آشنایی با مقررات
سیستم‌های لوله‌کشی تحت‌فشار
ASME B31

ASNT Level III

ASME Authorized Inspector

International Welding Engineer (IWE)

سیروس یحیی‌پور

اویل ایندستری
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ASME B31

سیستم لوله کشی چیست؟

هدف سیستم لوله کشی بطور عمده انتقال مواد است.

PIPING

سیستم لوله کشی شامل :

- **لوله های صاف**
- **لوله های خم شده**
- **اتصالات**
- **فلنج ها**
- **درپوش ها**
- **شیرها**
- **اجزایی نظیر ساپورت ها, ضربه گیرها, آویزها و ... است.**

لوله کشی چه نیست؟

توجه:

لوله‌های بویلرها ، مخازن تحت فشار , مخازن ذخیره , راکتورها ,هدرها , مبدل های حرارتی , توزیع کننده ها , کلکتورها و هر وسیله ای که برای مقصد دیگری بجز انتقال مواد بکار رود ، لوله کشی محسوب نمی شود و یا جزیی از سیستم لوله کشی نیست.

ASME B31 انتشارات

- B31.1 Power Piping
- B31.3 Process Piping
- B31.4 **Transportation Systems for Liquids and Slurries**
- B31.5 Refrigeration Piping
- B31.8 **Gas Transmission and Distribution Piping Systems**
- B13.9 Building Services Piping
- B31.11 Slurry Transportation Piping Systems
- B31.12 Hydrogen Piping and Pipelines

ASME B31 Pressure Piping Codes

انتشارات B31 که در اینجا بحث می‌شود

- B 31.1 Power Piping
- B 31.3 Process Piping
- B31.8 Gas Transmission and Distribution Piping Systems

ASME Piping Codes B31.

- مقدمه
- مقررات B31.
- محدوده
- Fluid Service
- طراحی
- مواد
- Fabrication, Assembly, Erection
- بازرسی و آزمایش

Code B31.$^{1}_{3}{}_{8}$

ASME مخفف چه چیزهایی است؟

A	American
S	Society of
M	Mechanical
E	Engineers

برخی از عبارت‌های کلیدی کد

Shall	الزامات اجباری
May not	ممنوعیت
May Can	توصیه‌ها یا معافیت‌ها از ممنوعیت
Should	توصیه‌ها

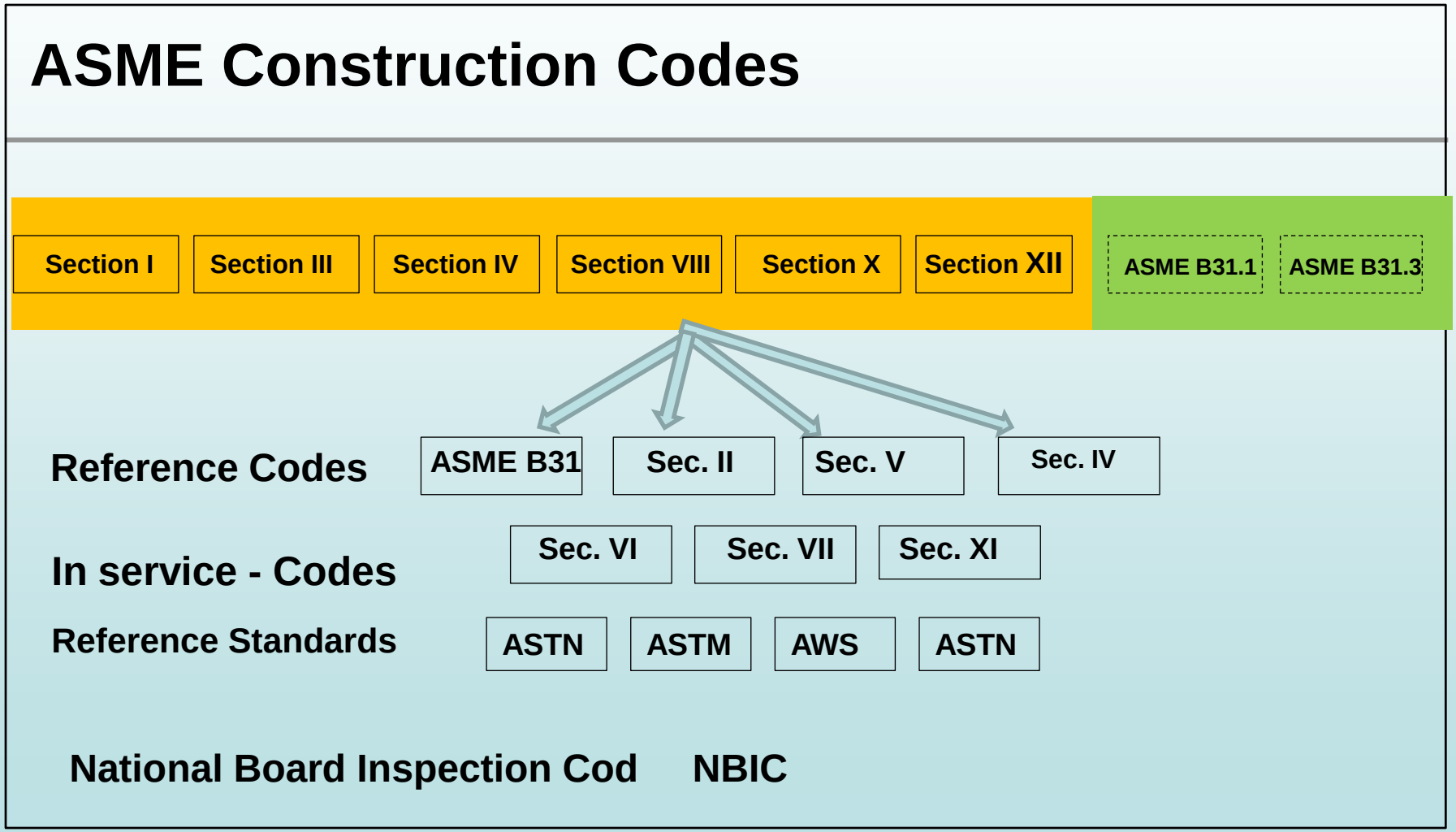
انتشارات کد

Editions	هر سه سال یک بار در ۱ July (۹۵،۹۸،۲۰۰۱،۲۰۰۴....) انتشارمی‌یابد.
Addenda	هر سال به صورت رنگی در ۱ July انتشار می‌یابدو شامل تغییرات، حذف‌ها و جابجایی‌هاست. ۶ ماه بعد از انتشار اجباری خواهد شد.
Interpretations	تفسیرهای سئوالات رسیده توسط کمیته‌های ASME منتشر می‌شوند امّا جزو کد نیستند (Non mandatory)
Code cases	بوسیله کمیته ASME جهت توضیح و روشن شدن الزامات موجود در کد یا تهیه مقررات جدیدی که الزم آن در کد حس می‌شود انتشار می‌یابند.
Errata	به محض انتشار اجباری هستند.
Re-affirmed	عبارتند از کدها و استانداردهای مرجع.

واحدها

Length:	**in**	**=**	**25,4 mm**
	ft	**=**	**304,8 mm**
	Yd	**=**	**914,4 mm**
Area:	**sq in**	**=**	**6,4516 cm^2**
	sq ft	**=**	**0,0929…m^2**
Volume:	**cu in**	**=**	**16,387 cm**
	cu ft	**=**	**28,317 l**
Force:	**lb f**	**=**	**4,448 N**
Energy:	**ft lb**	**=**	**1,355818 Nm (=J)**
Pressure	**psi**	**=**	**0,06894757 bar**
Temperature	**°F**	**=**	**32+1,8*T_c**

ارتباط انتشارات ASME



ASME Code Scope

Construction Codes Address: **کدهای ساخت شامل:**

- **Manufacturer‘s Authorization**
- **Materials** **مواد**
- **Design** **طراحی**
- **Fabrication** **ساخت**
- **Examination,**
- **Inspection** **بازرسی**
- **Testing,**
- **Certification** **گواهی نامه**
- **Assembly, Installation**
- **Pressure Relief** **تجهیزات کاهش فشار**

Not addressed: **مواردی را که شامل نمی شود**

In service Inspection , Repairs , Alterations

بازرسی حین بهره برداری **تعمیرات ،** **تغییرات**

Countries accepting ASME Code Construction and Requirement Boilers and Pressure Vessels

Albania *
Algeria
Argentina
Australia
Austria *
Bahamas
Bahrain
Bangladesh
Barbados
Belarus *
Belgium *
Bermuda
Bolivia
Bosnia and Herzegovina *
Brazil
Burma (Myanmar) *
Canada
Chile
China *
Colombia
Costa Rica
Croatia *
Cuba
Cyprus
Denmark *
Djibouti
Dominican Republic
Ecuador
* Egypt
* Estonia
Ethiopia
* Finland
Fiji
* France
Gambia
* Georgia
* Germany
Ghana
* Greece
* Hong Kong
* Hungary
* Iceland
* India
Indonesia
* Iraq
* Ireland
Israel
* Italy
Ivory Coast
Jamaica
* Japan
Jordan
Kazakhstan
* Kenya
Korea
Kuwait
Latvia
Lebanon
Libya
Lithuania *
Luxembourg *
Malawi
Malaysia
Malta *
Mauritius *
Mexico
Moldowa *
Morocco
Mozambique
Netherlands *
New Zealand
Nicaragua *
Nigeria *
Norway
Oman *
Pakistan
Paraguay *
Peru
Philippines
Poland *
Portugal
Puerto Rico *
Quatar *
Romania
Saint Lucia *
Saudi Arabia *
* Serbia
Singapore
South Africa
* Spain
Sri Lanka
Sudan
Swaziland
* Sweden
* Switzerland
Syria
Taiwan
Tanzania
Thailand
The Russian Federation
Trinidad and Tobago
* Tunisia
* Turkey
* United Arab Emirates
United Kingdom
* Uganda
Uruguay
USA
Venezuela
Yemen
Yugoslavia
Zambia
Zimbabwe

* Subject to approval of local authority

Source: Technical help to Exporters, British Standard Inst. (June 2004)

ASME B 31.1

100.1Scope

Scope: **Power and Auxiliary service Piping Systems for:**
electric generating stations
industrial plants
heating plants

main aspect: heat transfer
such as: Boiler External Piping

Data Reports and Stamping required over NPS 1/2
within Jurisdictional Limits of Code Section I

and: Non boiler External Piping
No Data Report and Stamping required
ASME Code Committee for Pressure Piping is responsible

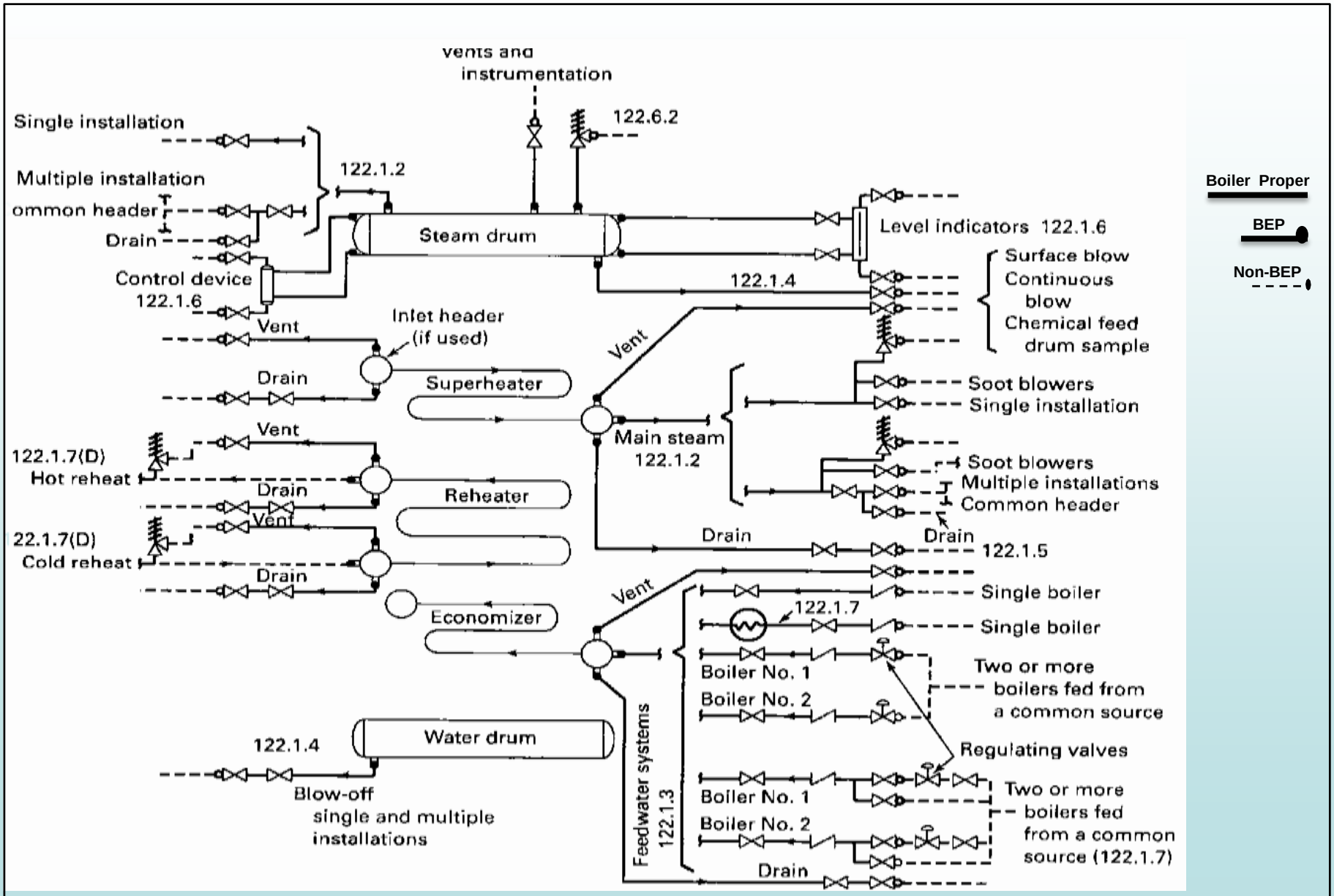
this includes:
central and district heating systems
geothermal piping from wellheads
fuel gas and fuel oil piping downstream plant meter set or inside the plant property line
gas and oil systems, air systems, hydraulic fluid systems
steam jet cooling systems in the power plant cycle

B 31.1 - 100.1, Scope (cont'd)

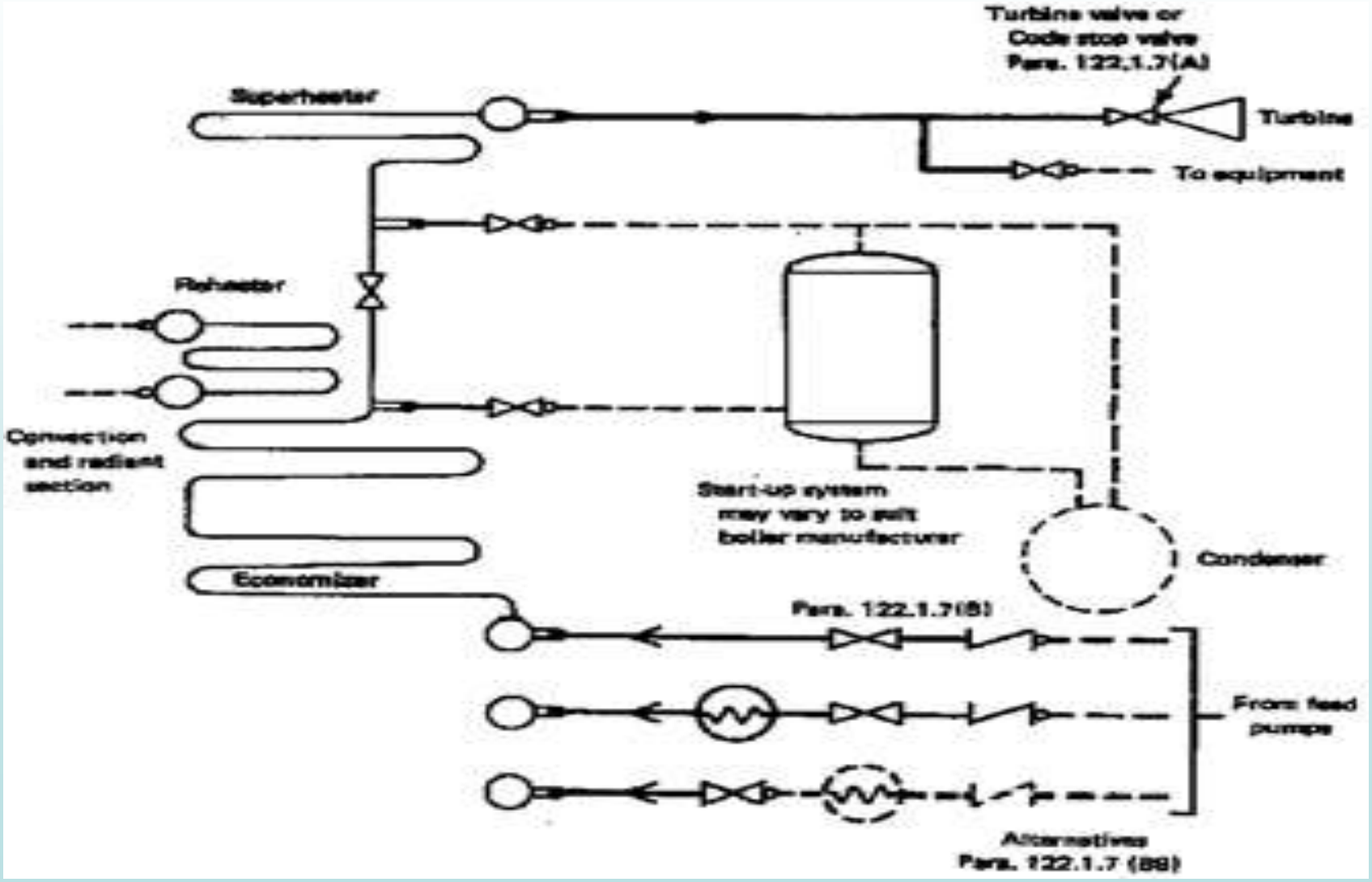
but except:

- **piping covered by other Sections of the ASME BPV Code**
- **Boilers and pressure vessels itself**
- **Stream heating piping ≤ 15 psig**
- **hot water heating piping ≤ 30 psig**
- **Plumbing**
- **hydraulic / pneumatic tool piping downstream the stop valve**
- **Federal control installations**
- **Nuclear installation piping → Code Section III**
- **B 31.9 building services piping**
- **Fuel gas piping inside industrial buildings - ANSI Z 223.1**
- **pulverized fuel piping → NFPA 8503**

