 95—44 is included in this edition of Section 8 in order to validate existing stocks.

*** Indicates reaffirmation date.

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

Specifications and standards of the following organizations appear in the above list:

API — American Petroleum Institute
50 West 50th Street
New York 20, New York

ASA — American Standards Association
70 East 45th Street
New York 17, New York

ASME — American Society of Mechanical Engineers
29 West 39th Street
New York 18, New York

ASTM — American Society for Testing Materials
1916 Race Street
Philadelphia 3, Pennsylvania

AWS — American Welding Society
33 West 39th Street
New York 18, New York

AWWA — American Water Works Association
2 Park Avenue
New York 16, New York

MSS — Manufacturers Standardization Society of the Valve and Fittings Industry
420 Lexington Avenue
New York 17, New York

CIPRA — Cast Iron Pipe Research Association
Prudential Plaza
130 East Randolph Drive
Chicago, Illinois

NBFU — National Board of Fire Underwriters
85 John Street
New York 38, New York

NFPA — National Fire Protection Association
60 Batterymarch Street
Boston 10, Massachusetts

APPENDIX B

List of Material Specifications Incorporated in this Code by Reference (see Appendix A for dates)

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 (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 A21.10
ASA A21.11
AWWA C100
Steel pipe flanges . . . . . AWWA C207
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
Steel (heat-treated) for bolts and studs with suitable nuts and washers . . . . . ASTM A 325
Steel (quenched-and-tempered alloy) bolts and studs with suitable nuts . . . . . ASTM A 354

PIPE AND TUBING:

Brass (seamless) pipe . . . . . ASTM B 43
Carbon and alloy steel forgings for pressure vessel shells . . . . . ASTM A 372
Cast-iron pressure pipe . . . . . ASTM A 377
Cast-iron (centrifugally-cast) pipe . . . . . ASA A21.7
ASA A21.9
Cast-iron (pit-cast) pipe . . . . . ASA A21.3
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 (metal-arc-welded) pipe for high-pressure transmission service . . . . . ASTM A 381
Steel and iron (seamless and welded) line pipe . . . . . API 5L
Steel (seamless and welded) high-test line pipe . . . . . API 5LX
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 and iron pipe commonly used in piping systems. Note: This table is not complete. For the minimum specified yield strength of other grades and grades in other approved specifications, refer to the particular specification.

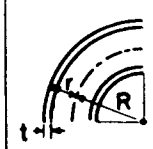
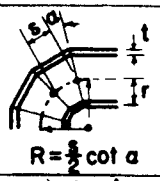
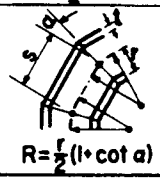
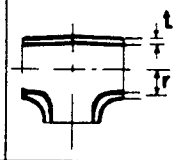
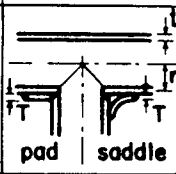
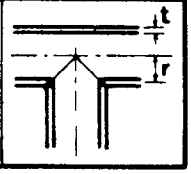
Specification	Specified Minimum Yield Strength (psi)
API 5L Grade A Seamless or Electric-welded	30,000
API 5L Grade B Seamless or Electric-welded	35,000
API 5L Lap-welded or Butt-welded Class I Open-Hearth	25,000
API 5L Lap-welded or Butt-welded Class II Open-Hearth	28,000
API 5L Lap-welded or Butt-welded 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
ASTM A381 Class Y-35	35,000
ASTM A381 Class Y-42	42,000
ASTM A381 Class Y-46	46,000
ASTM A381 Class Y-48	48,000

APPENDIX D

TABLE 1

FLEXIBILITY FACTORS k AND STRESS INTENSIFICATION FACTORS i

Description	Flexibility Factor k	Stress Intens. Factor
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
UNREINFOHCED 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 $\frac{5}{16}$ 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 F. Design Factors (841.1) $F = 0.60$, $E = 1.00$, $T = 1.00$. For dimensions see Figure for Example 1, Appendix E.

Header:

Nominal wall thickness:

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

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

Outlet:

Nominal 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 $= 8.625-(2 \times .322) = 7.981$ 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) $2\frac{1}{2}$ B+M (Assume $\frac{1}{4}$ inch Pad) $= 2\frac{1}{2} \times .322 + 0.25 = 1.05$ inch

or $2\frac{1}{2}$ H $= 2.5 \times .312 = 0.78$ 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))

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

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

Use reinf. pl. $\frac{1}{4}$ inch thick (minimum practicable) $\times$ 15.5 inch diameter

Area $(15.50-8.62) \times 0.25 = 1.72$ sq in.

