Steam Drum
Structure of vessels:
ASME Section VIII Division 1

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• Subsection B
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Subsection A
ASME VIII Div. 1

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Part UG

Scope
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Braced and Stayed Surfaces
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The maximum allowable stress value is the maximum unit stress permitted in a given material used in a vessel constructed under these rules. The maximum allowable tensile stress values permitted for different materials are given in Subpart 1 of Section II, Part D.
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### TABLE 1A

**SECTION I; SECTION III, CLASSES 2 AND 3;* SECTION VIII, DIVISION 1; AND SECTION XII**

**MAXIMUM ALLOWABLE STRESS VALUES $S$ FOR FERROUS MATERIALS**

(*See Maximum Temperature Limits for Restrictions on Class*)

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Openings and Reinforcements

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- UG-95 Examination of Surfaces During Fabrication
- UG-96 Dimensional Check of Component Parts
- UG-97 Inspection During Fabrication
- UG-98 Maximum Allowable Working Pressure
- UG-99 Standard Hydrostatic Test
- UG-100 Pneumatic Test (See UW-50)
- UG-101 Proof Tests to Establish Maximum Allowable Working Pressure
- UG-102 Test Gages
- UG-103 Nondestructive Testing
Standard’s terminology

• Inspection, examination, and testing are activities carried out to ensure that system meet the minimum requirements of the standard or code and the engineering design.

• inspection and examination do not mean the same thing.
<table>
<thead>
<tr>
<th>Corporate Responsibility:</th>
<th>Inspection [§340.1, §340.2]</th>
<th>Examination [§341.1, §341.2]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner.</td>
<td>Owner’s inspector or delegates of the owner’s inspector.</td>
<td>Examination (QC) personnel.</td>
</tr>
<tr>
<td>Individual Responsibility:</td>
<td>Verify that all required examinations and tests have been completed. Inspect piping to the extent necessary to be satisfied that it conforms to all applicable examination requirements of the Code and the engineering design.</td>
<td>Perform examinations required by B31.3. (Note that most QC manuals have sections devoted specifically to completion of examinations, such as material control, welding control, NDE control, pressure testing, and record keeping.)</td>
</tr>
<tr>
<td>Primary Quality Management Function:</td>
<td>Quality assurance, including quality audit.</td>
<td>Quality control.</td>
</tr>
<tr>
<td><strong>Owner's Inspectors [¶340.4]</strong></td>
<td><strong>Examination Personnel [¶342.1, ¶342.2]</strong></td>
<td></td>
</tr>
<tr>
<td>----------------------------------</td>
<td>---------------------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Appointment</strong></td>
<td>B31.3 does not list any specific requirements. Examiners are usually employees of the manufacturer, fabricator, or erector, or employees of a service agency subcontracted by the manufacturer, fabricator, or erector.</td>
<td></td>
</tr>
<tr>
<td>Inspectors shall be designated by the owner, and shall be the owner, an employee of the owner, an employee of an engineering or scientific organization, or of a recognized insurance or inspection company acting as the owner's agent.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Restrictions</strong></td>
<td>In-process examinations must be performed by personnel other than those performing the production work [¶342.2].</td>
<td></td>
</tr>
<tr>
<td>Inspectors shall not represent or be an employee of the piping manufacturer, fabricator, or erector, unless the owner is also the manufacturer, fabricator, or erector.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Education and Experience</strong></td>
<td>B31.3 is very loose regarding personnel qualification and certification. It simply states that “examiners shall have training and experience commensurate with the needs of the specified examinations.” By a reference note to [¶342.1], for evaluation of personnel, B31.3 indicates that SNT-TC-1A may be used as a guide. (2)</td>
<td></td>
</tr>
<tr>
<td>B31.3 requires that inspectors have 10 or more years experience in the design, fabrication, or inspection of industrial piping (3). However, each 20% of satisfactorily completed work toward an engineering degree recognized by the Accreditation Board for Engineering and Technology can be considered equivalent to 1 year of experience, up to 5 years total [¶340.4(b)].</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Certification</strong></td>
<td>B31.3 requires that the employer certify records of examiners employed, showing dates and results of personnel qualifications, and maintain the records and make them available to the inspector.</td>
<td></td>
</tr>
<tr>
<td>No requirements stated.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

Pardad Petrodanesh Co
Mechanical Department
www.petrodanesh.ir
Eng. Esmaeil Keynezhad
UG-91    THE INSPECTOR

(a) All references to Inspectors throughout this Division mean the Authorized Inspector as defined in this paragraph. All inspections required by this Division of Section VIII shall be:

(1) by an Inspector regularly employed by an ASME accredited Authorized Inspection Agency,\textsuperscript{33} i.e., the

\textsuperscript{32} See UG-90(b) and UG-90(c)(1) for summaries of the responsibilities of the Manufacturer and the duties of the Inspector.

\textsuperscript{33} Whenever Authorized Inspection Agency or AIA is used in this Code, it shall mean an Authorized Inspection Agency accredited by ASME in accordance with the requirements in the latest edition of ASME QAI-1.
inspection organization of a state or municipality of the United States, a Canadian province, or an insurance company authorized to write boiler and pressure vessel insurance, except that

(2) inspections may be by the regularly employed user’s Inspector in the case of a User-Manufacturer which manufactures pressure vessels exclusively for its own use and not for resale [see UG-116(a)(1)].