B 31.1 FIG 100.1.2(B) DRUM TYPE BOILERS

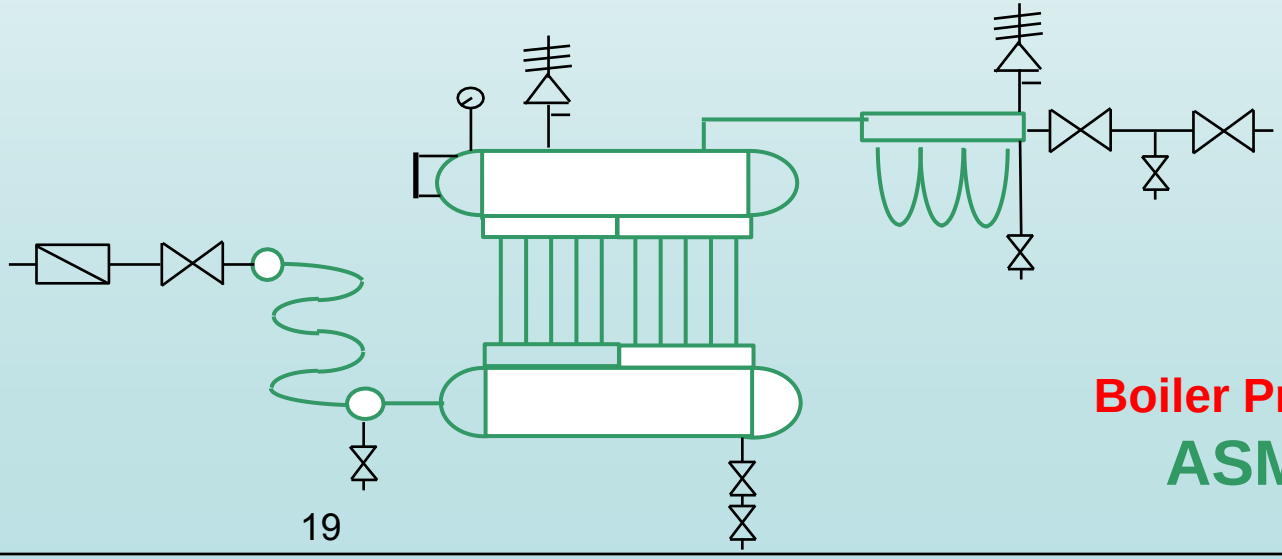


B 31.1 FIG 100.1.2(A) FORCED FLOW STEAM GENERATOR



Section I Boiler

Boiler External Piping: B31.1
ASME S- other PP-Stamp
System Requirements in 122.1
Inspection: by Authorized Inspector
Pressure Test of entire Boiler after Assembly



Boiler Proper: Section I
ASME S-Stamp

ASME B 31.1 Contents

Chapters:

- **I 100 - Scope and definitions**
- **II 101 - Design**

  101 - Conditions and criteria

  103 - Pressure design of piping components

  105 - Selection and limitation of piping components

  110 - Selection and limitation of piping joints

  119 - Expansion, Flexibility, supporting

  122 - Systems
- **III 123 - Materials**
- **IV 126 - Dimensional requirements**
- **V 127 - Fabrication, assembly, erection**
- **VI 136 - Examination, inspection and testing**

Appendices

Appendices

Mandatory Appendices

Appendix A Table A-1, Carbon Steel STRESS VALUES
Table A-2, Low and Intermediate Alloy Steel STRESS VALUES
Table A-3, Stainless Steels STRESS VALUES
Table A-4, Nickel and High Nickel Alloys STRESS VALUES
Table A-5, Cast Iron STRESS VALUES
Table A-6, Copper and Copper Alloys STRESS VALUES
Table A-7, Aluminum and Aluminum Alloys STRESS VALUES
Table A-8, Temperatures 1200°F and Above STRESS VALUES
Table A-9, Titanium and Titanium Alloys STRESS VALUES
Appendix B Table B-1, Thermal Expansion Data
Table B-1 (SI), Thermal Expansion Data
Appendix C Table C-1, Moduli of Elasticity for Ferrous Material Table
C-1 (SI), Moduli of Elasticity for Ferrous Material Table
C-2, Moduli of Elasticity for Nonferrous Material Table C-2
(SI), Moduli of Elasticity for Nonferrous Material
Appendix D Table D-1, Flexibility and Stress Intensification Factors
Chart D-1, Flexibility Factor k and Stress Intensification Factor I
Chart D-2, Correction Factor c
Fig. D-1, Branch Connection Dimensions
Appendix F Referenced Standards
Appendix G Nomenclature
Appendix H Preparation of Technical Inquiries
Appendix J Quality Control Requirements for Boiler External Piping (BEP)

Appendices

Non mandatory Appendices

Appendix II	**Rules for the Design of Safety Valve Installations**
Appendix III	**Rules for Nonmetallic Piping**
Appendix IV	**Corrosion Control for ASME B31.1 Power Piping Systems**
Appendix V	**Recommended Practice for Operation, Maintenance, and Modification of Power Piping Systems**
Appendix VI	**Approval of New Materials**
Appendix VII	**Procedures for the Design of Restrained Underground Piping**

ASME B 31.3 300.1 Scope

Scope: Piping for all fluids within the property lines of facilities for chemicals and petroleum Main aspect: Product transportation

Except: non toxic fluids at 0 ... 15 psig and -20°F ... 366°F

- boiler external piping
- boiler proper, pressure vessels
- piping according to B31.1, B 31.4, B31.5, B31.6

  B 31.8, B 31.11
- Plumbing
- fire protection systems

Definitions: 300.2

ASME B 31.3 Contents

Chapters

APPENDICES

TABLE 300.4
STATUS OF APPENDICES IN B31.3

Appendix	Title	Status
A	Stress Tables for Metallic Piping and Bolting Materials	Requirements
B	Stress Tables and Allowable Pressure Tables for Nonmetals	Requirements
C	Physical Properties of Piping Materials	Requirements (1)
D	Flexibility and Stress Intensification Factors	Requirements (1)
E	Reference Standards	Requirements
F	Precautionary Considerations	Guidance (2)
G	Safeguarding	Guidance (2)
H	Sample Calculations for Branch Reinforcement	Guidance
J	Nomenclature	Information
K	Allowable Stress for High Pressure Piping	Requirements (3)
L	Aluminum Alloy Pipe Flanges	Specification (5)
M	Guide to Classifying Fluid Services	Guidance (2)
Q	Quality System Program	Guidance (2)
V	Allowable Variations in Elevated Temperature Service	Guidance (2)
X	Metallic Bellows Expansion Joints	Requirements
Z	Preparation of Technical Inquiries	Requirements (4)

NOTES:
(1) Contains default requirements, to be used unless more directly applicable data are available.
(2) Contains no requirements but Code user is responsible for considering applicable items.
(3) Contains requirements applicable only when use of Chapter IX is specified.
(4) Contains administrative requirements.
(5) Contains pressure-temperature ratings, materials, dimensions, and markings of forged aluminum alloy flanges.

ASME B 31.3 chapter I

Responsibilities (§ 300)

Owner: Overall responsibilities for Code compliance and establishment of (supplementary) requirements cover Jurisdictional requirements

Designer: Responsible for compliance of engineering design with Code / additional requirements Qualification as per 301.1

Manufacturer: Responsibility for material, components workmanship according to design and code

Owner's Inspector: Ensure that inspection, examination, and requirements are met.

Qualification as per 340.4

ASME B 31.3 Fluid Services

Appendix M:

Category **D** fluid service:

Nontoxic, non flammable , not dangerous , designated by owner – design pressure ≤150psig.

Normal fluid service

Category **M** fluid service:

Toxic fluids, even at single exposure of small quantities, non protected personal, designated by owner

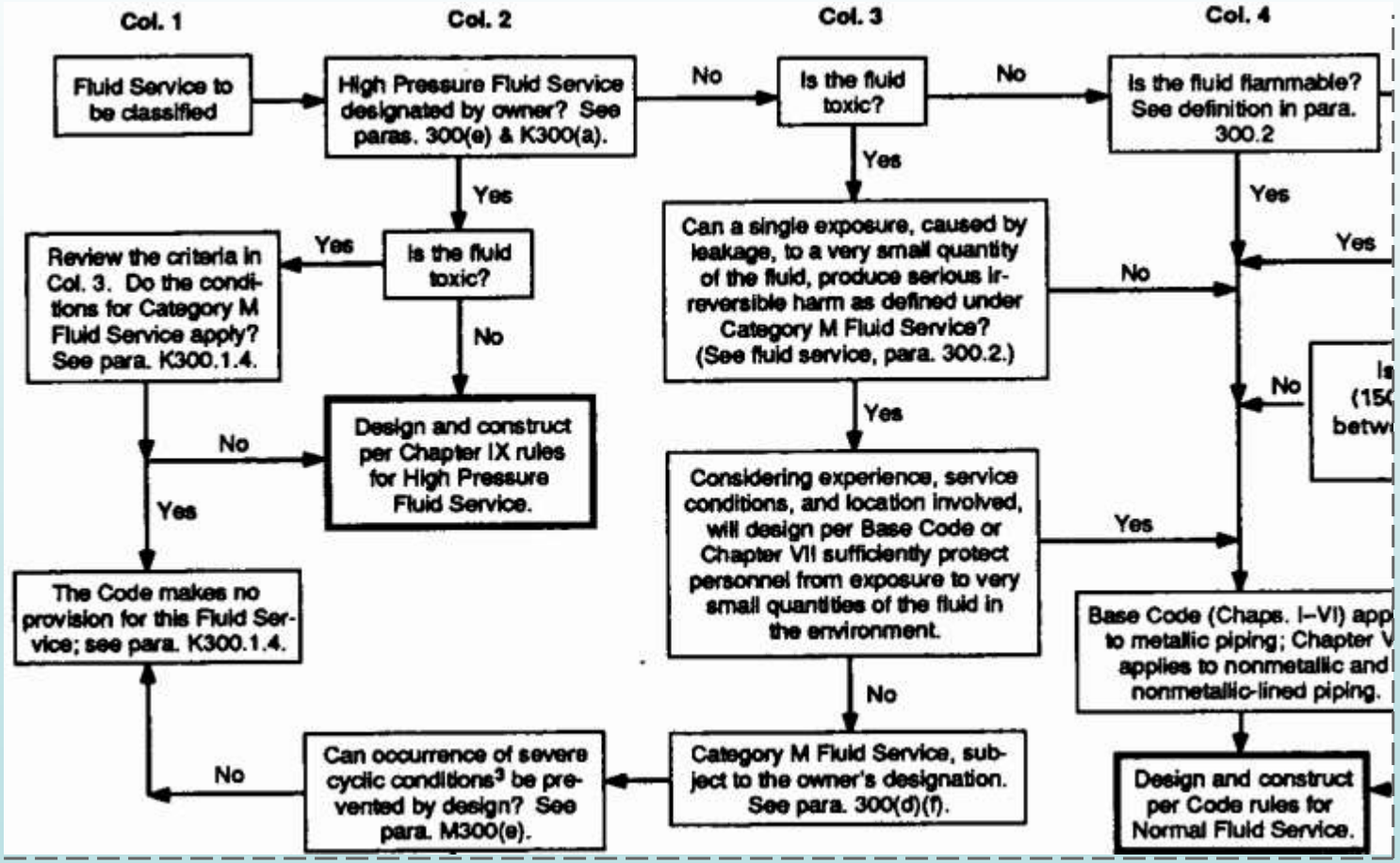
High pressure fluid service:

over Class 2500, designated by owner alternative rules in chapter IX

Severe Cyclic Service:

Piping over 7000 Cycles and significant displacement stress

B 31.3 FIG. M300 GUIDE TO CLASSIFYING FLUID SERVICES



301.1 Qualifications of the Designer

301.1 Qualifications of the Designer

The Designer is the person(s) in charge of the engineering design of a piping system and shall be experienced in the use of this Code.

The qualifications and experience required of the Designer will depend on the complexity and criticality of the system and the nature of the individual's experience. The owner's approval is required if the individual does not meet at least one of the following criteria.

(a) Completion of an engineering degree, requiring four or more years of full-time study, plus a minimum of 5 years experience in the design of related pressure piping

(b) Professional Engineering registration, recognized by the local jurisdiction, and experience in the design of related pressure piping.

(c) Completion of an engineering associates degree, requiring at least 2 years of full-time study, plus a minimum of 10 years experience in the design of related pressure piping.

(d) Fifteen years experience in the design of related pressure piping. Experience in the design of related pressure piping is satisfied by piping design experience that includes design calculations for pressure, sustained and occasional loads, and piping flexibility.

B 31.3 Chapter II: Design

Design Criteria (302)

Piping Components with Specific Ratings (Table 326.1) Pressure according to the rating at the operating temperature or according to the provisions of B 31.3

Without Specific Rating:
Considered as seamless pipe corresponding to the schedule or class

Variations above the ratings or Appendix A Stress Values allowed by: (302.2.4)
33% for no more than 10 hr at any one time, and no more than 100 hr/yr.
20% for no more than 50 hr at any one time, and no more than 500 hr/yr

Subject to the Owner‘s approval.

B 31.3 Chapter II: Design

301.2: Design Pressure: Most severe conditions expected in service

301.3: Design Temperature

301.4: Ambient Influences to be considered:

- cooling effects on pressure (vacuum)
- fluid expansion effects
- atmospheric icing
- low ambient temp

301.5: Dynamic Effects: - Impact - external or internal
- wind
- earth quake
- vibration

301.6: Weight Effects: Live, dead, test and cleaning fluid loads (incl. snow & ice)

301.7: Thermal Expansion and Contraction Effects

301.10: Cyclic Effects

301.11: Air Condensatin Effects

B 31.3 Pressure Design of Components

304.1 Straight Pipe
Internal Pressure
External Pressure (Section VIII-1 UG-28ff)
304.2 Curved Segments of Pipe
304.3 Branch Connections
(Reinforcement Calculation)
304.4 Closures
304.5 Flanges and Blanks
304.6 Reducers (Reference Stds)
304.7 Other Components
listed - Table 326.1
Non listed - calcs or proof test UG-101
Expansion Joints - App. X

Table 326.1

Table 326.1: Specifications and Standards (sample)

. . .	ASME Boiler and Pressure Vessel Code
B1.1	Unified Inch Screw Threads
B1.20.1	Pipe Threads, General Purpose (Inch)
B16.1	C.I. Pipe Flanges and Flanged Fittings — 25, 125, 250 & 800 Classes
B16.3	M.I. Thd. Fittings
B16.4	G.I. Thd. Fittings
B16.5	Pipe Flanges & Flanged Fittings
B16.9	Wrought Steel Butt Welding Fittings
B16.10	Face-to-Face and End-to-End Dimensions of Valves
B16.11	Forged Steel Fittings, S.W. & Threaded
B16.14	Ferrous Plugs, Bushings & Locknuts with Pipe Threads
B16.15	Cast Bronze Threaded Fittings, Classes 125 and 250
B16.20	Metallic Gaskets for Pipe Flanges — Ring Joint, Spiral Wound, & Jacketed
B16.21	Non-Metallic Flat Gaskets for Pipe Flanges
B16.22	Wrought Copper & Copper Alloy Solder Joint Pressure Fittings
B16.24	Cast Copper Alloy Pipe Flanges & Flanged Fittings — Class 150, 300, 400, 600, 900, 1500, and 2500
B16.25	Butt Welding Ends
B16.28	Wrought Steel Butt Welding Short Radius Elbows and Returns
B16.34	Valves — Flanged, Threaded, and Welding End
B16.42	Ductile Iron Pipe Flanges and Flanged Fittings — Classes 150 and 300
B16.47	Large Diameter Steel Flanges
B18.2.2	Square and Hex Nuts (Inch Series)
B18.21.1	Lock Washers (Inch Series)
B31.3	Process Piping
B31.4	Liquid Transportation Systems for Hydrocarbons, Liquid Petroleum Gas, Anhydrous Ammonia, and Alcohols
B31.8	Gas Transmission & Distribution Piping Systems
B36.10M	Welded and Seamless Wrought Steel Pipe
B36.19M	Stainless Steel Pipe
TDP-1	Recommended Practices for the Prevention of Water Damage to Steam Turbines Used for Electric Power Generation -- Fossil Fueled Plants

Appendix E : acceptable editions!

ASME B16.34

Marking Examples

	Forged Valve Group 1.9	Cast Valve Group 1.1
Manufacturer	RVC	RVC
Material	SA-182 F11 Cl.2	A-216 WCB
Heat No.	1234 (to SA-182 §16 !)	1234
(Trade Designation	Superforge	Supercast)
Conformity	B16.34	ASME B16.34 SPL
Rating	300	300
Temperature	optional for special and intermediate rated valves	
Size	NPS 4	NPS 4
Serial No.	555 (When MTR required to SA-182)	
Identification Plate:	Manufacturer`s Name RVC	
	Class 300	300#SPL
Rating @ 100F:	750psi at 100F	750psi at 100F

Special Markings: Limitations for gaskets or bolting if applicable

Reference: MSS SP-25

B16.34 Example: Minimum Wall Thickness

Inside meter *d*, in. [Note (1)]	Class 150	300	400	600	900	1500	2500	4500
1.00	0.16	0.19	0.19	0.19	0.25	0.28	0.44	0.88
1.12	0.17	0.19	0.19	0.19	0.25	0.31	0.50	0.98
1.25	0.19	0.19	0.19	0.19	0.26	0.34	0.53	1.08
1.37	0.19	0.19	0.20	0.20	0.28	0.38	0.57	1.18
1.50	0.19	0.19	0.22	0.22	0.29	0.39	0.62	1.28
1.87	0.21	0.22	0.23	0.24	0.31	0.44	0.75	1.57
2.00	0.22	0.25	0.25	0.25	0.31	0.46	0.79	1.67
2.25	0.22	0.25	0.26	0.26	0.34	0.50	0.88	1.87
2.50	0.22	0.25	0.28	0.28	0.36	0.56	0.95	2.06
2.75	0.22	0.27	0.29	0.29	0.39	0.62	1.04	2.26
2.87	0.22	0.27	0.30	0.30	0.41	0.63	1.09	2.36
3.00	0.22	0.28	0.31	0.31	0.42	0.66	1.14	2.45
3.50	0.25	0.29	0.34	0.34	0.47	0.75	1.29	2.85
3.62	0.25	0.29	0.35	0.36	0.48	0.75	1.34	2.95
3.87	0.25	0.30	0.36	0.37	0.50	0.81	1.42	3.14
4.00	0.25	0.31	0.38	0.38	0.51	0.83	1.47	3.24
4.37	0.25	0.32	0.39	0.41	0.56	0.91	1.59	3.53
4.75	0.26	0.34	0.42	0.43	0.59	0.98	1.72	3.83
5.00	0.28	0.34	0.44	0.44	0.63	1.02	1.81	4.02
5.37	0.28	0.36	0.44	0.46	0.66	1.09	1.93	4.31

Table 2-1.1 Ratings for Group 1.1 Materials

A 105 (1)(2)	A 515 Gr.70 (1)	A 696 Gr. C	A 672 Gr. B70 (1)
A 216 GR. WCB (1)	A 516 Gr. 70 (1)(3)	A 350 Gr. LF6 Cl. 1 (4)	A 672 Gr. C70 (1)
A 350 Gr. LF2 (1)	A 537 Cl. 1 (5)	A 350 Gr. LF3 (6)	

NOTES:

(1) Upon prolonged exposure to temperatures above 425C°, the carbide phase of steel may be converted to graphite. Permissible, but not recommended for prolonged usage above 425°C.