Fillet welds (assuming two $\frac{1}{4}$ 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 $\frac{5}{16}$ 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 F. Design Factors (841.1) $F = 0.60$, $E = 1.00$, $T = 1.00$. For dimensions see Figure for Example 2 in Appendix E.

Header:

Nominal wall thickness:

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

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

Outlet:

Nominal 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×.312) = 15.376 inch

Reinforcement required:

$A_R = d \times t = 15.376 \times 0.283 = 4.35$ sq in.

Reinforcement provided:

$A_1 = (H-t)\, d = .029 \times 15.376 = 0.44$ sq in.

Effective area in outlet:

Height (L) $2\frac{1}{2}$ B+M (Assume $\frac{5}{16}$ inch Pl.) = 2.5×312+.312 = 1.09 inch
or $2\frac{1}{2}$ H = 2.5×.312 = 0.78 inch. Use 0.78 inch

$A_2 = 2\,(B-t_b)\, L = 2. \times .064 \times .78 = 0.10$ 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 $\frac{5}{16}$ inch Pl. Net reqd. length (Neglecting welds)

3.83÷.312 = 12.3 inch

Use Plate 29 inches long

$A_3 = .312 \times (29-16) = 4.05$ sq in.

Two $\frac{1}{4}$ inch welds to outlet

2×.25×.25×.50 = .06 sq in.

A_3 provided 4.11 sq in.

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

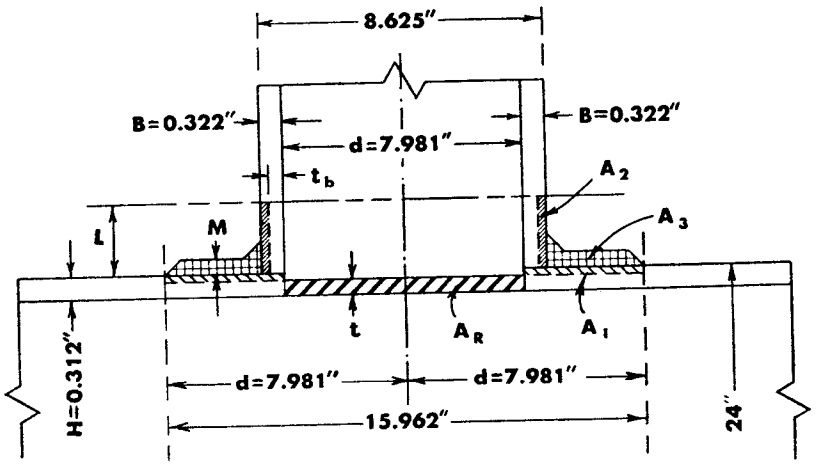


FIGURE FOR EXAMPLE 1

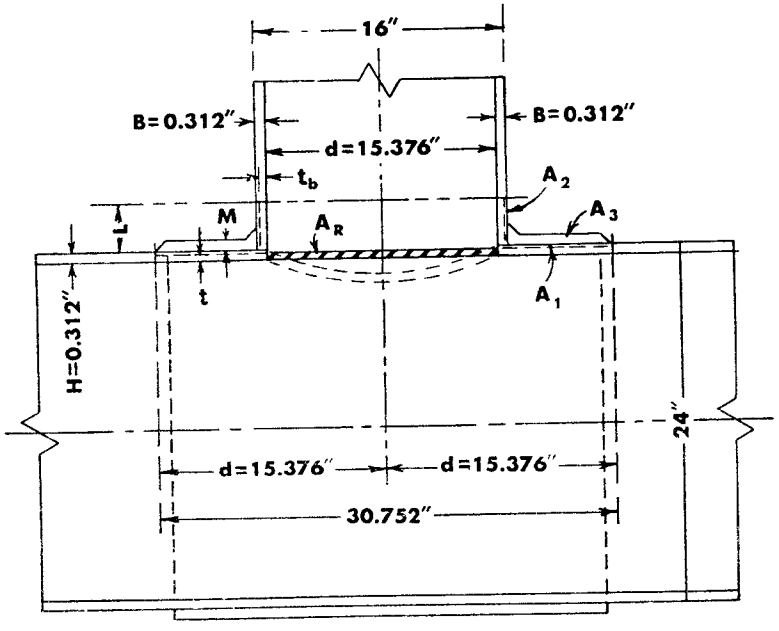


FIGURE FOR EXAMPLE 2

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 $\frac{1}{8}$ 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 should 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 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 Specification A53-55T

(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, both crop ends from each length of pipe shall be flattened between parallel plates, with the weld at the point of maximum bending, until the opposite walls of the pipe meet. No opening in the weld shall take place until the distance between the plates is less than two-thirds of the original outside diameter of the pipe. No cracks or breaks in the metal elsewhere than in the weld shall occur until the distance between the plates is less than one-third of the original outside diameter of the pipe, but in no case less than five times the thickness of the pipe wall. Evidence of lamination or burnt material shall not develop during the entire flattening process, and the weld shall not show injurious defects.