(2) Only killed steel shall be used above 455°C. (3) Not to be used over 455°C. (4) Not to be used over 260°C.

(5) Not to be used over 370°C. (6) Not to be used over 345°C.

A – Standard Class

Temperature, °C	Working Pressures by Class, bar						
	150	300	600	900	1500	2500	4500
−29 to 38	19.6	51.1	102.1	153.2	255.3	425.5	765.9
50	19.2	50.1	100.2	150.4	250.6	417.7	751.9
100	17.7	46.6	93.2	139.8	233.0	388.3	699.0
150	15.8	45.1	90.2	135.2	225.4	375.6	676.1
200	13.8	43.8	87.6	131.4	219.0	365.0	657.0
250	12.1	41.9	83.9	125.8	209.7	349.5	629.1
300	10.2	39.8	79.6	119.5	199.1	331.8	597.3
325	9.3	38.7	77.4	116.1	193.6	322.6	580.7
350	8.4	37.6	75.1	112.7	187.8	313.0	563.5
375	7.4	36.4	72.7	109.1	181.8	303.1	545.5
400	6.5	34.7	69.4	104.2	173.6	289.3	520.8
425	5.5	28.8	57.5	86.3	143.8	239.7	431.5
450	4.6	23.0	46.0	69.0	115.0	191.7	345.1
475	3.7	17.4	34.9	52.3	87.2	145.3	261.5
500	2.8	11.8	23.5	35.3	58.8	97.9	176.3
538	1.4	5.9	11.8	17.7	29.5	49.2	88.6

Table 2-1.1 Ratings for Group 1.1 Materials

A 105 (1)(2)	A 515 Gr.70 (1)	A 696 Gr. C	A 672 Gr. B70 (1)
A 216 GR. WCB (1)	A 516 Gr. 70 (1)(3)	A 350 Gr. LF6 Cl. 1 (4)	A 672 Gr. C70 (1)
A 350 Gr. LF2 (1)	A 537 Cl. 1 (5)	A 350 Gr. LF3 (6)	

NOTES:
(1) Upon prolonged exposure to temperatures above 425C°, the carbide phase of steel may be converted to graphite. Permissible, but not recommended for prolonged usage above 425°C.
(2) Only killed steel shall be used above 455°C.
(3) Not to be used over 455°C.
(4) Not to be used over 260°C.
(5) Not to be used over 370°C.
(6) Not to be used over 345°C.

B – Special Class

Temperature, °C	Working Pressures by Class, bar						
	150	300	600	900	1500	2500	4500
−29 to 38	19.8	51.7	103.4	155.1	258.6	430.9	775.7
50	19.8	51.7	103.4	155.1	258.6	430.9	775.7
100	19.8	51.6	103.3	154.9	258.2	430.3	774.5
150	19.6	51.0	102.1	153.1	255.2	425.3	765.5
200	19.4	50.6	101.1	151.7	252.9	421.4	758.6
250	19.4	50.5	101.1	151.6	252.6	421.1	757.9
300	19.4	50.5	101.1	151.6	252.6	421.1	757.9
325	19.2	50.1	100.2	150.3	250.6	417.6	751.7
350	18.7	48.9	97.8	146.7	244.6	407.6	733.7
375	18.1	47.1	94.2	141.3	235.5	392.5	706.5
400	16.6	43.4	86.8	130.2	217.0	361.7	651.0
425	13.8	36.0	71.9	107.9	179.8	299.6	539.3
450	11.0	28.8	57.5	86.3	143.8	239.6	431.4
475	8.4	21.8	43.6	65.4	109.0	181.6	326.9
500	5.6	14.7	29.4	44.1	73.5	122.4	220.4
538	2.8	7.4	14.8	22.2	36.9	61.6	110.8

B16.5 Pipe Flanged & Flanged Fitting

PRESSURE–TEMPERATURE RATINGS FOR GROUPS 1.1 THROUGH 3.17 MATERIALS

TABLE 2-1.1 RATINGS FOR GROUP 1.1 MATERIALS

Nominal Designation	Forgings	Castings	Plates
C–Si	A 105 (1)	A 216 Gr. WCB (1)	A 515 Gr. 70 (1)
C–Mn–Si	A 350 Gr. LF2 (1)		A 516 Gr. 70 (1)(2) A 537 Cl. 1 (3)
C–Mn–Si–V	A 350 Gr. LF6 Cl. 1 (4)		

NOTES:
(1) Upon prolonged exposure to temperatures above 800°F, the carbide phase of steel may be converted to graphite. Permissible, but not recommended for prolonged use above 800°F.
(2) Not to be used over 850°F. (3) Not to be used over 700°F. (4) Not to be used over 500°F.

WORKING PRESSURES BY CLASSES, psig

Class Temp., °F	150	300	400	600	900	1500	2500
–20 to 100	285	740	990	1480	2220	3705	6170
200	260	675	900	1350	2025	3375	5625
300	230	655	875	1315	1970	3280	5470
400	200	635	845	1270	1900	3170	5280
500	170	600	800	1200	1795	2995	4990
600	140	550	730	1095	1640	2735	4560
650	125	535	715	1075	1610	2685	4475
700	110	535	710	1065	1600	2665	4440
750	95	505	670	1010	1510	2520	4200
800	80	410	550	825	1235	2060	3430
850	65	270	355	535	805	1340	2230
900	50	170	230	345	515	860	1430
950	35	105	140	205	310	515	860
1000	20	50	70	105	155	260	430

304: PRESSURE DESIGN OF COMPONENTS

304.1.2 Straight Pipe Under Internal Pressure

(a) For t < D/6, the internal pressure design thickness shall not be less than that calculated in accordance with either Eq. (3a) or Eq. (3b):

$$t = \frac{PD}{2(SE + Py)} \qquad \text{Eq. (3a)}$$

(b) For t ≥ D/6, or for P/SE > 0.385, calculations of pressure design thickness for straight pipe requires special consideration of factors such as theory of failure, effects of fatigue, and thermal stress.

$$t_m = t + c$$

t_m = minimum required thicknes

t = pressure design thickness
c = mechanical and corrosion, erosion allowances
P = internal design gage pressure
D = Outside diameter of pipe
SE = Stress value incl. Quality factor from Table A
Y = coefficient from Table 304.1.1

B 31.3 TABLE A-1 (CONT´D)

BASIC ALLOWABLE STRESSES IN TENSION FOR METALS[1]

Numbers in Parentheses Refer to Notes for Appendix A Tables; Specifications Are ASTM Unless Otherwise Indicated[2]

Material	Spec. No.	P-No. (5)	Grade	Notes	Min. Temp., °F (6)	Specified Min. Strength, ksi		Min. Temp. to 100	200	300	400	500	60
						Tensile	Yield						
Stainless Steel (3) (4) Pipes and Tubes (2)													
18Cr–10Ni–Ti pipe smls > 3/8 in. thick	A 312	8	TP321	(30)(36)	–325	70	25	16.7	*16.7*	*16.7*	16.7	16.1	15.2
18Cr–10Ni–Ti pipe > 3/8 in. thick	A 376	8	TP321	(30)(36)	–325	70	25	16.7	*16.7*	*16.7*	16.7	16.1	15.2
18Cr–8Ni tube	A 269	8	TP304L	(14) (36)	–425	70	25	16.7	*16.7*	*16.7*	15.8	14.8	14.0
18Cr–8Ni pipe	A 312	8	TP304L	. . .	–425	70	25	16.7	*16.7*	*16.7*	15.8	14.8	14.0
Type 304L A 240	A 358	8	304L	(36)	–425	70	25	16.7	*16.7*	*16.7*	15.8	14.8	14.0
16Cr–12Ni–2Mo tube	A 269	8	TP316L	(14) (36)	–325	70	25	16.7	*16.7*	*16.7*	15.5	14.4	13.5
16Cr–12Ni–2Mo pipe	A 312	8	TP316L	. . .	–325	70	25	16.7	*16.7*	*16.7*	15.5	14.4	13.5
Type 316L A 240	A 358	8	316L	(36)	–325	70	25	16.7	*16.7*	*16.7*	15.5	14.4	13.5
18Cr–10Ni–Ti pipe smls > 3/8 in. thick	A 312	8	TP321	(28)(30)(36)	–325	70	25	16.7	*16.7*	*16.7*	16.7	16.1	15.2
18Cr–10Ni–Ti pipe > 3/8 in. thick	A 376	8	TP321	(28)(30)(36)	–325	70	25	16.7	*16.7*	*16.7*	16.7	16.1	15.2
18Cr–10Ni–Ti pipe smls > 3/8 in. thick	A 312	8	TP321H	(30)(36)	–325	70	25	16.7	*16.7*	*16.7*	16.7	16.1	15.2
18Cr–10Ni–Ti pipe > 3/8 in. thick	A 376	8	TP321H	. . .	–325	70	25	16.7	*16.7*	*16.7*	16.7	16.1	15.2

B

DOES NOT INCLUDE QUALITY FACTORS

TABLE A-1 (CONT'D)
BASIC ALLOWABLE STRESSES IN TENSION FOR METALS[1]

Numbers in Parentheses Refer to Notes for Appendix A Tables; Specifications Are ASTM Unless Otherwise Indicated

Material	Spec. No.	P-No. or S-No. (5)	Grade	Notes	Min. Temp., °F (6)	Specified Min. Strength, ksi		Min. Temp. to 100	200	300
						Tensile	Yield			
Carbon Steel (Cont'd)										
Pipes and Tubes (2) (Cont'd)										
...	A 53	1	B	(57)(59)	B					
...	A 106	1	B	(57)						
...	A 333									
...	A 334	1	6	(57)	−50	60	35	20.0	20.0	20.0
...	A 369	1	FPB	(57)	−20					
...	A 381	S-1	Y35	...	A					
...	API 5L	S-1	B	(57)(59)(77)	B					
...	A 139	S-1	C	(8b)	A	60	42			
...	A 139	S-1	D	(8b)	A	60	46	20.0	20.0	20.0
...	API 5L	S-1	X42	(55)(77)	A	60	42	20.0	20.0	20.0
...	A 381	S-1	Y42	...	A	60	42	20.0	20.0	20.0
...	A 381	S-1	Y48	...	A	62	48	20.6	19.7	18.7
...	API 5L	S-1	X46	(55)(77)	A	63	46	21.0	21.0	21.0
...	A 381	S-1	Y46	...	A	63	46	21.0	21.0	21.0
...	A 381	S-1	Y50	...	A	64	50	21.3	20.3	19.3
A 516 Gr. 65	A 671	1	CC65	(57)(67)	B	65	35	21.7	21.3	20.7
A 515 Gr. 65	A 671	1	CB65							
A 515 Gr. 65	A 672	1	B65	(57)(67)	A	65	35	21.7	21.3	20.7
A 516 Gr. 65	A 672	1	C65	(57)(67)	B					

B 31.3 TABLE A-1 (CONT´D)

TABLE A-1 (CONT'D)
BASIC ALLOWABLE STRESSES IN TENSION FOR METALS[1]
Numbers in Parentheses Refer to Notes for Appendix A Tables; Specifications Are ASTM Unless Otherwise Indicated

Basic Allowable Stress *S*, ksi (1), at Metal Temperature, °F (7)														
400	500	600	650	700	750	800	850	900	950	1000	1050	1100	Grade	Spec. No.
													Carbon Steel (Cont'd) Pipes and Tubes (2) (Cont'd)	
						SINGLE BAR: CAUTION RE USE ABOVE THIS TEMPERATURE - SEE NOTE.								
20.0	18.9	17.3	17.0	16.5	13.0	10.8	8.7	6.5	4.5	2.5	1.6	1.0	B	A 53
													B	A 106
													6	A 333
													6	A 334
													FPB	A 369
													Y35	A 381
													B	API 5L
						DOUBLE BAR: DO NOT USE ABOVE THIS TEMPERATURE (366°F PER NOTE)								
...	...	...	...	...	...	...	...	...	...	...	...	...	C	A 139
20.0	...	...	...	...	...	...	...	...	...	...	...	...	D	A 139
20.0	...	...	...	...	...	...	...	...	...	...	...	...	X42	API 5L
17.8	16.9	16.0	15.5	...	...	...	...	...	...	...	...	...	Y42	A 381
21.0	...	...	...	...	...	...	...	...	...	...	...	...	Y48	A 381
21.0	...	...	...	...	...	...	...	...	...	...	...	...	X46	API 5L
18.4	17.4	16.5	16.0	...	...	...	...	...	...	...	...	...	Y46	A 381
20.0	18.9	17.3	17.0	16.8	13.9	11.4	9.0	6.5	4.5	2.5	...	...	Y50	A 381
20.0	18.9	17.3	17.0	16.8	13.9	11.4	9.0	6.5	4.5	2.5	1.6	1.0	CC65	A 671
													CB65	A 671
													B65	A 672
													C65	A 672

B 31.3

TABLE 302.3.4

LONGITUDINAL WELD JOINT QUALITY FACTOR, E_j...

No.	Type of Joint		Type of Seam	Examination	Factor, E_j
1	Furnace butt weld, continuous weld		Straight	As required by listed specification	0.60 [Note (1)]
2	Electric resistance weld		Straight or spiral	As required by listed specification	0.85 [Note (1)]
3	Electric fusion weld				
	(a) Single butt weld		Straight or spiral	As required by listed specification or this Code	0.80
	(with or without filler metal)			Additionally spot radiographed per para. 341.5.1	0.90
				Additionally 100% radiographed per para. 344.5.1 and Table 341.3.2	1.00

304.2 Curved and Mitered Segments of Pipe

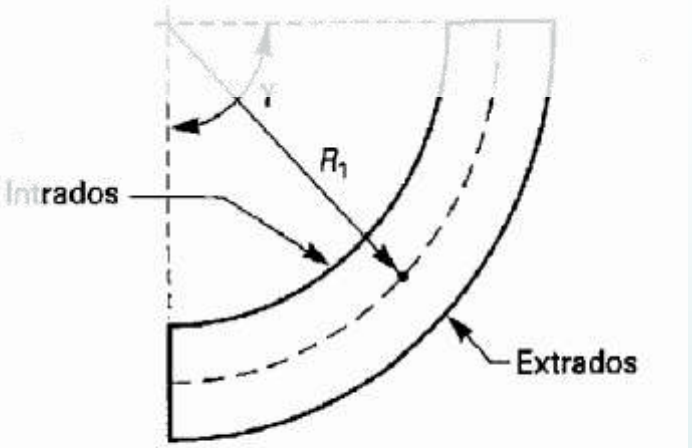


FIG. 304.2.1 NOMENCLATURE FOR PIPE BENDS

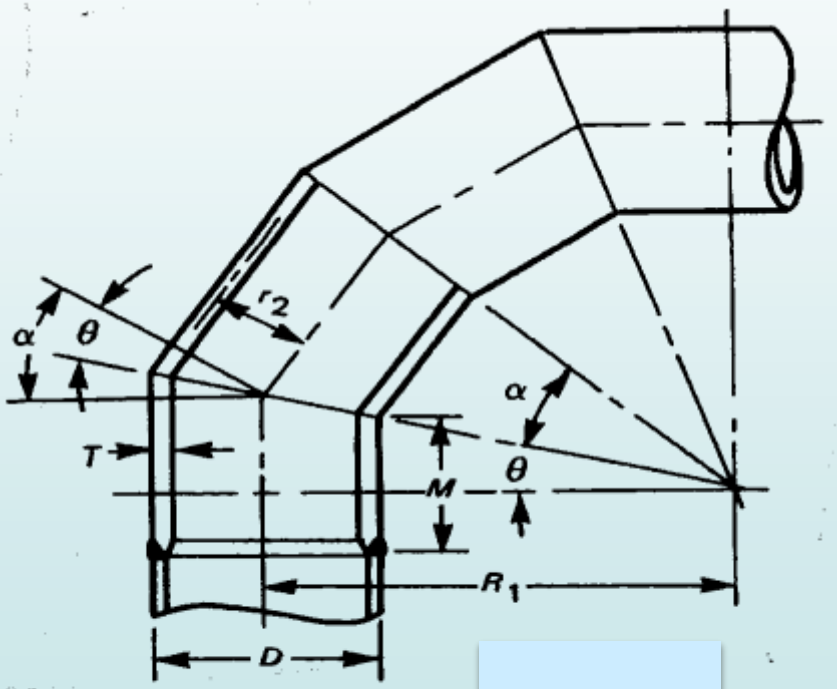


FIG. 304.2.3 NOMENCLATURE FOR MITER BENDS

304.2 Curved and Mitered Segments of Pipe

finished form shall be determined in accordance with Eq. (2) and Eq. (3c):

304.2 Curved and Mitered Segments of Pipe

304.2.1 Pipe Bends. The minimum required thickness t_m of a bend, after bending, in its

$$t = \frac{PD}{2[(SE/I) + PY]}$$

where at the intrados (inside bend radius)

and at the extrados (outside bend radius)

$$I = \frac{4(R_1/D) - 1}{4(R_1/D) - 2}$$

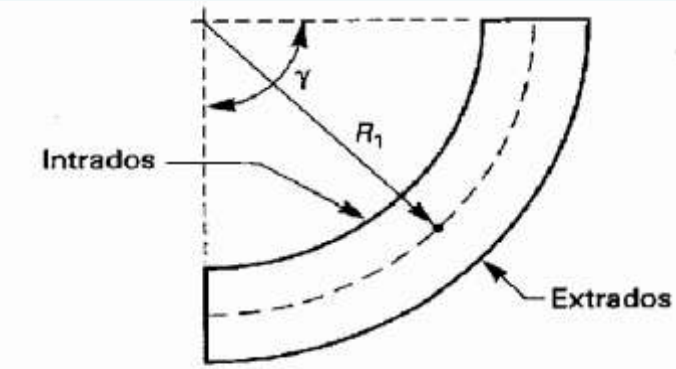


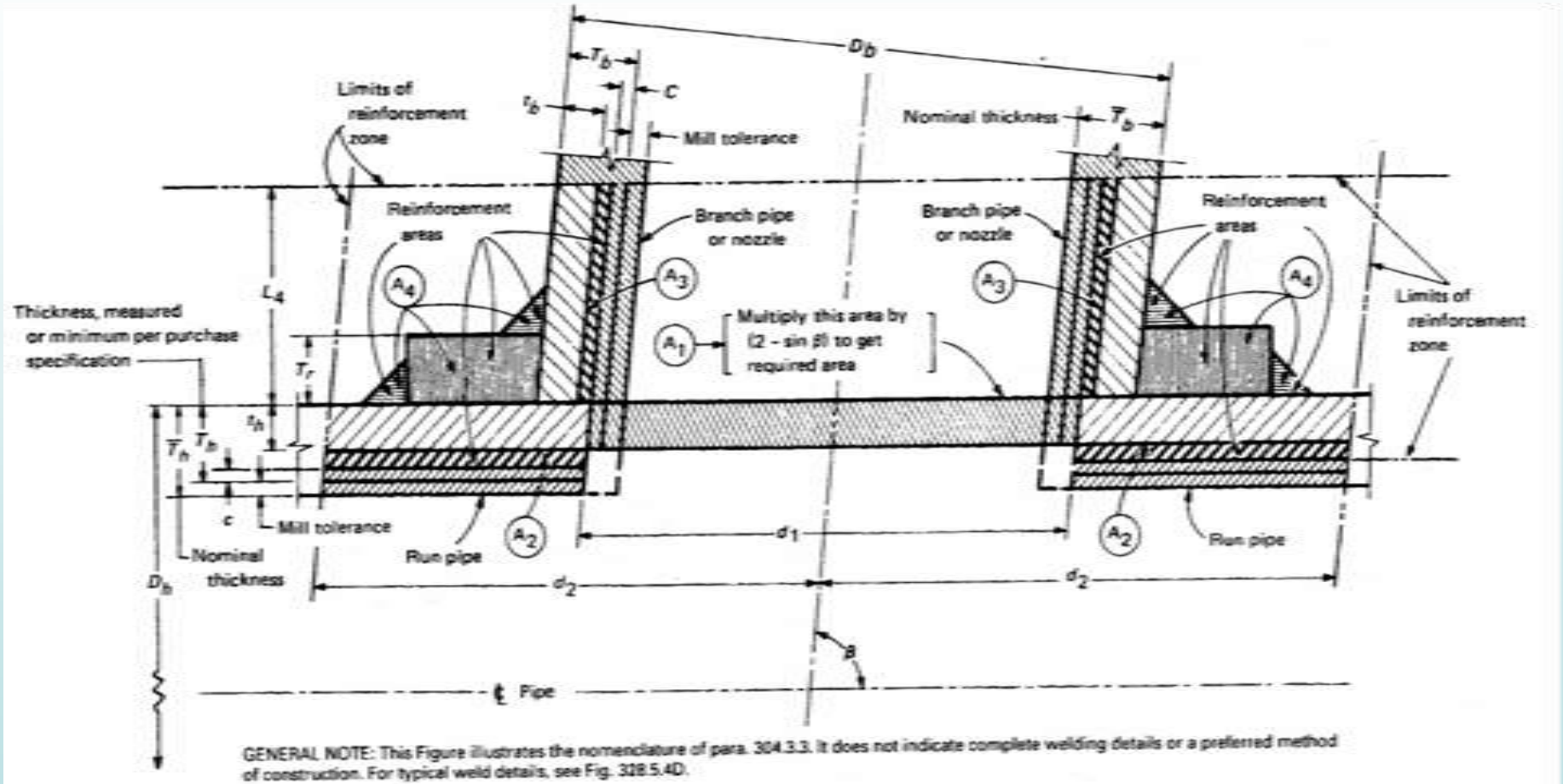
FIG. 304.2.1 NOMENCLATURE FOR PIPE BENDS

and at the sidewall on the bend centerline radius, I = 1.0.

R_1 = bend radius of welding elbow or pipe bend Thickness variations from the intrados to the extrados and along the length of the bend shall be gradual. The thickness requirements apply at the mid-span of the bend, y/2, at the intrados, extrados, and bend centerline radius. The minimum thickness at the end tangents shall not be less than the requirements of para. 304.1 for straight pipe (see Fig. 304.2.1).

$$I = \frac{4(R_1/D) + 1}{4(R_1/D) + 2}$$

304.3 Branch Connections



GENERAL NOTE: This Figure illustrates the nomenclature of para. 304.3.3. It does not indicate complete welding details or a preferred method of construction. For typical weld details, see Fig. 328.5.4D.

FIG. 304.3.3 BRANCH CONNECTION NOMENCLATURE

B 31.3 Piping Components

305	Pipe (Material and Service Limitations) - App. A
306	Fittings, Bends and Branch Connections
307	Valves and Specialty Components
308	Flanges, Blanks, Gaskets
309	Bolting
310	Piping Joints - General
311	Welded Joints
312ff	Flanged Joints and other joints
319	Flexibility and Analysis
321	Supporting

319.4 Flexibility Analysis

319.4 Flexibility Analysis

319.4.1 Formal Analysis Not Required.

No formal analysis of adequate flexibility is required for a piping system which:

(a) duplicates, or replaces without significant change, a system operating with a successful service record;

(b) can readily be judged adequate by comparison with previously analyzed systems;

(c) is of uniform size, has no more than two points of fixation, no intermediate restraints, and falls within the limitations of empirical Eq. (16):

$$\frac{Dy}{(L-U)^2} \leq K_1$$

where

D = outside diameter of pipe, mm (in.)

y = resultant of total displacement strains, mm (in.), to be absorbed by the piping system

L = developed length of piping between anchors, m (ft)

U = anchor distance, straight line bet m (ft)

K_1 = 208,000 S_A/E_a, $(mm/m)^2$ = 30 S_A/E_a, $(in./ft)^2$

319.4 Flexibility Analysis

where
SA = allowable displacement stress range per Eq. (I a), MPa (ksi)

Ea = reference modulus of elasticity al MPa (ksi)

319.4.2 Formal Analysis Requirements

(a) Any piping system which does not meet the criteria in para. 319.4.1 shall be analyzed by a simplified, approximate, or comprehensive method of analysis, as appropriate.

(b) A simplified or approximate method may be applied only if used within the range of configurations for which its adequacy has been demonstrated.

(c) Acceptable comprehensive methods of analysis include analytical and chart methods which provide an evaluation of the forces, moments, and stresses caused by displacement strains (see para. 319.2.1).

(d) Comprehensive analysis shall take into account stress intensification factors for any component other than straight pipe. Credit may be taken for the extra flexibility of such a component.

ASME B 31.3

Chapter III: Materials

Listed Materials: (Appendix A shows stress values) are acceptable.

Unlisted Material may be used provided it meets the Code

323.2.3 Temperature Limits
lower limits: Table A-1 sets absolute limits
Table 323.2.2 - Requirements for Impact Testing
upper limits: Table A-1 sets limits
Exemptions per 323.2.1

Section II- C Filler Metals شناسایی فلزات پرکننده در AWS

SFA- 5.1, 5.5: SMAW Electrode Classification

E7018, E7018M, E7016-1HzR

E XXX X X XX

Electrode

Strength in KSI

Position
- 1= All Position
- 2= Flat and horizontal fillets
- 4= Vertical down

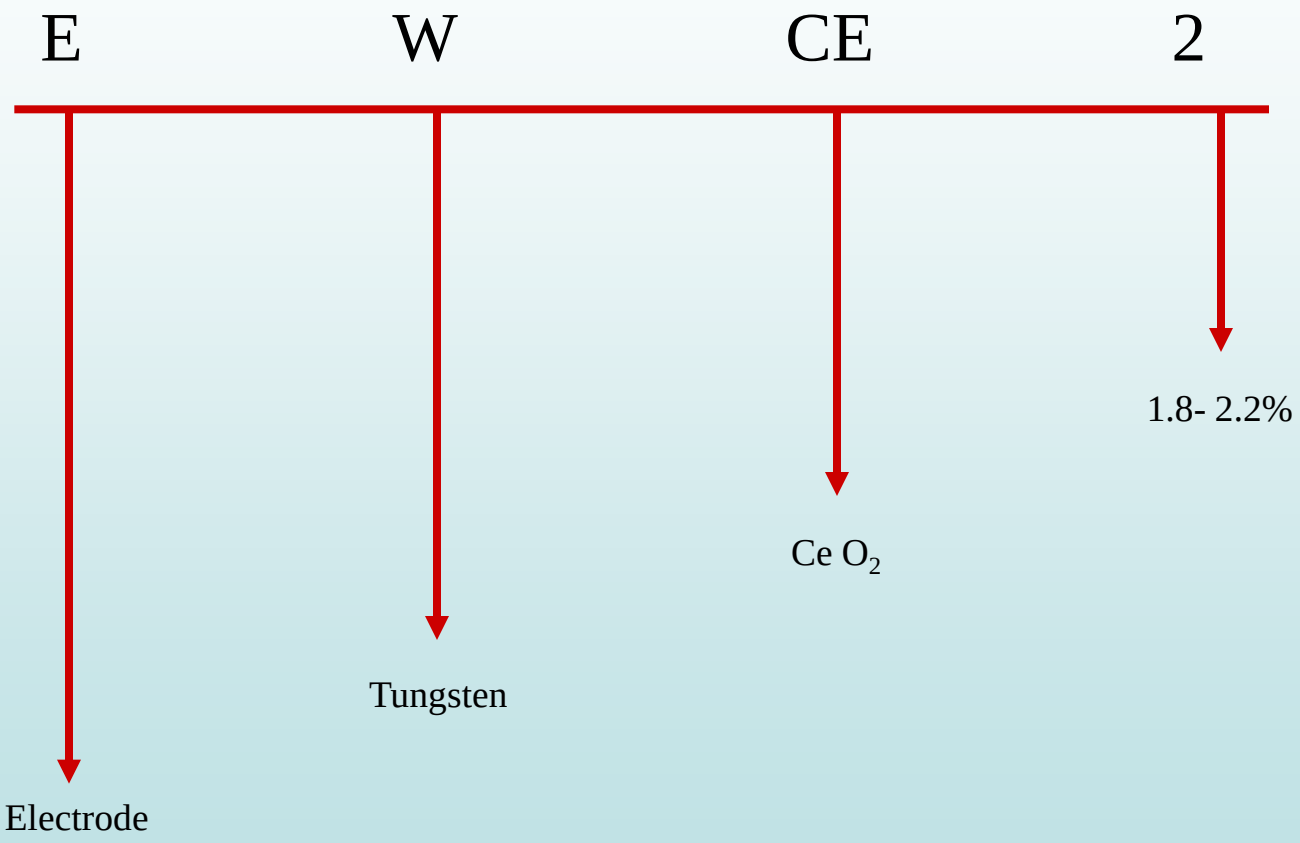
- 0= DCEP d
- 1= AC or DCEP d
- 2= AC or DCEN m
- 3= AC or DC i
- 4= AC or DC i
- 5= DCEP m
- 6= AC or DCEP m
- 7= AC or DCEP m

"penetration"

Chemical Composition of weld Deposit

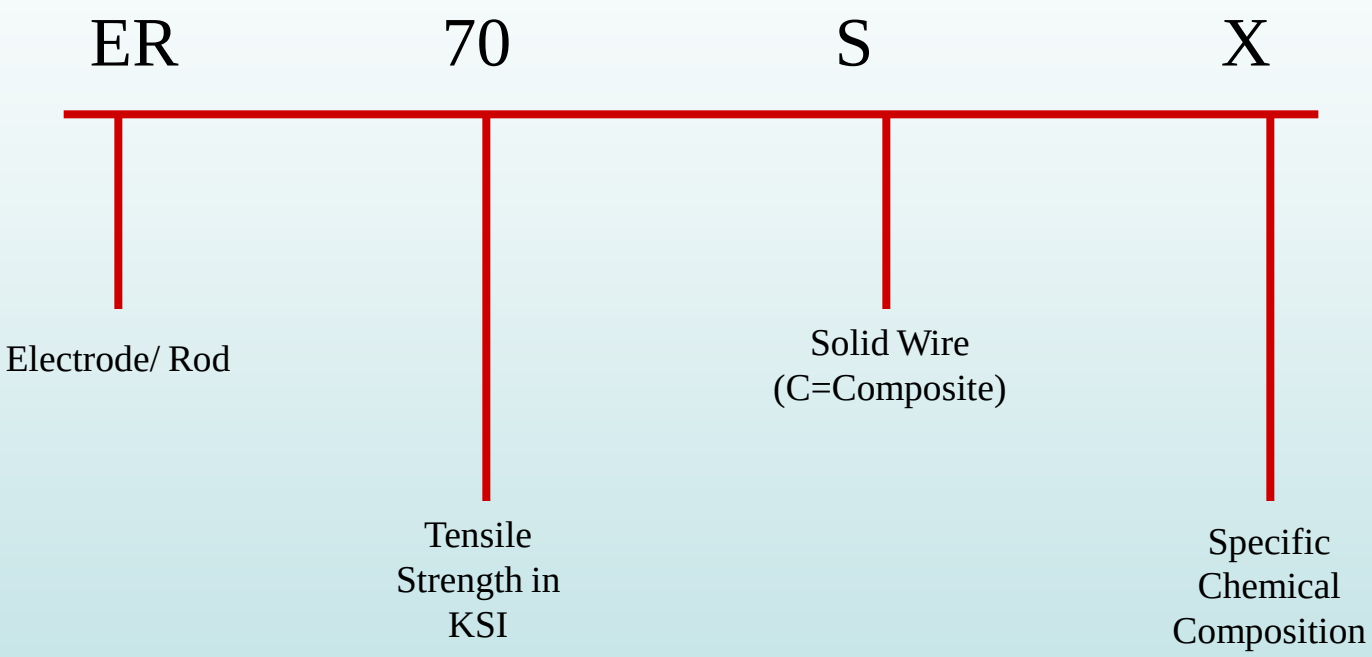
Section II- C Filler Metals شناسایی فلزات پرکننده در AWS

GTAW SFA-5.12 Electrode Classification



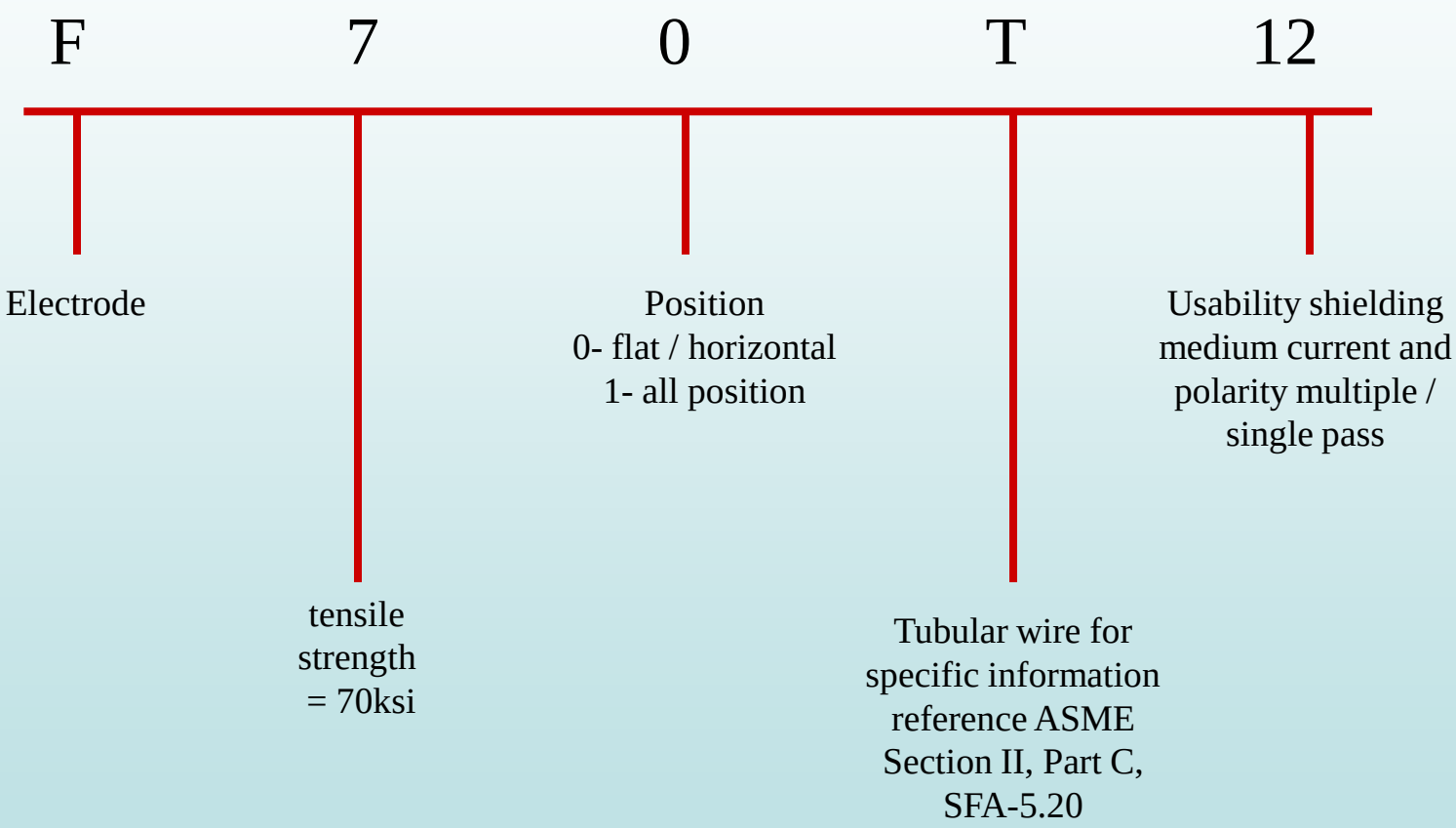
Section II- C Filler Metals شناسایی فلزات پرکننده در AWS

GMAW SFA-5.18 Electrode Classification



ASME Section II- C شناسایی فلزات پرکننده در AWS

FCAW SFA-5.20 Electrode Classification



F-No الکترودها و مفتول‌های پرکنندهٔ فولادکربنی و فولادهای آلیاژی

QW-432- F- Numbers

F-No.	ASME Specification Steel and Steel Alloys	AWS Classification
1	SFA-5.1	EXX20, EXX22, EXX24, EXX27, EXX28
1	SFA-5.4	EXXX(X)-25, EXXX(X)-26
1	SFA-5.5	EXX20-X, EXX27-X
2	SFA-5.1 & 5.5	EXX12, EXX13, EXX14, EXX19, E(X)XX13-X
3	SFA-5.1 & 5.5	EXX10, EXX11, E(X)XX10-X, E(X)XX11-X
4	SFA-5.1	EXX15, EXX16, EXX18, EXX48
4	SFA-5.4 other than austenitic and duplex	EXXX(X)15, EXXX(X)16, EXXX(X)17
4	SFA-5.5	E(X)XX15-X, E(X)XX16-X, E(X)XX18-X
5	SFA-5.4 (austenitic and duplex)	EXXX(X), EXXX(X)16, EXXX(X)17
6	SFA-5.2	All Classifications
6	SFA-5.9	All Classifications
6	SFA-5.17, SFA-5.18	All Classifications
6	SFA-5.20	All Classifications
6	SFA-5.22, SFA-5.23	All Classifications
6	SFA-5.25, SFA-5.26	All Classifications
6	SFA-5.28, SFA-5.29	All Classifications
6	SFA-5.30	IN Ms-X, IN 5XX, In 3XX(X)

Continued….