(d) For seamless pipe the test section shall not be less than 2½ 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 ¾ of the original outside diameter for butt-weld, or ⅔ 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:

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

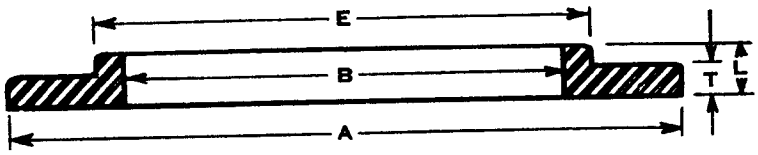
Where:

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 181-1

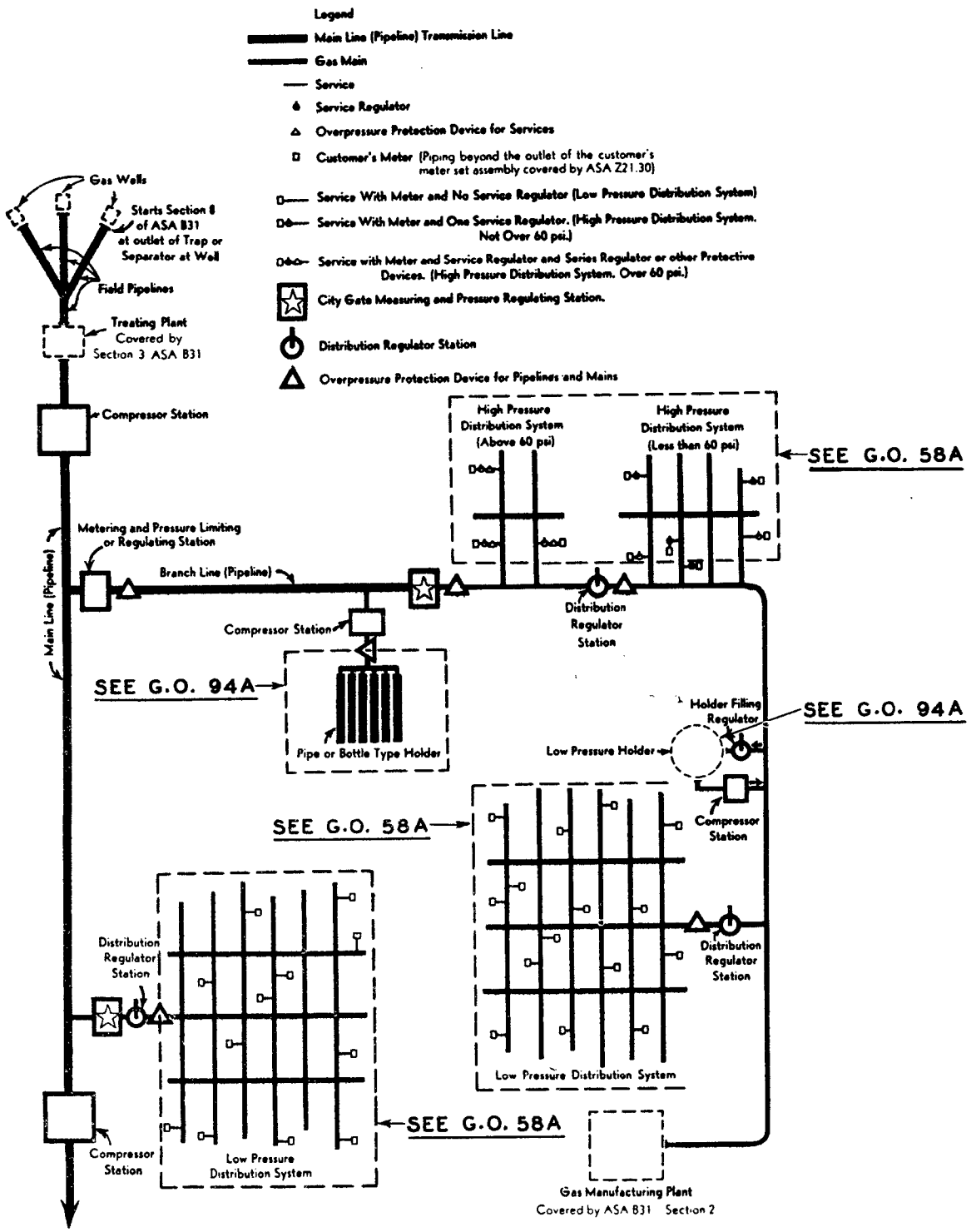
Pipe Size Inches	Outside Diameter A	Thickness T	Inside Diameter B	Length of Hub L	Outside Diameter of Hub E	Drilling Template: Number of Bolts	Drilling Template: Diameter and Length of Bolts	Drilling Template: Diameter of Bolt Circle	Approx. Weight Each Pounds
6	11	9/16	6.72	1¼	7 9/16	8	¾ x 2¼	9½	13
8	13½	9/16	8.72	1¼	9 11/16	8	¾ x 2¼	11¾	18
10	16	11/16	10.88	1¼	12	12	⅞ x 2¼	14¼	26
12	19	11/16	12.88	1¼	14¾	12	⅞ x 2¼	17	42
14	21	¾	14.14	1¼	15¾	12	1 x 2¼	18¾	44
16	23½	¾	16.16	1¼	18	16	1 x 2¼	21¼	58
18	25	¾	18.18	1¼	19¾	16	1⅛ x 3	22¾	59
20	27½	¾	20.20	1¼	22	20	1⅛ x 3	25	69
22	29½	1	22.22	1¼	24¼	20	1¼ x 3½	27¼	76
24	32	1	24.25	1¼	26¼	20	1¼ x 3½	29½	113
26	34¼	1	26.25	1¼	28¼	24	1¼ x 3½	31¾	126
28	36½	1	28.25	1¼	30¼	28	1¼ x 3½	34	139
30	38¾	1	30.25	1¼	32¼	28	1¼ x 3½	36	152
32	41¼	1⅛	32.25	1¼	34¾	28	1½ x 4	38½	206
34	43¾	1⅛	34.25	1¼	36¾	32	1½ x 4	40½	217
36	46	1⅛	As	1¼	38¾	32	1½ x 4	42¾	234
38	48¼	1⅛		1¼	40¾	32	1½ x 4	45¼	264
40	50¾	1⅛		1¼	43	36	1½ x 4	47¼	280
42	53	1¼		1¼	45	36	1½ x 4¼	49½	328
44	55¼	1¼		2¼	47	40	1½ x 4¼	51¾	349
46	57¼	1¼	Specified	2¼	49	40	1½ x 4¼	53¾	363
48	59¼	1⅜		2¼	51	44	1½ x 4¼	56	426
50	61¾	1⅜		2¼	53	44	1¾ x 4¾	58¼	451
52	64	1⅜	by	2¼	55	44	1¾ x 4¾	60½	477
54	66¼	1⅜		2¼	57	44	1¾ x 4¾	62¾	504
60	73	1½		2¾	63	52	1¾ x 5	69¼	643
66	80	1½		2¾	69	52	1¾ x 5	76	754
72	86¼	1½	Purchaser	2¾	75	60	1¾ x 5	82¼	846