QW -440 ترکیب شیمیایی جوش

- ترکیب شیمیایی فلز جوش براساس QW-404.5 باید در WPS و PQR مشخص شود.

QW-422
A-Numbers
Classification of Ferrous Weld Metal Analysis for Procedure Qualification

		Analysis, % [Note (1)]					
A-no.	Type of Weld Deposit	C	Cr	Mo	Ni	Mn	Si
1	Mill Steel	0.20	…	…	…	1.60	1.00
2	Carbon – Molybdenum	0.15	0.50	0.40-0.65	…	1.60	1.00
3	Carbon (0.4% to 2%) – Molybdenum	0.15	0.40-2.00	0.40-0.65	…	1.60	1.00
4	Carbon (2% to 6%)- Molybdenum	0.15	2.00-6.00	0.40-1.50	…	1.60	2.00
5	Carbon (6% to 10.5%)- Molybdenum	0.15	6.00-10.50	0.40-1.50	…	1.20	2.00
6	Carbon – martensitic	0.15	11.00-15.00	0.70	…	2.00	1.00
7	Carbon - Ferritic	0.15	11.00-30.00	1.00	…	1.00	3.00
8	Chromium- nickel	0.15	14.50-3.00	4.00	7.50-15.00	2.50	1.00
9	Chromium- Nickel	0.30	19.00-30.00	6.00	15.00-37.00	2.50	1.00
10	Nickel to 4%	0.15	…	0.55	0.80-4.00	1.70	1.00
11	Manganese- Molybdenum	0.17	…	0.25-0.75	0.85	1.25-2.25	1.00
12	Nickel – Chrome- Molybdonum	0.15	1.50	0.25-0.80	1.25-2.80	0.75-2.25	1.00

Note:
(1) Single Values shown above are Maximum.

QW/ QB – 422 Ferrous P-Numbers and S-Numbers

Grouping of Base Metals for Qualification

Spec. No.	Type or Grade	UNS No.	Minimum Specified Tensile, ksi [Note (1)].	Welding				Brazing		Nominal Composition	Product Form
				P-No.	Group No.	S-No.	Group No.	P-No.	S-No.		
SA-36	…	K02600	58	1	1	…	…	101	…	C-Mn-Si	Plate
SA-53	Type F	…	48	1	1	…	…	101	…	C	Furnace Welded Pipe
SA-53	Type S, Gr. A	K02504	48	1	1	…	…	101	…	C	Smls. pipe
SA-53	Type S, Gr. A	K02504	48	1	1	…	…	101	…	C	Resistance welded pipe
SA-53	Type S, Gr. B	K03005	60	1	1	…	…	101	…	C-Mn	Resistance welded pipe
SA-53	Type S, Gr. B	K03005	60	1	1	…	…	101	…	C-Mn	Smls. pipe
SA-105	…	K03504	70	1	2	…	…	101	…	C-Si	Pipeflange
SA-106	A	K02501	48	1	1	…	…	101	…	C-Si	Smls. pipe
SA-106	B	K03006	60	1	1	…	…	101	…	C-Si	Smls. pipe
SA-106	C	K03501	70	1	2	…	…	101	…	C-Si	Smls. pipe
A-108	1015 CW	G10150	60	…	…	1	1	…	101	C	Bar
A-108	1018 CW	G10180	60	…	…	1	1	…	101	C	Bar
A-108	1020 CW	G10200	60	…	…	1	1	…	101	C	Bar

Section IX Base Material P-Numbers

1	**Carbon Steel**
3	**Up to ½% Cr and up to ½% Mo**
4	**1 to 2% Cr and up to ½% Mo**
5A	**2 to 3% Cr, 1% Mo Alloy Steel**
5B	**5 to 10% Cr, 1% Mo Alloy Steel**
5C	**All 5A and 5B Materials heat treated to 85ksi+**
6	**Martensite Stainless Steel**
7	**Ferrite Stainless Steel**
8	**Austenitic Stainless Steel**
9	**2 to 5% Ni Alloy Steel**
10	**Mn- V, Cr-V, 9% Ni, High Cr Alloy Steels**
11	**Low Alloy Steel, Quenched and Tempered to 95ksi+**
21	**1.2% Mg of Mn Alloy Aluminum**
22	**1.2% Mn, 2.5% Mg, 0.25% Cu Aluminum**
23	**1.3% Mg, 0.7% Si, 0.25% Cr Aluminum**
25	**1.5% Mg, 0.8% Mn, 0.15% Cr Aluminum**
31	**Copper**
32	**Admiralty, Naval, Aluminum Brass, Muntz Metal**
33	**Cu- Si Alloys**
34	**Cu- Ni Alloys**
41	**Nickel**
51	**Titanium**
61	**Zirconium**

ASME Section II Part C SFA-Numbers

SFA-5.1	**Carbon Steel Electrodes for Shielded Metal Arc welding**
SFA-5.2	**Carbon and Low Steel Rods for Oxyfuel Gas Welding**
SFA-5.3	**Aluminum and Aluminum Alloy Electrodes for Shielded Metal Arc Welding**
SFA-5.4	**Stainless Steel Electrodes for. Shielded Metal Arc Welding**
SFA-5.5	**Low – Alloy Steel Electrodes for Shielded Metal Arc Welding**
SFA-5.6	**Covered Copper and Copper Alloy Arc Welding Electrodes**
SFA-5.7	**Copper and Copper Alloy Bare Welding Rods and electroes**
SFA-5.8	**Filler metal for Brazing and Braze Welding**
SFA-5.9	**Bare Stainless Steel Welding Electrodes and Rods**
SFA-5.10	**Bare Aluminum and Aluminum Alloy Welding Electrodes and Rods**
SFA-5.11	**Nickel and Nickel Alloy Welding Electrodes for Shielded Metal Arc Welding**
SFA-5.12	**Tungsten and Tungsten Alloy Electrodes. For Arc Welding and Cutting**
SFA-5.13	**Solid Surfacing Welding Rods and Electrodes**
SFA-5.14	**Nickel and Nickel Alloy Bare Welding Electrodes and Rods**
SFA-5.15	**Welding Electrodes and Rods for Case Iron**
SFA-5.16	**Titanium and Titanium Alloy Welding Rods and Electrodes**
SFA-5.17	**Carbon Steel Electrodes and Fluxes for Submerged Arc Welding**
SFA-5.18	**Carbon Steel Filler metals for Gas Shielded Arc Welding**
SFA-5.20	**Carbon Steel Electrodes for Flux Cored Arc Welding**
SFA-5.21	**Composite Surfacing Welding Rods and Electrodes**
SFA-5.22	**Stainless Steel Electrodes for Flux Cored Arc Welding and Stainless Steel Flux Cored Rods for Gas Tungsten Arc Weling**
SFA-5.23	**Low Alloy Steel Electrodes and Fluxes for Submerged Arc Welding**

ASME Code Section IX

P-No. لیست خلاصه

Base Metal	Welding	Brazing
Steel and Steel alloys	P-No. 1 through P-No. 11 inch. P-No. 5A, 5B, and 5C	P-No. 101 through P-No. 103
Aluminum and aluminum – base alloys	P-No. 21 through P-No.25	P-No. 104 and P-No. 105
Copper and copper-base alloys	P-No. 31 through P-No. 35	P-No. 107 and P-No. 108
Nickel and nickel- base alloys	P-No. 41 through P-No. 47	P-No. 110 through P-No. 112
Titanium and titanium-base alloys	P-No. 51 through P-No. 53	P-No. 115
Zirconium and zirconium – base alloys	P-No. 61 through P-No. 62	P-No. 117

ASME Code Section IX

- اگر فلز پایه‌ای با شماره شناسایی UNS برای آن P-No. و Group-No. در نظر گرفته شده باشد. هر فلز پایه‌ای با هر شماره ASME بشرطی که UNS-No. آنها یکی باشد، همان P-No. و Group-No را خواهند داشت. به عنوان مثال SB-163 با UNS No8800 دارای P-No. 45 است. بنابراین تمام فلزات با UNS No8800 نظیر SB-407، SB-408، SB-514 و غیره همان P-No. 45 را دارند.

ASME Code Section IX

QW-400.2 S- Numbers (Non- Mandatory)

- S-No. برای آن دسته از فلزاتی که صرفا توسط ASM B 31. تأیید شده‌اند و یا آن موادی که توسط Code Cases پذیرفته شده‌اند اما در لیست فلزات مجاز ASME Sec II قرار ندارد، طراحی شده است.
- این مواد تحت S-No. یا S-No. به همراه Group- No.هایی که شبیه P-No.ها هستند طبقه‌بندی شده‌اند. اما استفاده از S-No. اجباری نیست.
- روش‌های جوشکاری که با یک P-No. یا P-No به همراه Group-No. تأیید شده باشند برای تمام S-No. ها یا S-No.ها به همراه Group-No. تأیید هستند.
- روش‌های جوشکاری که با یک S-No. یا S-No. به همراه Group-No. تأیید می‌شوند. برای فلزات با P-No. مورد تأیید نیستند.
- روش‌های جوشکاری که از فلزاتی استفاده می‌کنند که دارای P-No. یا S-No. نیستند باید هر یک بطور جداگانه تأیید شوند.

ASME Code Section IX

- مواد‌ی که تحت استاندارد ASME تولید می‌شوند نیز باید تحت S-No. یا P-No. به همراه Group-No. در نظر گرفته شوند. به عنوان مثال: چون SA-240 Type 304 دارای Group-No.1 و P-No. 8 است بنابراین فولاد A 240 Type 304 هم دارای Group- No. 1 و S-No. 8 می‌باشد.
- جهت آزمایش تأیید مهارت جوشکاران در صورتیکه مهارت جوشکاری بر اساس P-No. یا P-No. به همراه Group-No. تأیید گرد وی برای تمام S-No. یا S-No به همراه Group-No.های مشابه تأیید خواهد شد. عکس این موضوع نیز صادق است.

ASME Code Section IX

QW-430 F- Numbers

- شماره‌های F-No. در جدول QW-432 با این هدف طراحی شده‌اند، که تعداد PQR ها و WPQ ها را به حداقل برسانند.
- مبنای اساسی F-No. عبارت است از قابلیت استفاده Usability الکترودها و فلزات پرکننده
- طبقه‌بندی‌های F-No. به معنای جایگزینی فلزات پرکننده و الکترود با یکدیگر بدون در نظر گرفتن تطابق ترکیب فلز پایه و فلز پرکننده، خواص مکانیکی، ساختار متالوژیکی، عملیات حرارتی پس از جوشکاری و ملاحظات بهره‌برداری نیست.

QW-432.1	Steel and Steel Alloys
QW-432.2	Aluminum and Aluminum – base Alloys
QW-432.3	Copper and Copper- Base Alloys
QW-432.4	Nickel and Nickel- Base Alloys
QW-432.5	Titanium and Titanium Alloys
QW-432.6	Zirconium and Zirconium Alloys
QW-432.7	Hard-Facing Weld Metal Overlay

ASME Material Specification

A – 516 (90) Gr 60

ASTM Material

Acceptance for use in Code Constructions

ASME Code Committee on Materials

SA – 516 Gr 60 (Type, Class)

ASME Material

Published in Section II Part A/B

no year

Society for ASME

B 31.3 TABLE A-1

DOES NOT INCLUDE QUALITY FACTORS

B31_3.PPT 09/03

TABLE A-1 (CONT'D)
BASIC ALLOWABLE STRESSES IN TENSION FOR METALS[1]

Numbers in Parentheses Refer to Notes for Appendix A Tables; Specifications Are ASTM Unless Otherwise Indicated

Material	Spec. No.	P-No. or S-No. (5)	Grade	Notes	Min. Temp., °F (6)	Specified Min. Strength, ksi		Min. Temp. to 100	200	300
						Tensile	Yield			
Carbon Steel (Cont'd)										
Pipes and Tubes (2) (Cont'd)										
...	A 53	1	B	(57)(59)	B					
...	A 106	1	B	(57)						
...	A 333	1	6	(57)	−50	60	35	20.0	20.0	20.0
...	A 334									
...	A 369	1	FPB	(57)	−20					
...	A 381	S-1	Y35	...	A					
...	API 5L	S-1	B	(57)(59)(77)	B					
...	A 139	S-1	C	(8b)	A	60	42			
...	A 139	S-1	D	(8b)	A	60	46	20.0	20.0	20.0
...	API 5L	S-1	X42	(55)(77)	A	60	42	20.0	20.0	20.0
...	A 381	S-1	Y42	...	A	60	42	20.0	20.0	20.0
...	A 381	S-1	Y48	...	A	62	48	20.6	19.7	18.7
...	API 5L	S-1	X46	(55)(77)	A	63	46	21.0	21.0	21.0
...	A 381	S-1	Y46	...	A	63	46	21.0	21.0	21.0
...	A 381	S-1	Y50	...	A	64	50	21.3	20.3	19.3
A 516 Gr. 65	A 671	1	CC65	(57)(67)	B	65	35	21.7	21.3	20.7
A 515 Gr. 65	A 671	1	CB65							
A 515 Gr. 65	A 672	1	B65	(57)(67)	A	65	35	21.7	21.3	20.7
A 516 Gr. 65	A 672	1	C65	(57)(67)	B					

B 31.3 TABLE A-1 (CONT´D)

TABLE A-1 (CONT'D)
BASIC ALLOWABLE STRESSES IN TENSION FOR METALS[1]

Numbers in Parentheses Refer to Notes for Appendix A Tables; Specifications Are ASTM Unless Otherwise Indicated

Basic Allowable Stress *S*, ksi (1), at Metal Temperature, °F (7)														
400	500	600	650	700	750	800	850	900	950	1000	1050	1100	Grade	Spec. No.
													Carbon Steel (Cont'd) Pipes and Tubes (2) (Cont'd)	
						SINGLE BAR: CAUTION RE USE ABOVE THIS TEMPERATURE - SEE NOTE.								
20.0	18.9	17.3	17.0	16.5	13.0	10.8	8.7	6.5	4.5	2.5	1.6	1.0	B	A 53
													B	A 106
													6	A 333
													6	A 334
													FPB	A 369
													Y35	A 381
													B	API 5L
						DOUBLE BAR: DO NOT USE ABOVE THIS TEMPERATURE (366°F PER NOTE)								
...	...	...	...	...	...	...	...	...	...	...	...	...	C	A 139
...	...	...	...	...	...	...	...	...	...	...	...	...	D	A 139
20.0	...	...	...	...	...	...	...	...	...	...	...	...	X42	API 5L
20.0	...	...	...	...	...	...	...	...	...	...	...	...	Y42	A 381
17.8	16.9	16.0	15.5	...	...	...	...	...	...	...	...	...	Y48	A 381
21.0	...	...	...	...	...	...	...	...	...	...	...	...	X46	API 5L
21.0	...	...	...	...	...	...	...	...	...	...	...	...	Y46	A 381
18.4	17.4	16.5	16.0	...	...	...	...	...	...	...	...	...	Y50	A 381
20.0	18.9	17.3	17.0	16.8	13.9	11.4	9.0	6.5	4.5	2.5	...	...	CC65	A 671
20.0	18.9	17.3	17.0	16.8	13.9	11.4	9.0	6.5	4.5	2.5	1.6	1.0	CB65	A 671
													B65	A 672
													C65	A 672

Table 323.2.2 Low Temperature

TABLE 323.2.2
REQUIREMENTS FOR LOW TEMPERATURE TOUGHNESS TESTS FOR METALS
These Toughness Test Requirements Are in Addition to Tests Required by the Material Specification

Type of Material	Column A Design Minimum Temperature at or Above Min. Temp. in Table A-1 or Fig. 323.2.2A		Column B Design Minimum Temperature Below Min. Temp. in Table A-1 or Fig. 323.2.2A
1 Gray cast iron	A-1 No additional requirements		B-1 No additional requirements
2 Malleable and ductile cast iron; carbon steel per Note (1)	A-2 No additional requirements		B-2 Materials designated in Box 2 shall not be used.
	(a) Base Metal	(b) Weld Metal and Heat Affected Zone (HAZ) [Note (2)]	
3 Other carbon steels; low and intermediate alloy steels; high alloy ferritic steels; duplex stainless steels	A-3 (a) No additional requirements	A-3 (b) Weld metal deposits shall be impact tested per para. 323.3 if design min. temp. $< -29°C$ ($-20°F$), except as provided in Notes (3) and (5), and except as follows: for materials listed for Curves C and D of Fig. 323.2.2A, where corresponding welding consumables are qualified by impact testing at the design minimum temperature or lower in accordance with the applicable AWS specification, additional testing is not required.	B-3 Except as provided in Notes (3) and (5), heat treat base metal per applicable ASTM specification listed in para. 323.3.2; then impact test base metal, weld deposits, and HAZ per para. 323.3 [see Note (2)]. When materials are used at design min. temp. below the assigned curve as permitted by Notes (2) and (3) of Fig. 323.2.2A, weld deposits and HAZ shall be impact tested [see Note (2)].
4 Austenitic stainless steels	A-4 (a) If: (1) carbon content by analysis $\geq 0.1\%$; or (2) material is not in solution heat treated condition; then, impact test per para. 323.3 for design min. temp. $< -29°C$ ($-20°F$) except as provided in Notes (3) and (6)	A-4 (b) Weld metal deposits shall be impact tested per para. 323.3 if design min. temp. $< -29°C$ ($-20°F$) except as provided in para. 323.2.2 and in Notes (3) and (6)	B-4 Base metal and weld metal deposits shall be impact tested per para. 323.3. See Notes (2), (3), and (6).