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

FIGURE 804-A

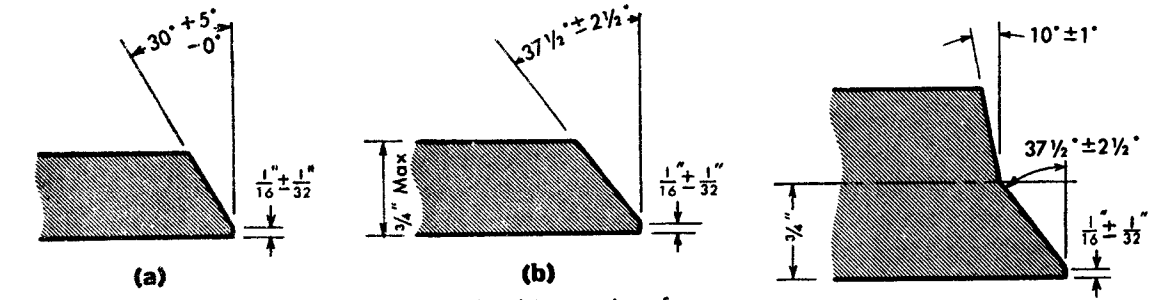
DIAGRAM SHOWING SCOPE OF SECTION 8 OF ASA B31

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



APPLICABLE SECTIONS OF ASA CODE B 31.8 ARE AMENDED IN THEIR ENTIRETY TO CONFORM TO C.P.U.C. GENERAL ORDERS 58A AND 94A.

FIGURE 823-A

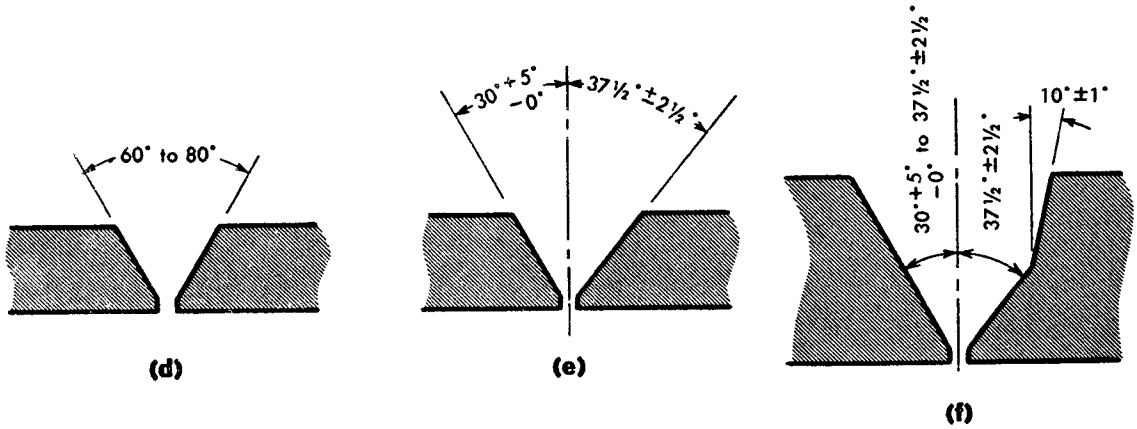


Optional End Preparation of Pipe

Standard End Preparation of Pipe and Butt Welding Fittings 3/4" and Thinner

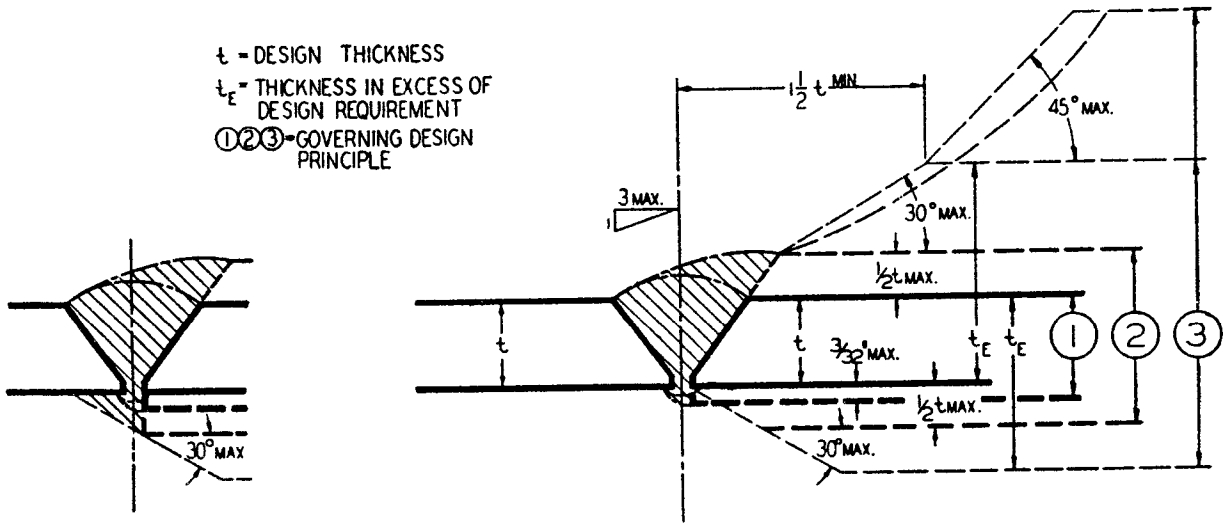
Suggested End Preparation, Pipe and Fittings Over 3/4" Thickness

STANDARD END PREPARATIONS



ACCEPTABLE COMBINATIONS OF PIPE END PREPARATIONS

FIGURE 823-B



Explanatory Notes:

The sketch in Figure 823-B is designed to illustrate some acceptable preparations of ends having unequal thickness providing the following basic precepts are compiled with:

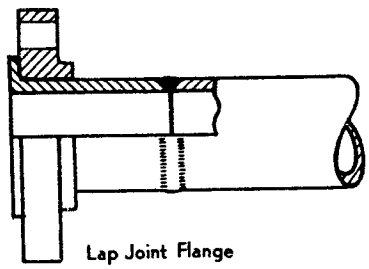
1. Where materials of unequal unit strengths (specified minimum yield) are joined together, and the full strength of the higher unit strength material is required, design conditions require that the thickness of the end having the lower physical property be such that its strength be at least equal to that of the adjoining part.
2. The transition between ends of unequal thickness may be accomplished by taper or welding as illustrated or by means of a prefabricated transition ring.
3. The transition weld shall have a slope not greater than 1:3. (Approx. 18°). Excess metal thickness of the heavier section may be tapered for a smooth transition by an angle not exceeding 30° with reference to the pipe surface.
4. Physical properties of the deposited weld metal shall be at least equal to those of the higher strength pipe material.

The design principles governing the preparation of ends having unequal thickness should comply with the following:

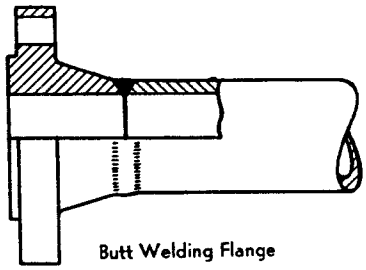
1. If the nominal wall thickness of adjoining ends are equal in thickness or do not vary more than 3/32", no special treatment is necessary provided full penetration and bond is accomplished in welding.
2. Where the nominal internal or external offset does not exceed 1/2 the thinner wall section, the transition may be made by welding or taper, provided full penetration and bond is accomplished and the basic precepts are adhered to.
3. Where the nominal wall section of valves, fittings, etc., is greater than required for the design strength of the joint, such additional metal may be tapered to the accepted re-entrant angle as illustrated.
4. For piping to operate at hoop stress of less than 20 per cent of the specified minimum yield strength, if the nominal wall thickness does not vary more than 1/8" no special treatment is necessary provided adequate penetration and bond is accomplished in welding.

FIGURE 823-C

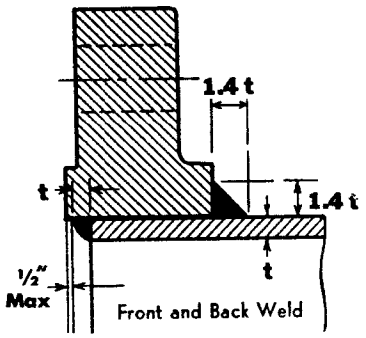
RECOMMENDED ATTACHMENT DETAILS OF FLANGES



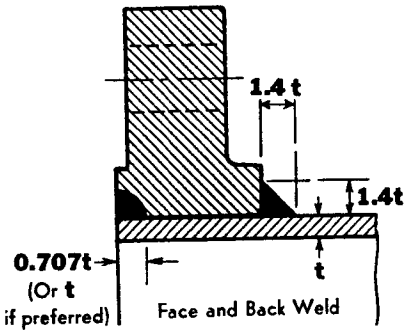
(1)



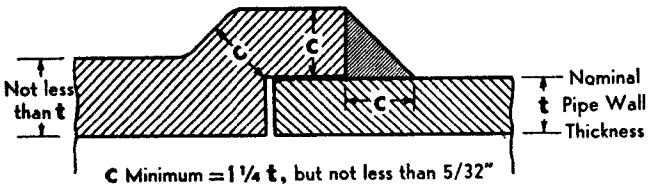
(2)



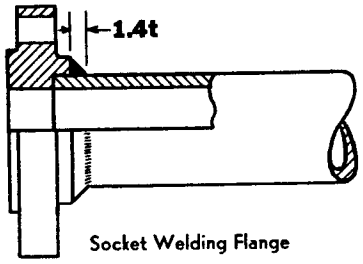
(3)



(4)



(5)