Fig. 323.2.2A Min. Temp. Without Impact Testing

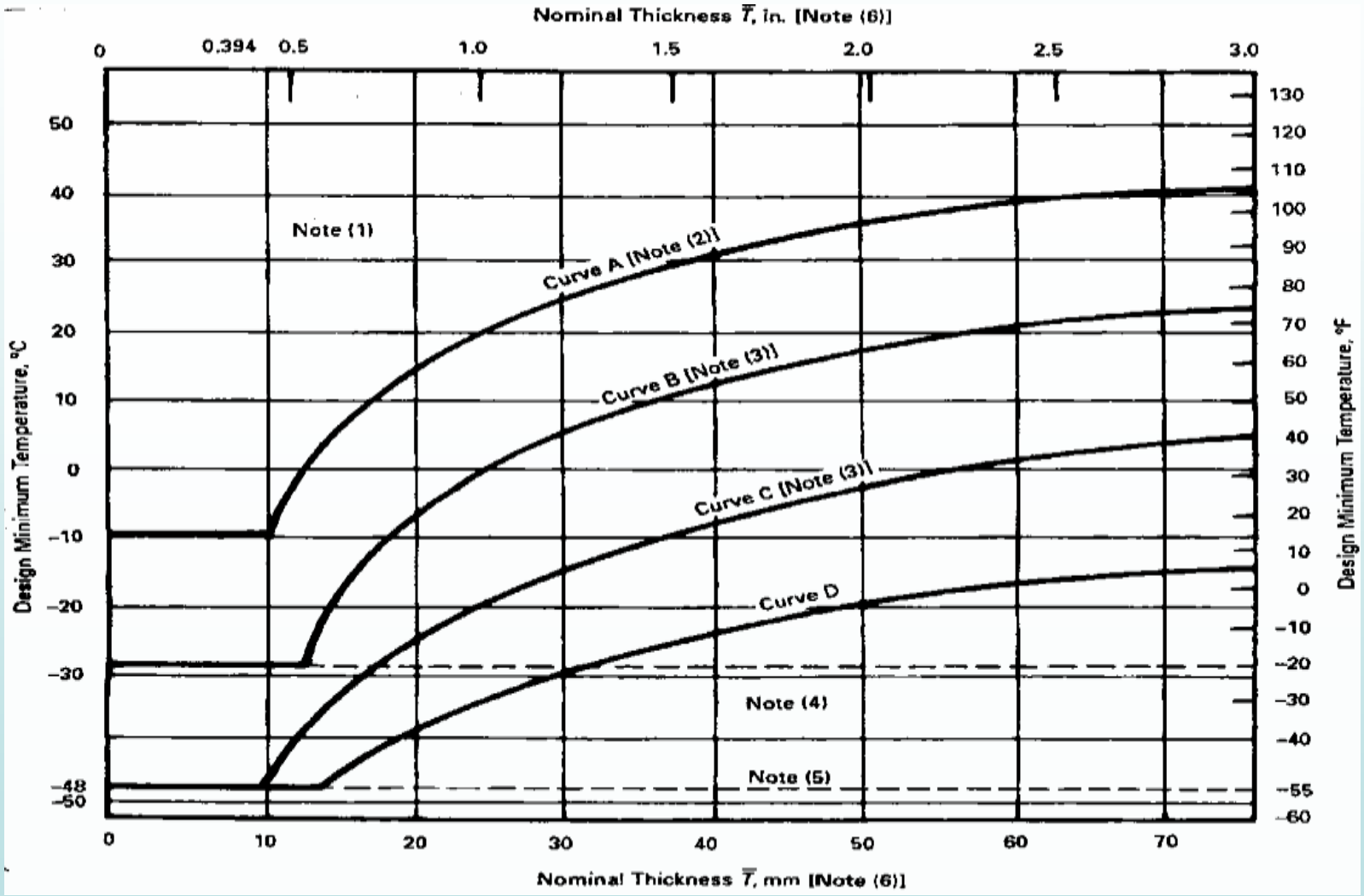
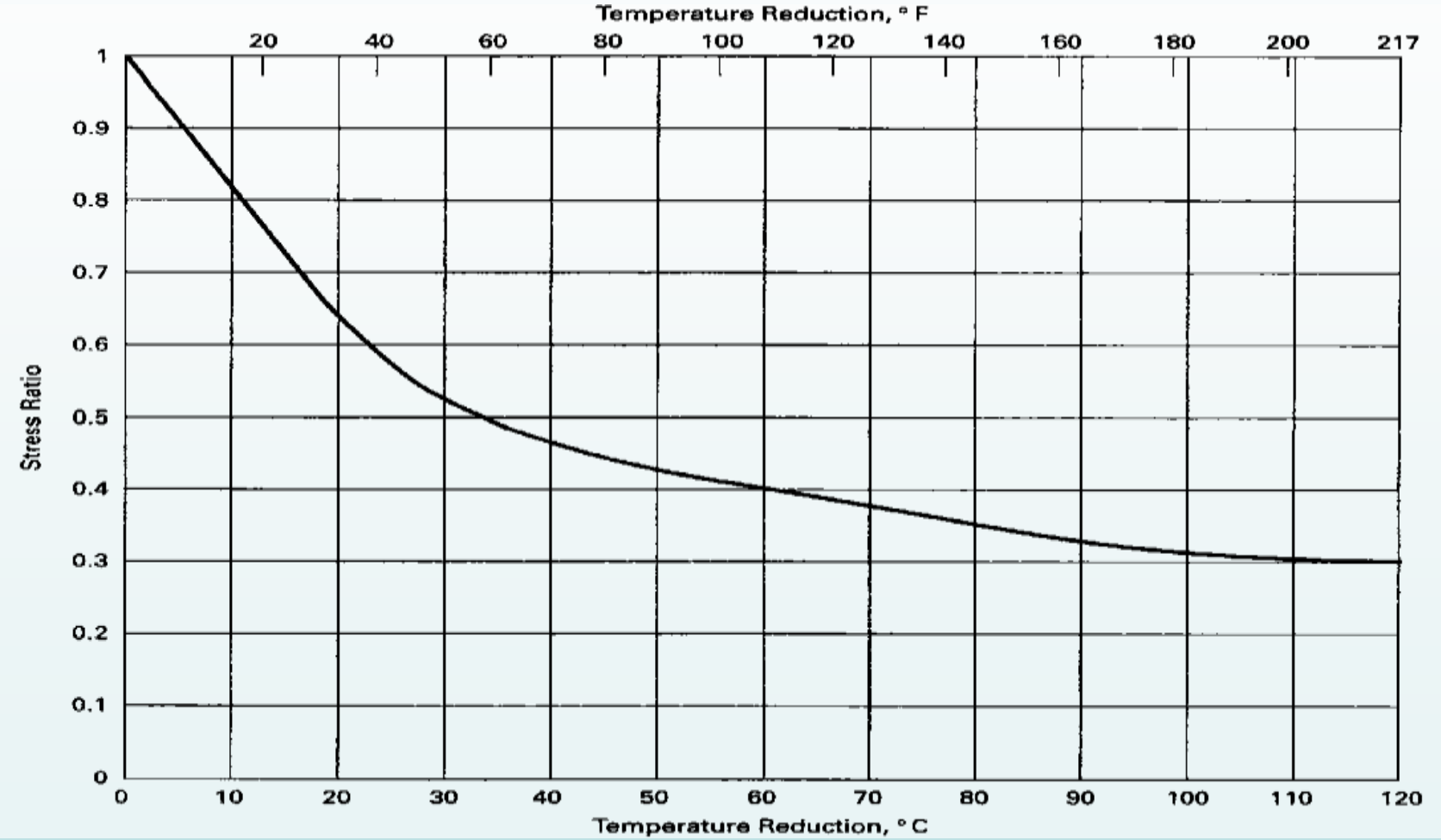


Fig. 323.2.2B MDMT Reduction

FIG. 323.2.2B REDUCTION IN MINIMUM DESIGN METAL TEMPERATURE WITHOUT IMPACT TESTING



B31_3.PPT 9-03

B 31.3

Fig. 323.2.2B MDMT Reduction

GENERAL NOTES:

(a) The Stress Ratio is defined as the maximum of the following:

(1) nominal pressure stress (based on minimum pipe wall thickness less allowances) divided by S at the design minimum temperature;

(2) for piping components with pressure ratings, the pressure for the condition under consideration divided by the pressure rating at the design minimum termperature;

(3) combined longitudinal stress due to pressure, dead weight, and displacement strain (stress intensification factors are not included in this calculation) divided by S at the design minimum temperature. In calculating longitudinal stress, the forces and moments in the piping system shall be calculated using nominal dimensions and the stresses shall be calculated using section properties based on the nominal dimensions less corrosion, erosion, and mechanical allowances.

(b) Loadings coincident with the metal temperature under consideration shall be used in determining the Stress Ratio as defined above.

B 31.3

Chapter V: Fabrication, Assembly, Erection

328: Welding ⇒ ASME Code Section IX for test requirements
Procedures and performance may be qualified by others
Manufacturer is responsible.
327.3: Welding Materials ⇒ ASME Code Section IX

327.4: Preparation for Welding, Cleaning, Misalignment Tolerances

327.5: Welding Requirements
Butt welds, fillet welds, welded branch connections, attachment welds
Welding preheat (330)
Heat treatment (331, Table 331.1.1- Exemption Footnotes)

332: Bending and Forming

B 31.3 CHAPTER V

328.2 Welding Qualifications

328.2.1 Qualification Requirements

(a) Qualification of the welding procedures to used and of the performance of welders and weld operators shall conform to the requirements of the BPV Code, Section IX except as modified herein.

(b) Where the base metal will not withstand the 180 deg. guided bend required by Section IX, a qualify welded specimen is required to undergo the same deg of bending as the base metal, within 5 deg.

ASME Code Section IX

Qualification of a Welding Procedure تایید کیفیت روش

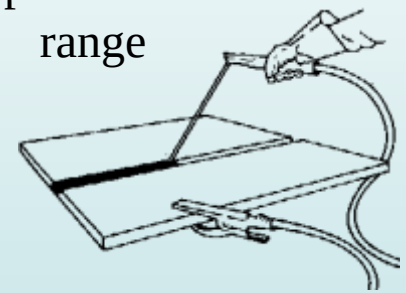
Drawing + Construction Code
Materials
Design
Impact testing
PWHT etc.

RTC

Draft WPS
Range of
Welding
Variables
Essentials and
nonessentials

RTC

Welding of a test coupon from the range



testing

PQR
Record of
Actual values
And results

Certification
Date Signature

RTC

Documentation

WPS
Essentials +
nonessentials

Date
Signature

RTC

Qualification

ASME Code Section IX

QW – 250 ff Samples

متغیرهای WPS

Paragr.	Brief	
QW 402.1	Groove Design	Nonessential Variable

No new PQR, just WPS Revision

QW -403.11 P-No. qualified — Essential Variable

SA-516 Gr. 60	P-No. 1	
SA-240-360 L	P-No.8	

New PQR, new WPS

QW 403.5 Group number qualified — Supplementary Essential Variable

SA-516 Gr. 60	P-No. 1	Gr. 1
SA-516 Gr. 70	P-No. 1	Gr. 2

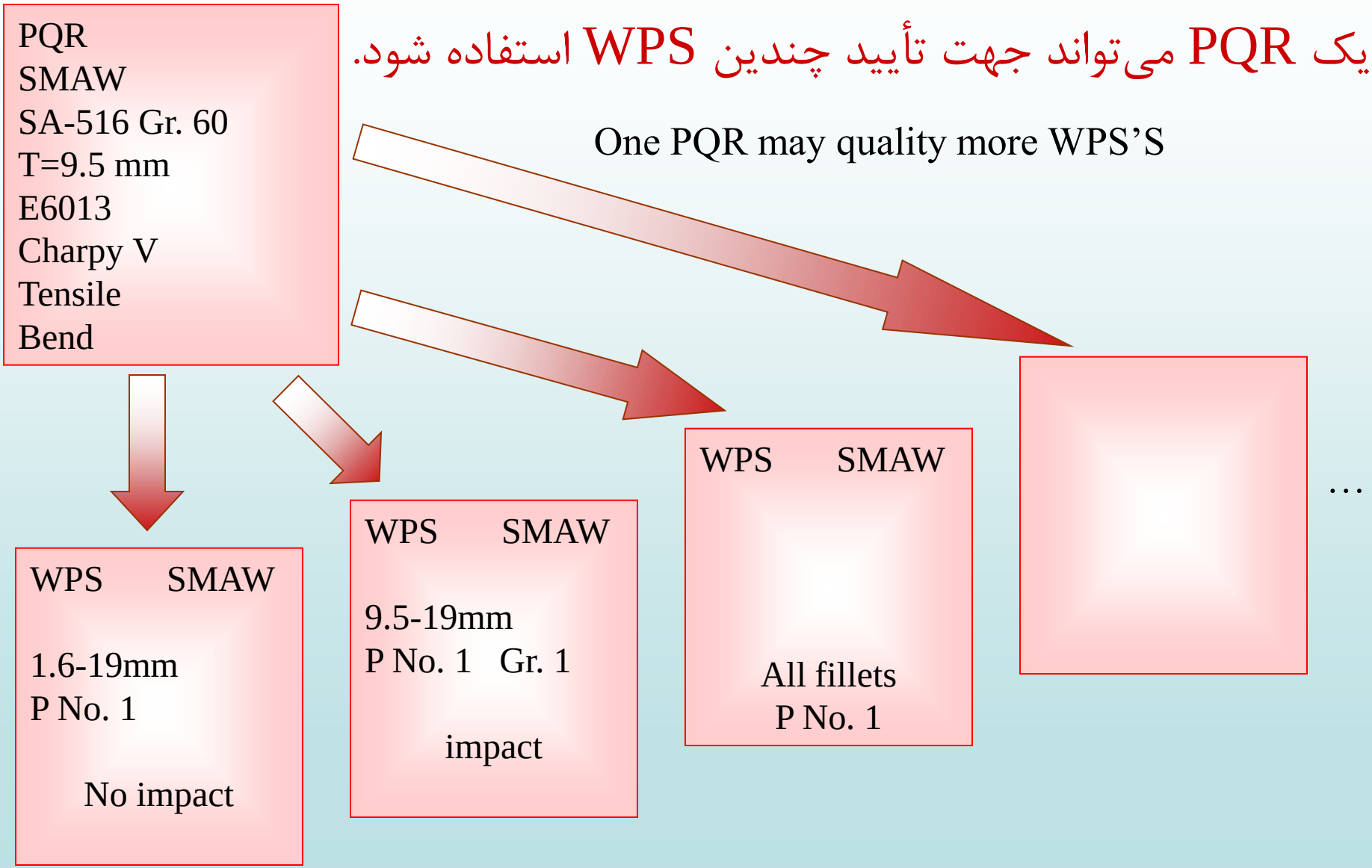
Construction Code:

- Impact testing: new PQR, new WPS
- No Impact test: do not consider

ASME Code Section IX

یک PQR می‌تواند جهت تأیید چندین WPS استفاده شود.

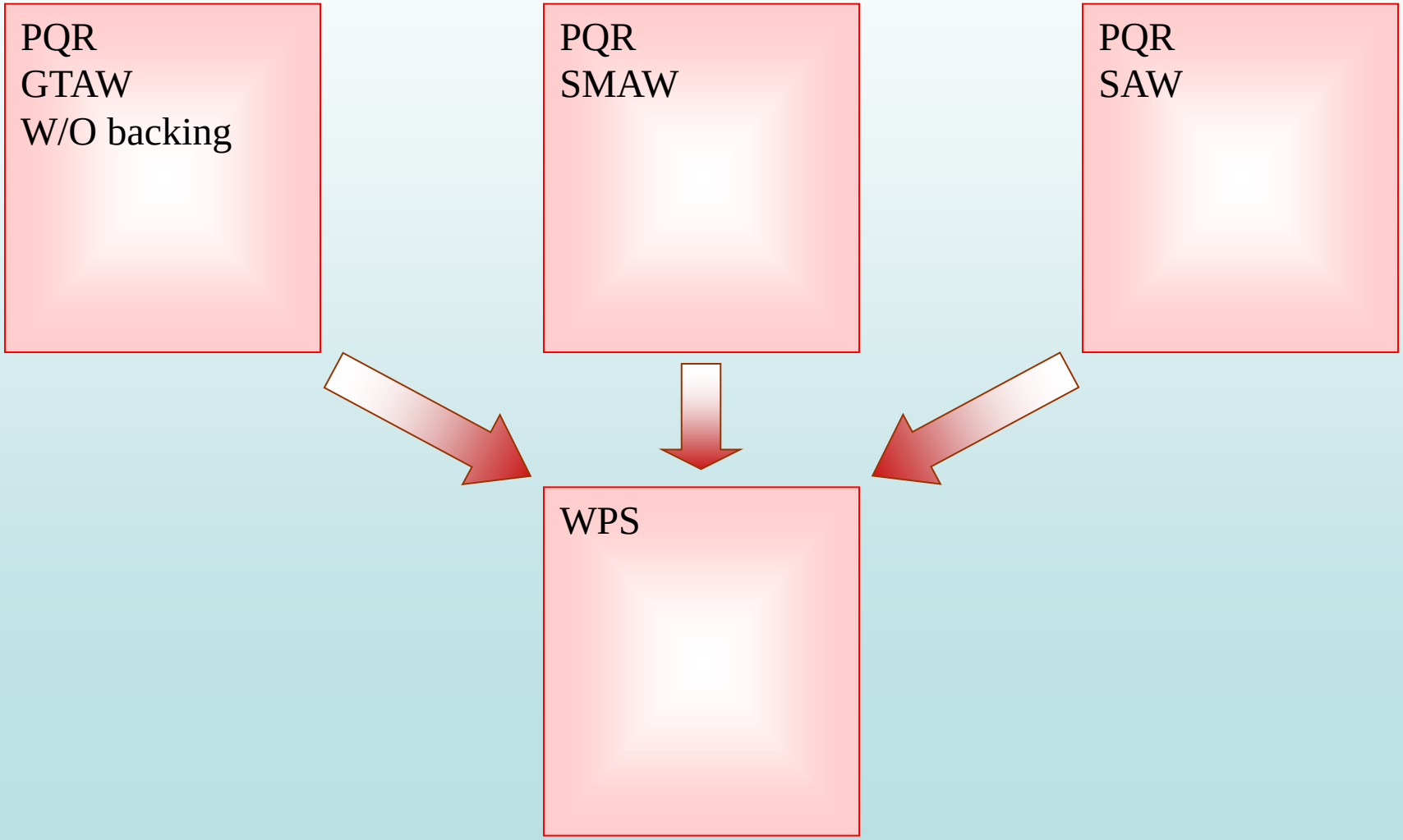
One PQR may quality more WPS'S



ASME Code Section IX

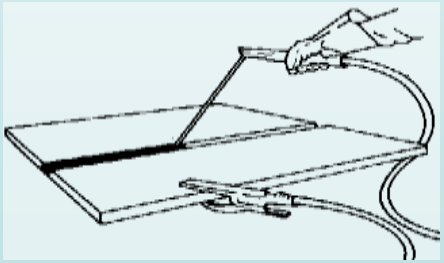
یک WPS می‌تواند توسط چند PQR تا ئید گردد.

One WPS may be supported by more PQR’S



ASME Code Section IX

Qualification of a welder:	مراحل تأیید مهارت
Selection of welders	انتخاب جوشکار
Selection of welding variables, i.e.	درنظرگرفتن متغیرهای جوشکاری
Distinguishing of positions	مشخص کردن وضعیت
Distinguishing of pipe diameters	مشخص کردن قطر لوله
Distinguishing of used F-Numbers of filler metals Etc.	F-Number الکترود یا مفتول و ...



Welding of test coupons

Testing (VT and
2 bend tests or RT)

WPS

RTC

Certification
Data
Signature

ASME Code Section IX

QW-322 تاریخ انقضاء و تایید مجدد جوشکاران

- اگر جوشکاری در طول 6 ماه با فرآیندی که بر اساس آن مهارت وی تایید شده بود جوشکاری نکند، گواهینامه وی اعتبار خود را از دست خواهد داد.
- اگر جوشکار در طول 6 ماه با روش‌های دیگری از جوش دستی یا نیمه اتوماتیک کارکرده باشد بنحوی که مهارت وی در فرآیند قبلی حفظ شده باشد گواهینامه وی می‌تواند مجددا تایید گردد.
- در صورتیکه به هر دلیلی مهارت جوشکاری در یک فرآیند جوشکاری مورد شک واقع شود گواهینامه وی را می‌توان در آن فرآیند لغو کرد. اما صلاحیت وی در مورد دیگر فرآیندها، همچنان معتبر خواهد بود.

B 31.3 Chapter V: Fabrication, Assembly, Erection

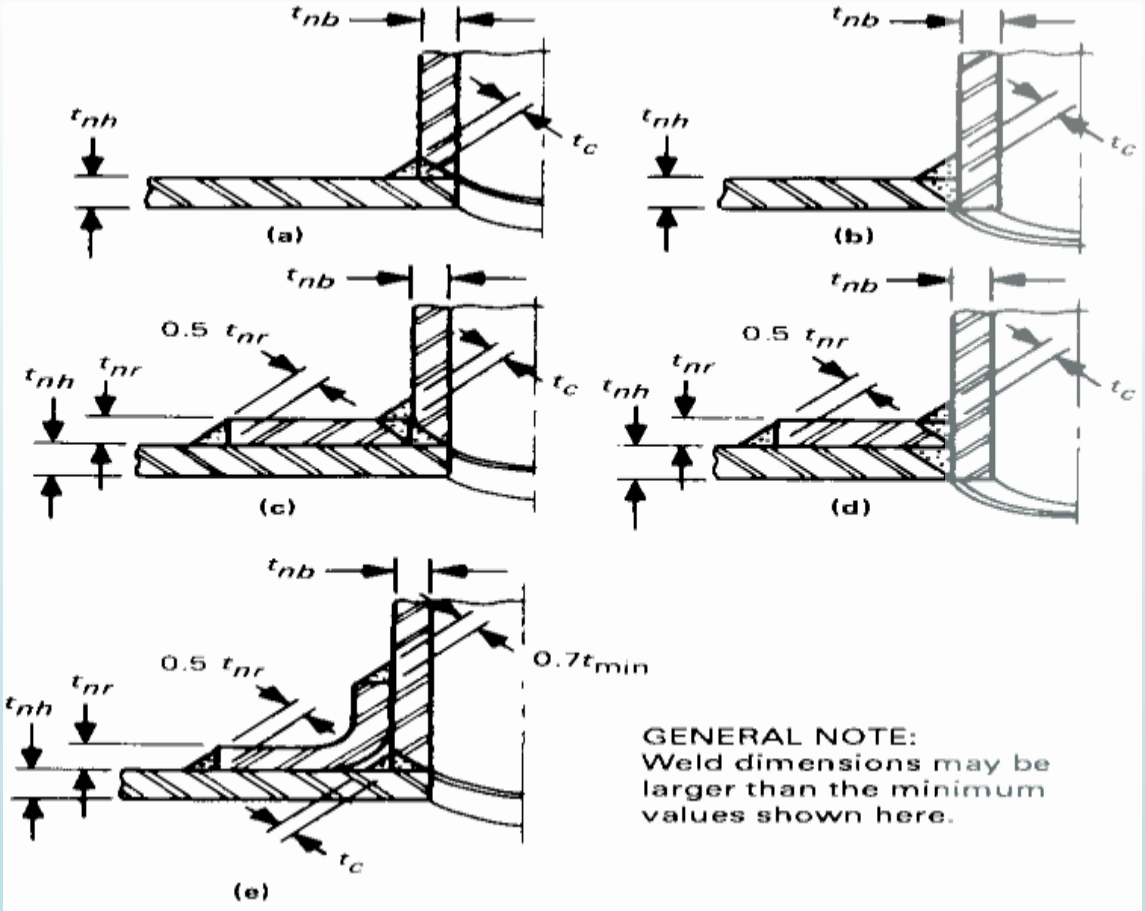


Fig. 328.5.4 (D) Welding Details for Branch Attachment Welds

t_c = min {6,4mm; $0,7t_{nb}$}

t_{min}= min {t_{nb}; t_{nr}}

B 31.3 FIG. 328.5.2B

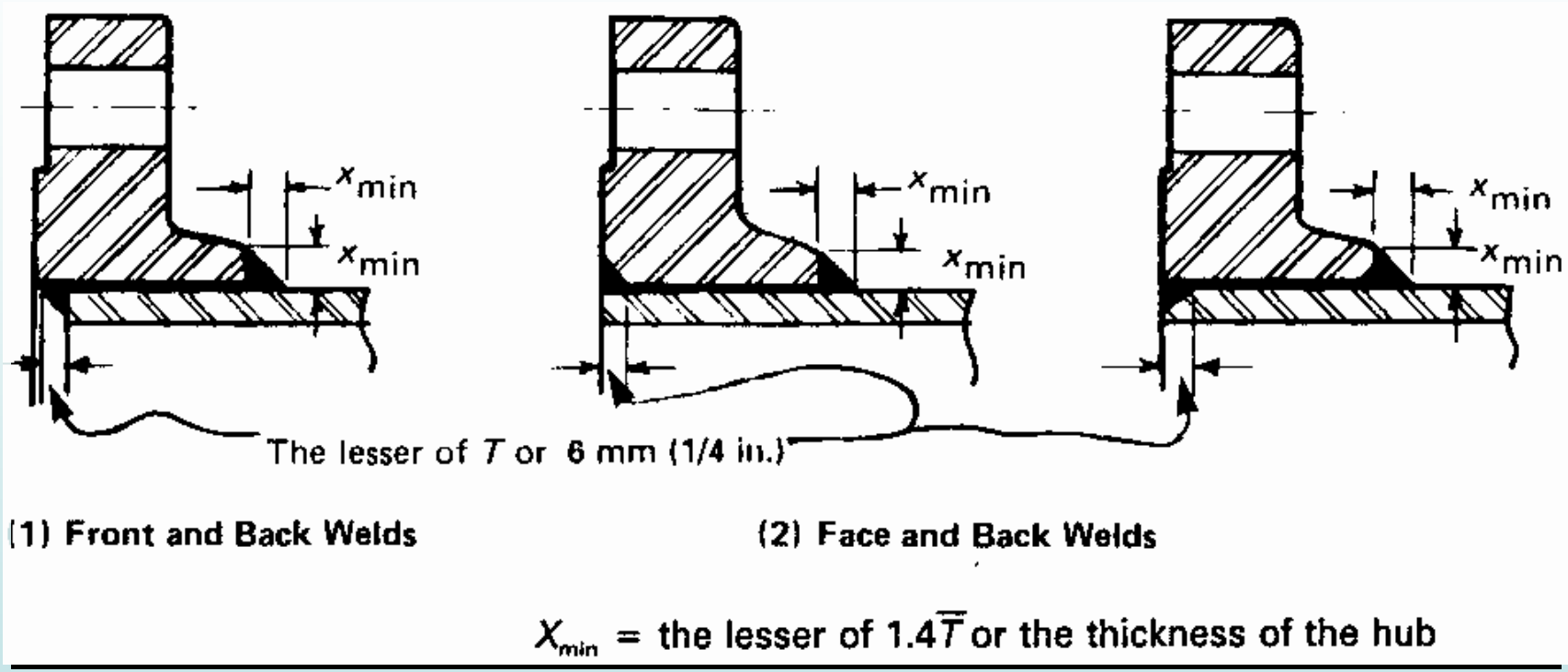


FIG. 328.5.2B TYPICAL DETAILS FOR DOUBLE-WELDED SLIP-ON AND SOCKET WELDING FLANGE ATTACHMENT WELDS

B 31.3 TABLE 330.1.1 PREHEAT TEMPERATURES

Base Metal P-No. [Note (1)]	Weld Metal Analysis A-No. [Note (2)]	Base Metal Group	Nominal Wall Thickness		Specified Min. Tensile Strength, Base Metal		Min. Temperature			
							Required		Recommended	
			mm	in.	MPa	ksi	°C	°F	°C	°F
1	1	Carbon steel	< 25	< 1	≤ 490	≤ 71	. . .	. . .	10	50
			≥ 25	≥ 1	All	All	. . .	. . .	79	175
			All	All	> 490	> 71	. . .	. . .	79	175
3	2, 11	Alloy steels, Cr ≤ ½%	< 13	< ½	≤ 490	≤ 71	. . .	. . .	10	50
			≥ 13	≥ ½	All	All	. . .	. . .	79	175
			All	All	> 490	> 71	. . .	. . .	79	175
4	3	Alloy steels ½% < Cr ≤ 2%	All	All	All	All	149	300	. . .	. . .
5	4, 5	Alloy steels, 2¼% ≤ Cr ≤ 10%	All	All	All	All	177	350	. . .	. . .
6	6	High alloy steels martensitic	All	All	All	All	. . .	. . .	149[3]	300[3]
7	7	High alloy steels ferritic	All	All	All	All	. . .	. . .	10	50
8	8, 9	High alloy steels austenitic	All	All	All	All	. . .	. . .	10	50
9A, 9B	10	Nickel alloy steels	All	All	All	All	. . .	. . .	93	200

B 31.3 TABLE 331.1.1 REQUIREMENTS FOR HEAT TREATMENT

Base Metal P-Number [Note (1)]	Weld Metal Analysis A-Number [Note (2)]	Base Metal Group	Nominal Wall Thickness		Specified Min. Tensile Strength, Base Metal		Metal Temperature Range		Holding Time			Brinell Hardness, [Note (4)] Max.
									Nominal Wall [Note (3)]		Min. Time,	
			mm	in.	MPa	ksi	°C	°F	min/mm	hr/in.	hr	
1	1	Carbon steel	≤19	≤¾	All	All	None	None	...	...	...	...
			>19	>¾	All	All	593–649	1100–1200	2.4	1	1	...
3	2, 11	Alloy steels, Cr ≤ ½%	≤19	≤¾	≤490	≤71	None	None	...	...	...	...
			>19	>¾	All	All	593–718	1100–1325	2.4	1	1	225
			All	All	>490	>71	593–718	1100–1325	2.4	1	1	225
4	3	Alloy steels, ½% < Cr ≤ 2%	≤13	≤½	≤490	≤71	None	None	...	...	...	...
			>13	>½	All	All	704–746	1300–1375	2.4	1	2	225
			All	All	>490	>71	704–746	1300–1375	2.4	1	2	225
5	4, 5	Alloy steels, (2¼% ≤ Cr ≤ 10%)										
		≤3% Cr, and ≤0.15% C, and	≤13	≤½	All	All	None	None	...	...	...	...
		>3% Cr, or >0.15% C, or	>13	>½	All	All	704–760	1300–1400	2.4	1	2	241
6	6	High alloy steels martensitic	All	All	All	All	732–788	1350–1450	2.4	1	2	241
		A 240 Gr. 429	All	All	All	All	621–663	1150–1225	2.4	1	2	241
7	7	High alloy steels ferritic	All	All	All	All	None	None	...	...	...	...
8	8, 9	High alloy steels austenitic	All	All	All	All	None	None	...	...	...	
9A, 9B	10	Nickel alloy steels	≤19	≤¾	All	All	None	None	...	...	...	...
	...		>19	>¾	All	All	593–635	1100–1175	1.2	½	1	...

ASME B 31.3 chapter I

Responsibilities (300) مسئولیت کارفرما طراح ، نصاب و بازرس

Owner: Overall responsibilities for Code compliance and establishment of (supplementary) requirements cover Jurisdictional requirements

Designer: Responsible for compliance of engineering design with Code / additional requirements Qualification as per 301.1

Manufacturer: Responsibility for material, components workmanship according to design and code

Owner's Inspector: Ensure that inspection, examination, and testing requirements are metal Qualification as per 340.4

B 31.3 Chapter VI: Inspection, Examination, Testing

340 Inspection: Owner's Responsibility

341 Examination: Manufacturer or Owner visual and nondestructive examination

341.3 Examination Requirements and Acceptance Criteria (Table)

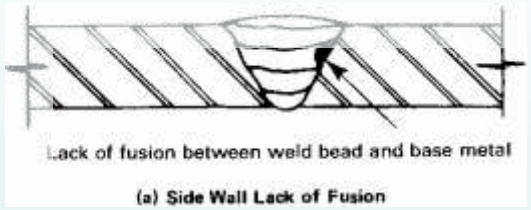
342 Examination Personnel

344 Types of Examination

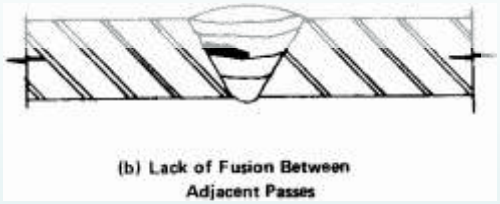
345 Leak Test (after PWHT and NDE)
to ensure leak tightness
Hydrostatic (345.4 @ 1.5 x MAWP x S_{test}/S_{design})
or Pneumatic testing (345.5)

346 Records
design records,
examination procedures and personnel qualifications 5 years.

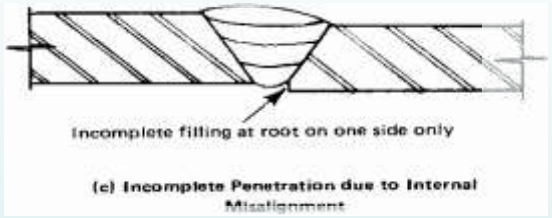
B 31.3 FIG. 341.3.2 TYPICAL WELD IMPERFECTIONS



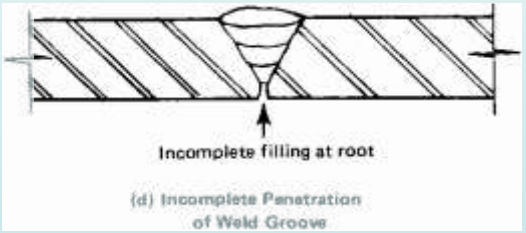
(a) Side Wall Lack of Fusion



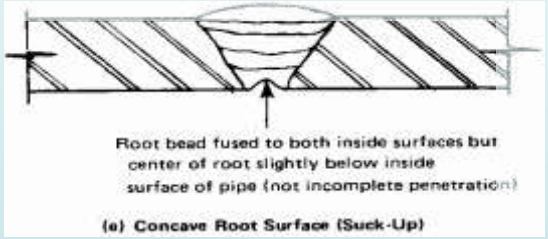
(b) Lack of Fusion Between Adjacent Passes



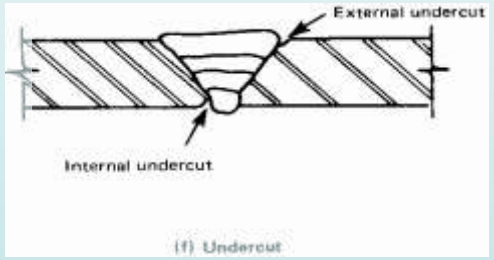
(c) Incomplete Penetration due to Internal Misalignment



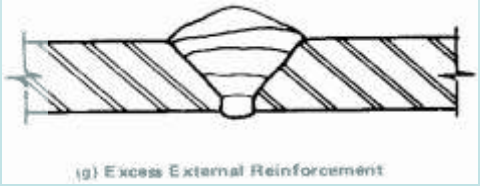
(d) Incomplete Penetration of Weld Groove



(e) Concave Root Surface (Suck-Up)



(f) Undercut



(g) Excess External Reinforcement

B 31.3 TABLE 341.3.2

ACCEPTANCE CRITERIA FOR WELDS

Kind of Imperfection	Criteria (A to M) for Types of Welds, for Service Conditions, and for Required Examination Methods [Note (1)]																		
	Normal Fluid Service						Severe Cyclic Conditions								Category D Fluid Service				
	Methods		Types of Weld				Methods				Types of Weld				Method	Types of Weld			
	Visual	Radiography	Girth and Miter Groove	Longitudinal Groove [Note (2)]	Fillet [Note (3)]	Branch Connection [Note (4)]	Visual	Radiography	Magnetic Particle	Liquid Penetrant	Girth and Miter Groove	Longitudinal Groove [Note (2)]	Fillet [Note (3)]	Branch Connection [Note (4)]	Visual	Girth and Miter Groove	Longitudinal Groove [Note (2)]	Fillet [Note (3)]	Branch Connection [Note (4)]
Crack	×	×	A	A	A	A	×	×	×	×	A	A	A	A	×	A	A	A	A
Lack of fusion	×	×	A	A	A	A	×	×	...	...	A	A	A	A	×	C	A	NA	A
Incomplete penetration	×	×	B	A	NA	B	×	×	...	...	A	A	NA	A	×		A	NA	B
Internal porosity	...	×	E	E	NA	E	...	×	...	...	D	D	NA	D	...	...	...	...	...
Slag inclusion, tungsten inclusion, or elongated indication	...	×	G	G	NA	G	...	×	...	...	F	F	NA	F	...	...	...	...	...
Undercutting	×	...	H	A	H	H	×	×	...	...	A	A	A	A	×	I	A	H	H
Surface porosity or exposed slag inclusion [Note (5)]	×	...	A	A	A	A	×	...	...	...	A	A	A	A	×	A	A	A	A
Surface finish	...	...	...	...	...	...	×	...	...	...	J	J	J	J	...	...	...	...	...
Concave root surface (suck-up)	×	×	K	K	NA	K	×	×	...	...	K	K	NA	K	×	K	K	NA	K
Reinforcement or internal protrusion	×	...	L	L	L	L	×	...	...	...	L	L	L	L	×	M	M	M	M