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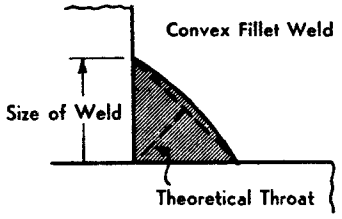
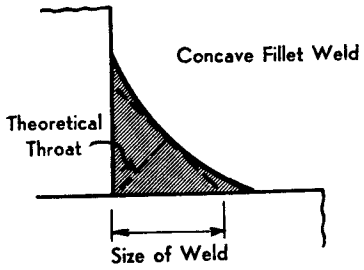
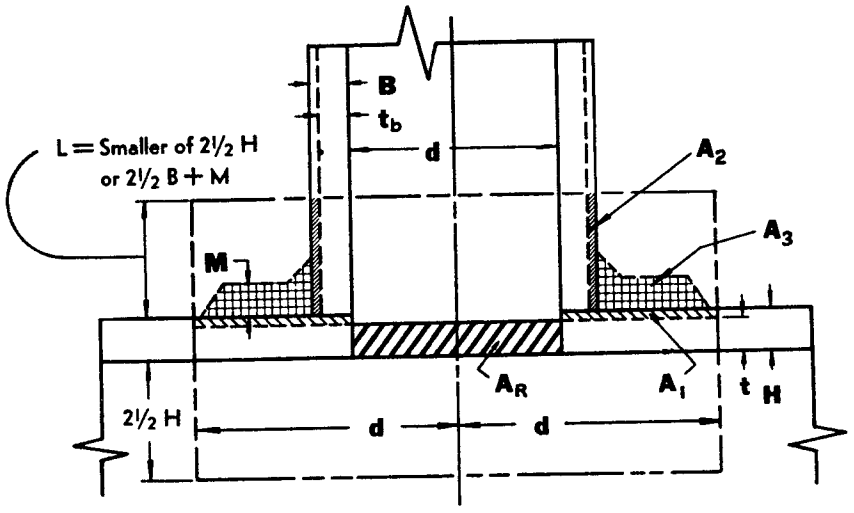


(7)



(8)

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)

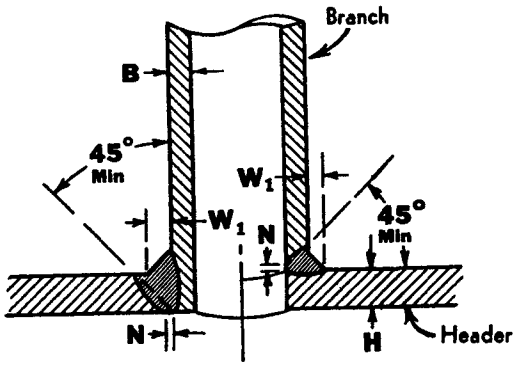
t = Required Nominal Wall Thickness of the Header
(Under the appropriate section of the code)

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



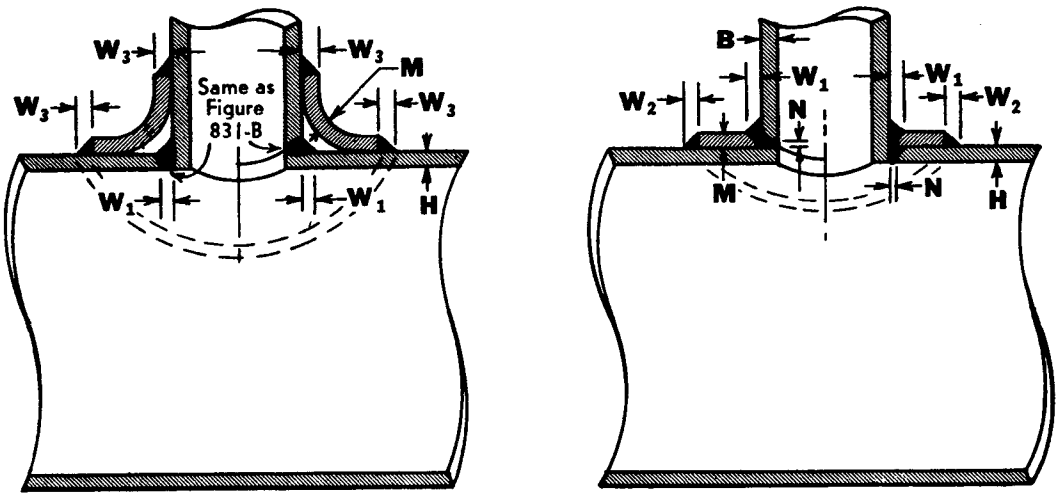
When a Welding Saddie is used it shall be inserted over this type of connection

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

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

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)

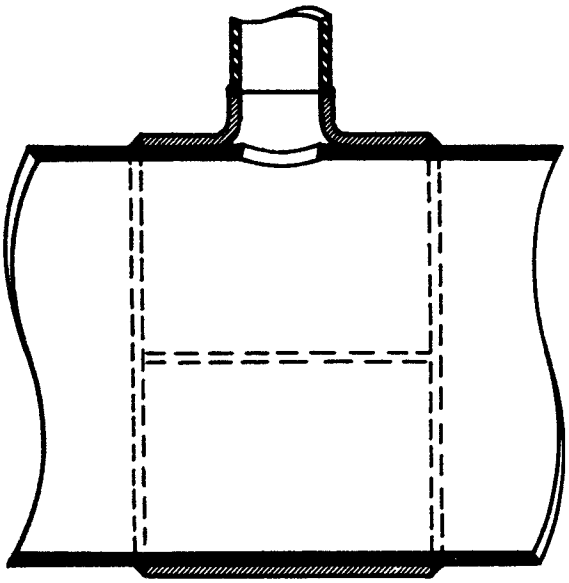
All Welds to have equal Leg Dimensions and a Minimum Throat = .707 X Leg Dimension.