B 31.3 Criterion Value Notes for Table 341.3.2

Symbol	Criterion Measure	Acceptable Value Limits [Note (6)]
A	Extent of imperfection	Zero (no evident imperfection)
B	Depth of incomplete penetration Cumulative length of incomplete penetration	$\leq$ 1 mm (1/32 in.) and $\leq 0.2T_w$ $\leq$ 38 mm (1.5 in.) in any 152 mm (6 in.) weld length
C	Depth of lack of fusion and incomplete penetration Cumulative length of lack of fusion and incomplete penetration [Note (7)]	$\leq 0.2T_w$ $\leq$ 38 mm (1.5 in.) in any 152 mm (6 in.) weld length
D	Size and distribution of internal porosity	See BPV Code, Section VIII, Division 1, Appendix 4
E	Size and distribution of internal porosity	For $T_w \leq$ 6 mm (1/4 in.), limit is same as D For $T_w >$ 6 mm (1/4 in.), limit is 1.5 $\times$ D
F	Slag inclusion, tungsten inclusion, or elongated indication Individual length Individual width Cumulative length	 $\leq T_w/3$ $\leq$ 2.5 mm (1/32 in.) and $\leq T_w/3$ $\leq T_w$ in any $12T_w$ weld length
G	Slag inclusion, tungsten inclusion, or elongated indication Individual length Individual width Cumulative length	 $\leq 2T_w$ $\leq$ 3 mm (1/8 in.) and $\leq T_w/2$ $\leq 4T_w$ in any 152 mm (6 in.) weld length
H	Depth of undercut	$\leq$ 1 mm (1/32 in.) and $\leq T_w/4$
I	Depth of undercut	$\leq$ 1.5 mm (1/16 in.) and $\leq$ [$T_w/4$ or 1 mm (1/32 in.)]
J	Surface roughness	$\leq$ 500 min. Ra per ASME B46.1
K	Depth of root surface concavity	Total joint thickness, incl. weld reinf., $\geq T_w$
L	Height of reinforcement or internal protrusion [Note (8)] in any plane through the weld shall be within limits of the applicable height value in the tabulation at right, except as provided in Note (9). Weld metal shall merge smoothly into the component surfaces.	For T_w, mm (in.) / Height, mm (in.) $\leq$ 6 (1/4) / $\leq$ 1.5 (1/16) > 6 (1/4), $\leq$ 13 (1/2) / $\leq$ 3 (1/8) > 13 (1/2), $\leq$ 25 (1) / $\leq$ 4 (5/32) > 25 (1) / $\leq$ 5 (3/16)
M	Height of reinforcement or internal protrusion [Note (8)] as described in L. Note (9) does not apply.	Limit is twice the value applicable for L above

$\times$ = required examination NA = not applicable . . . = not required

B 31.3 TABLE 341.3.2 (CONT'D)

NOTES:

(1) Criteria given are for required examination. More stringent criteria may be specified in the engineering design. See also paras. 341.5 and 341.5.3.

(2) Longitudinal groove weld includes straight and spiral seam. Criteria are not intended to apply to welds made in accordance with a standard listed in Table A-1 or Table 32b.1.

(3) Fillet weld includes socket and seal welds, and attachment welds for slip-on flanges, branch reinforcement, and supports. (4) Branch connection weld includes pressure containing welds in branches and fabricated laps.

(5) These imperfections are evaluated only for welds $\leq$ 5 mm (3/16 in.) in nominal thickness.

(b) Where two limiting values are separated by "and," the lesser of the values determines acceptance. Where two sets of values are separated by "or," the larger value is acceptable. T_w is the nominal wall thickness

(7) Tightly butted unfused root faces are unacceptable.

(8) For groove welds, height is the lesser of the measurements made from the surfaces of the adjacent components; both reinforcement and internal protrusion are permitted in a weld. For fillet welds, height is measured from the theoretical throat, Fig. 328.5.2A; internal protrusion does not apply.

(9) For welds in aluminum alloy only, internal protrusion shall not exceed the following values:
(a) for thickness $\leq$ 2 mm (5/64 in.): 1.5 mm (1/16 in.);
(b) for thickness > 2 mm and $\leq$ 6 mm (1/4 in.): 2.5 mm (3/32 in.).

For external reinforcement and for greater thicknesses, see the tabulation for Symbol L.

of the thinner of two components joined by a butt weld.

341.4 Extent of Required Examination

341.4 Extent of Required Examination

341.4.1 Examination Normally Required.
Piping in Normal Fluid Service shall be examined to the extent specified herein or to any greater extent specified in the engineering design. Acceptance criteria (..)para. 341.3.2 and in Table 341.3.2, for Normal Fluid Service unless otherwise specified.

(a) Visual Examination. At least the following in accordance with para. 344.2:

(I) sufficient materials and components, selected at random, to satisfy the examiner that they conform to specifications and are free from defects;

(2) at least 5% of fabrication. For welds, each welder's and welding operator's work shall be represented.

(3) 100% of fabrication for longitudinal welds, except those in components made in accordance with a listed specification. See para 341.5.1(a) for examination of longitudinal welds required to have a joint factor Ej of 0.90.

(4) random examination of the assembly of threaded, bolted, and other joints to satisfy the examiner that they conform to the applicable requirements of para. 335. When pneumatic testing is to be performed, all threaded, bolted, and other mechanical joints shall be examined.

341.4 Extent of Required Examination

(5) random examination during erection of piping, including checking of alignment, supports, and cold spring;

(6) examination of erected piping for evidence of defects that would require repair or replacement, and for other evident deviations from the intent of the design.

(b) Other Examination

(l) Not less than 5% of circumferential butt and miter groove welds shall be examined fully by random radiography in accordance with para. 344.5 or by random ultrasonic examination in accordance with para. 344.6. The welds to be examined shall be selected to ensure that the work product of each welder or welding operator doing the production welding is included. They shall also be selected to maximize coverage of intersections with longitudinal joints.(..) In-process examination in acc. with para. 344.7 may be substituted for all or part of the RT or UT, if specified in the engineering design or authorized by the Inspector.(..)

(c) Certifications and Records. The examiner shall be assured, by examination of certifications, records, and other evidence, that the materials and components are of the specified grades and that they have received required heat treatment, examination, and testing. The examiner shall provide the Inspector with a certification that all the quality control requirements of the Code and of the engineering design have been carried out.

B 31.3

TABLE 302.3.4 LONGITUDINAL WELD JOINT QUALITY FACTOR, E_j

No.	Type of Joint		Type of Seam	Examination	Factor, E_j
1	Furnace butt weld, continuous weld		Straight	As required by listed specification	0.60 [Note (1)]
2	Electric resistance weld		Straight or spiral	As required by listed specification	0.85 [Note (1)]
3	Electric fusion weld				
	(a) Single butt weld		Straight or spiral	As required by listed specification or this Code	0.80
	(with or without filler metal)			Additionally spot radiographed per para. 341.5.1	0.90
				Additionally 100% radiographed per para. 344.5.1 and Table 341.3.2	1.00

B 31.3 Chapter VI: Scope of NDE

Fluid Service	Long. Joint	Girth Joint	Branch conn.
Category D 341.4.2	VT 344.2	VT 344.2	VT 344.2
Normal 341.4.1	100% VT RT depd on Eff	5% VT 5% RT	5% VT
Category M M341	100% VT RT depd on Eff	100% VT 20% RT	100% VT RT for butt welds
Severe Cyclic Service-341.4.3	100% VT RT depd on Eff	100% RT	100% MT/PT, RT for butt welds
In addition all examination specified in the Engineering Design shall be required. For Details please refer to B31.3 Chapter VI			

NDE Personnel and Procedures

342 EXAMINATION PERSONNEL

342.1 Personnel Qualification and Certification Examiners shall have training and experience commensurate with the needs of the specified examinations. The employer shall certify records of the examiner employed, showing dates and results of personnel qualifications, and shall maintain them and make then available to the Inspector.

343 EXAMINATION PROCEDURES

Any examination shall be performed in accordance with a written procedure that conforms to one of the methods specified in para. 344, including special methods (see para. 344.1.2). Procedures shall be written a required in the BPV Code, Section V, Article 1, T-150. The employer shall certify records of the examination procedures employed, showing dates and results o procedure qualifications, and shall maintain them available to the Inspector.

344.7 In-Process Examination

344.7 In-Process Examination

344.7.1 Definition. **In-process examination comprises examination of the following, as applicable:**

(a) joint preparation and cleanliness;

(b) preheating;

(c) fit-up, joint clearance, and internal alignment prior to joining;

(d) variables specified by the joining procedure, in cluding filler material; and:

(l) (for welding) position and electrode;

(2) (for brazing) position, flux, brazing tempera ture, proper wetting, and capillary action;

(e) (for welding) condition of the root pass afte r cleaning - external and, where accessible, internal aided by liquid penetrant or magnetic particle examination when specified in the engineering design;

(f) (for welding) slag removal and weld condition between passes; and

(g) appearance of the finished joint.

345.4 Hydrostatic Leak Test

345.4 Hydrostatic Leak Test

345.4.1 Test Fluid. The fluid shall be water unless there is the possibility of damage due to freezing or to adverse effects of water on the piping or the process. In that case another suitable nontoxic liquid may be used. If the liquid is flammable, its flash point shall be at least 49°C (120°F), and consideration shall be given to the test environment.

345.4.2 Test Pressure. Except as provided in para. 345.4.3, the hydrostatic test pressure at any point in a metallic piping system shall be as follows:

(a) not less than 1 $^1/_2$ times the design pressure;

(b) for design temperature above the test temperature, the minimum test pressure shall be calculated by Eq. (24), except that the value of S_T/S shall not exceed 6.5:

$$P_T = \frac{1.5\ PS_T}{S}$$

where P_T = minimum test gage pressure

P = internal design gage pressure

S_T = stress value at test temperature

S = stress value at design temperature

(see Table A-1)

345.9 Alternative Leak Test

345.9 Alternative Leak Test

The following procedures and leak test method may be used only under the conditions stated in para. 345.1 (c).

345.9.1 Examination of Welds. **Welds, including those used in the manufacture of welded pipe and fittings, which have not been subjected to hydrostatic or pneumatic leak tests in accordance with this Code, shall be examined as follows.**

(a) Circumferential, longitudinal, and spiral groove welds shall be 100% radiographed in accordance with para. 344.5 or 100% ultrasonically examined in accordance with para. 344.6.

(b) All welds, including structural attachment welds, not covered in (a) above, shall be examined using the liquid penetrant method (para. 344.4) or, for magnetic materials, the magnetic particle method (para. 344.3).

(c) if the test pressure as defined above would produce a nominal pressure stress or longitudinal stress in excess of the yield strength at test temperature, the test pressure may be reduced to the maximum pressure that will not exceed the yield strength at test temperature. [See paras. 302.3:2(e) and (f).]

For metallic bellows expansion joints, see Appendix X, para. X302.2.3(a).

ASME B 31.3 Chapter IX

High pressure piping, Alternative Rules. Additional responsibilities:

- **owner shall provide all necessary information**
- **written design summary from the designer**

Restrictions

- **no nonmetallic piping**
- **no nonmetallic lined piping**
- **no provisions for Category M service**

Alternative Design Rules in Chapter IX apply only as a whole, not in part.

ASME B 31.8 Gas Transmission and Distribution Systems

800.1 Scope

Scope : up to the outlet of the customer's meter set assembly Main aspect: Long Distance Transportation

(incl. pipelines, compressor stations, metering stations, gas mains)

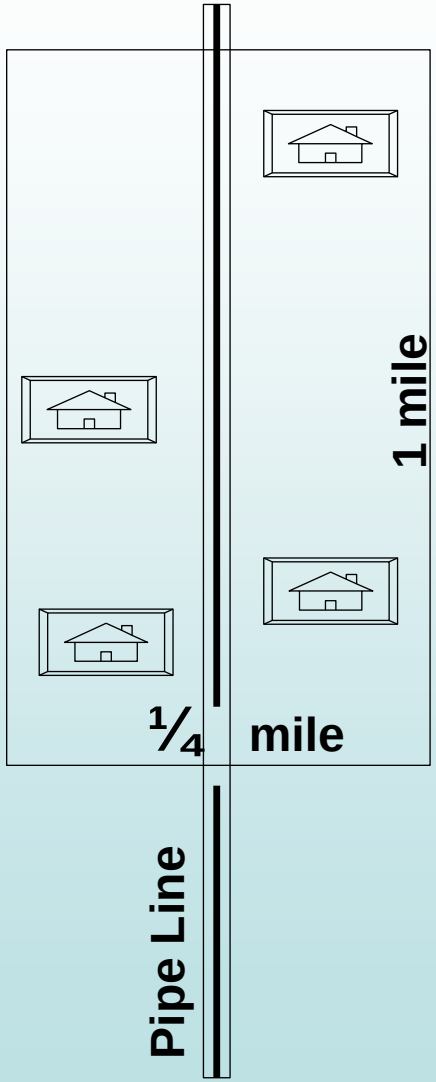
Except :

- pressure vessels
- temperatures below -20 F or above 450 F
- vent piping (atm. pressure)
- piping within property lines of processing plants
- wellhead assemblies
- heat exchangers
- liquid petroleum piping (B 31.4)
- liquid slurry, liquefied natural gas
- carbon dioxide transportation piping systems

Definitions 803

ASME B 31.8 Contents

Pipe Line Classifications



Class 1: up to 10 occupational buildings

Div. 1: $0{,}72 < F \leq 0{,}80$

Div. 2: $F \leq 0{,}72$

Class 2: up to 45 occupational buildings

Class 3: more than 45 occupational buildings or any public buildings (schools, et.)

Class 4: any multistory buildings, or heavy traffic or underground utilities

$$\text{Allowable Pressure } P = \frac{2\,S_Y t_{nom}}{D_O} F\,E\,T$$

ASME B 31.8 841 Basic Design Factor

TABLE 841.114A
BASIC DESIGN FACTOR *F*

Location Class	Design Factor *F*
Location Class 1, Division 1	0.80
Location Class 1, Division 2	0.72
Location Class 2	0.60
Location Class 3	0.50
Location Class 4	0.40

ASME B 31.8 Design Factors

TABLE 841.114B
DESIGN FACTORS FOR STEEL PIPE CONSTRUCTION

Facility	Location Class				
	1				
	Div. 1	Div. 2	2	3	4
Pipelines, mains, and service lines [see para. 840.2(b)]	0.80	0.72	0.60	0.50	0.40
Crossings of roads, railroads without casing:					
(a) Private roads	0.80	0.72	0.60	0.50	0.40
(b) Unimproved public roads	0.60	0.60	0.60	0.50	0.40
(c) Roads, highways, or public streets, with hard surface and railroads	0.60	0.60	0.50	0.50	0.40
Crossings of roads, railroads with casing:					
(a) Private roads	0.80	0.72	0.60	0.50	0.40
(b) Unimproved public roads	0.72	0.72	0.60	0.50	0.40
(c) Roads, highways, or public streets, with hard surface and railroads	0.72	0.72	0.60	0.50	0.40
Parallel encroachment of pipelines and mains on roads and railroads:					
(a) Private roads	0.80	0.72	0.60	0.50	0.40
(b) Unimproved public roads	0.80	0.72	0.60	0.50	0.40
(c) Roads, highways, or public streets, with hard surface and railroads	0.60	0.60	0.60	0.50	0.40
Fabricated assemblies (see para. 841.121)	0.60	0.60	0.60	0.50	0.40
Pipelines on bridges (see para. 841.122)	0.60	0.60	0.60	0.50	0.40
Compressor station piping	0.50	0.50	0.50	0.50	0.40
Near concentration of people in Location Classes 1 and 2 [See para. 840.3(b)]	0.50	0.50	0.50	0.50	0.40

ASME B 31.8 Long Joint Factors

TABLE 841.115A
LONGITUDINAL JOINT FACTOR *E*

Spec. No.	Pipe Class	*E* Factor	Spec. No.	Pipe Class	*E* Factor
ASTM A 53	Seamless	1.00	ASTM A 671	Electric Fusion Welded	
	Electric Resistance Welded	1.00		Classes 13, 23, 33, 43, 53	0.80
	Furnace Butt Welded — Continuous Weld	0.60		Classes 12, 22, 32, 42, 52	1.00
ASTM A 106	Seamless	1.00	ASTM A 672	Electric Fusion Welded	
ASTM A 134	Electric Fusion Arc Welded	0.80		Classes 13, 23, 33, 43, 53	0.80
ASTM A 135	Electric Resistance Welded	1.00		Classes 12, 22, 32, 42, 52	1.00
ASTM A 139	Electric Fusion Welded	0.80	API 5L	Seamless	1.00
ASTM A 211	Spiral Welded Steel Pipe	0.80		Electric Resistance Welded	1.00
ASTM A 333	Seamless	1.00		Electric Flash Welded	1.00
	Electric Resistance Welded	1.00		Submerged Arc Welded	1.00
ASTM A 381	Double Submerged-Arc-Welded	1.00		Furnace Butt Welded	0.60

TABLE 841.116A
TEMPERATURE DERATING FACTOR *T*
FOR STEEL PIPE

Temperature, °F	Temperature Derating Factor *T*
250 or less	1.000
300	0.967
350	0.933
400	0.900
450	0.867

ASME B 31.8 Pressure Test

TABLE 841.322(f)
TEST REQUIREMENTS FOR PIPELINES AND MAINS TO OPERATE AT HOOP STRESSES OF 30% OR MORE OF THE SPECIFIED MINIMUM YIELD STRENGTH OF THE PIPE

1	2	3	4	5
Location Class	Permissible Test Fluid	Pressure Test Prescribed		Maximum Allowable Operating Pressure, the Lesser of
		Minimum	Maximum	
1 Division 1	Water	1.25 × m.o.p.	None	t.p. ÷ 1.25
1 Division 2	Water	1.1 × m.o.p.	None	t.p. ÷ 1.1
	Air	1.1 × m.o.p.	1.1 × d.p.	or d.p.
	Gas	1.1 × m.o.p.	1.1 × d.p.	
2	Water	1.25 × m.o.p.	None	t.p. ÷ 1.25
	Air	1.25 × m.o.p.	1.25 × d.p.	or d.p.
3 & 4 (Note (1))	Water	1.40 × m.o.p.	None or d.p.	t.p. ÷ 1.40 or d.p.

m.o.p. = maximum operating pressure (not necessarily the maximum allowable operating pressure)
d.p. = design pressure
t.p. = test pressure

ASME B 31.8 Pressure Test Hoop Stress

TABLE 841.33
MAXIMUM HOOP STRESS PERMISSIBLE DURING TEST

Test Medium	Class Location, % of Specified Minimum Yield Strength		
	2	3	4
Air	75	50	40
Gas	30	30	30