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

Note: Provide hole in reinforcement to reveal leakage in buried welds and to provide venting during welding and heat treatment. (Par. 831.41h.)

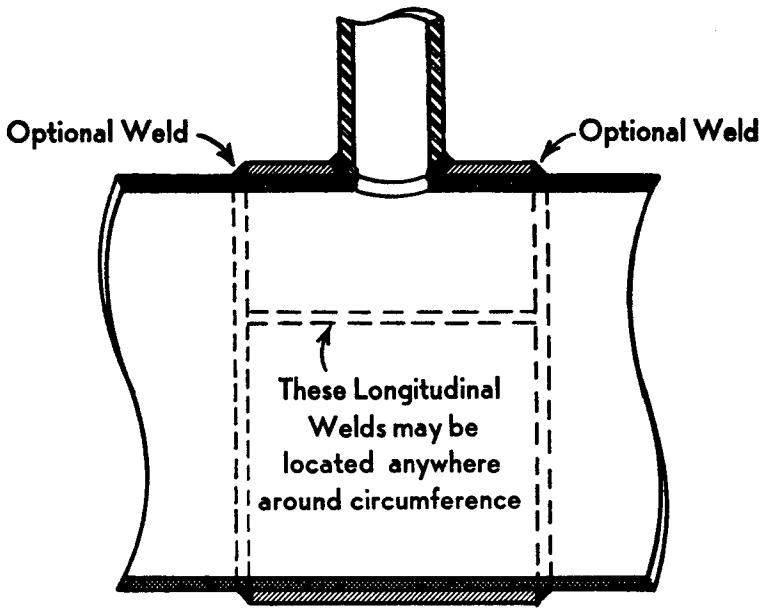
FIGURE 831-D

WELDING DETAILS FOR OPENINGS WITH COMPLETE ENCIRCLEMENT
TYPES OF REINFORCEMENT



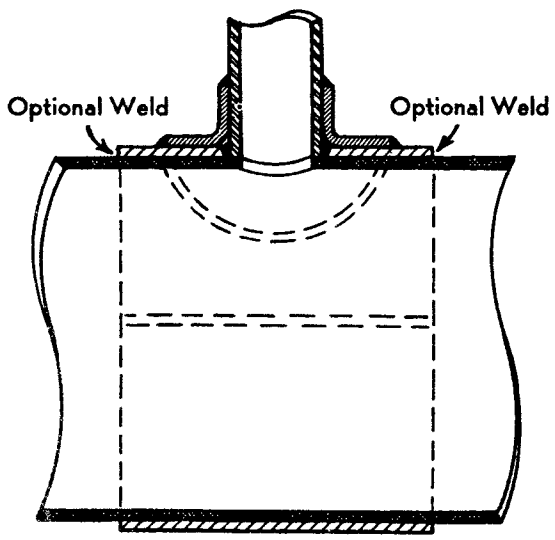
TEE TYPE

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

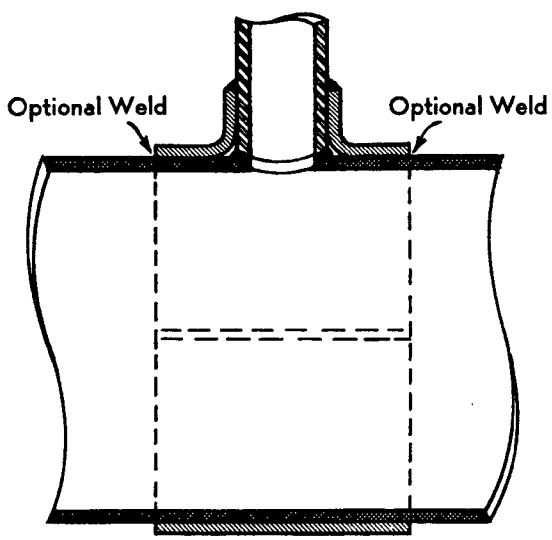


SLEEVE TYPE

Note: Provide hole in reinforcement to reveal leakage in buried welds and to provide venting during welding and heat treatment. (Par. 831.41h.) Not required for Tee Type.



SADDLE AND SLEEVE TYPE



SADDLE TYPE

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