Except as permitted in (2) above, the Inspector shall not be in the employ of the Manufacturer. All Inspectors shall have been qualified by a written examination under the rules of any state of the United States or province of Canada which has adopted the Code.

(b) In addition to the duties specified, the Inspector has the duty to monitor the Manufacturer’s Quality Control System as required in Appendix 10.
APPENDIX 10 of Section VIII
QUALITY CONTROL SYSTEM

• 10-1 GENERAL
• 10-2 OUTLINE OF FEATURES TO BE INCLUDED IN THE WRITTEN DESCRIPTION OF THE QUALITY CONTROL SYSTEM
• 10-3 AUTHORITY AND RESPONSIBILITY
• 10-4 ORGANIZATION
• 10-5 DRAWINGS, DESIGN CALCULATIONS, AND SPECIFICATION CONTROL
• 10-6 MATERIAL CONTROL
• 10-7 EXAMINATION AND INSPECTION PROGRAM
• 10-8 CORRECTION OF
• NONCONFORMITIES
• 10-9 WELDING
• 10-10 NONDESTRUCTIVE EXAMINATION
• 10-11 HEAT TREATMENT
• 10-12 CALIBRATION OF MEASUREMENT AND TEST EQUIPMENT
• 10-13 RECORDS RETENTION
• 10-14 SAMPLE FORMS
• 10-15 INSPECTION OF VESSELS AND VESSEL PARTS
• 10-16 INSPECTION OF PRESSURE RELIEF VALVES

Note: These are like ISO9001 requirements in nature
Subsection B
ASME VIII Div. 1

Requirements Pertaining to Methods of Fabrication of Pressure Vessels
Subsection B

- **Part UW**
  Requirements for Pressure Vessels Fabricated by Welding

- **Part UF**
  Requirements for Pressure Vessels Fabricated by Forging

- **Part UB**
  Requirements for Pressure Vessels Fabricated by Brazing
Part UW
Requirements for Pressure Vessels Fabricated by Welding

• General
• Materials
• Design
• Fabrication
• Inspection and Tests
• Marking and Reports
• Pressure Relief Devices
Part UW

General

• UW-1 Scope

• UW-2 Service Restrictions

• UW-3 Welded Joint Category
Heads

- Figures show typical types of closure heads. Elliptical, hemispherical, and torispherical are the most commonly used head types. Note that all head types have a straight flange (sf) section, which simplifies welding the head to the adjacent cylindrical shell section. The elliptical and torispherical heads have an indicated head depth (h), which is measured from the straight flange to the maximum point of curvature on the inside surface.
Hemispherical
Elliptical
Flanged and Dished (torispherical)
Toriconical

\( \alpha \)

\( r \)

\( ID \)

\( t \)

\( sf \)
<table>
<thead>
<tr>
<th>Part</th>
<th>Thickness, ( t ), in.</th>
<th>Pressure, ( P ), psi</th>
<th>Stress, ( S ), psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylindrical shell</td>
<td>( \frac{Pr}{SE_1 - 0.6P} )</td>
<td>( \frac{SE_1t}{r + 0.6t} )</td>
<td>( \frac{P(r + 0.6t)}{tE_1} )</td>
</tr>
<tr>
<td>Spherical shell</td>
<td>( \frac{Pr}{2SE_1 - 0.2P} )</td>
<td>( \frac{2SEt}{r + 0.2t} )</td>
<td>( \frac{P(r + 0.2t)}{2tE} )</td>
</tr>
<tr>
<td>2:1 Semi-Elliptical head</td>
<td>( \frac{PD}{2SE - 0.2P} )</td>
<td>( \frac{2SEt}{D + 0.2t} )</td>
<td>( \frac{P(D + 0.2t)}{2tE} )</td>
</tr>
<tr>
<td>Torispherical head with 6% knuckle</td>
<td>( \frac{0.885PL}{SE - 0.1P} )</td>
<td>( \frac{SEt}{0.885L + 0.1t} )</td>
<td>( \frac{P(0.885L + 0.1t)}{tE} )</td>
</tr>
<tr>
<td>Conical Section ((\alpha = 30^{\circ}))</td>
<td>( \frac{PD}{2 \cos \alpha (SE - 0.6P)} )</td>
<td>( \frac{2SEt \cos \alpha}{D + 1.2t \cos \alpha} )</td>
<td>( \frac{P(D + 1.2t \cos \alpha)}{2tE \cos \alpha} )</td>
</tr>
</tbody>
</table>

**Summary of ASME Code Equations**
Stiffener ring

Moment Axis of Ring

Stiffener Rings on Pressure Vessel Cylinders

h = Depth of Head

h/3

L L L L L L

L L L L L L
Gap (not to exceed 8 times the thickness of the shell plate)

Butt Weld

See UG-29 (c)

Shell

Web of Stiffener

Flange of Stiffener

Butt Weld

Gap in Ring for Drainage

Strut Member

Section J–K

Length of any gap in unsupported shell not to exceed length of arc shown in Fig. UG-29.2
FIG. UG-29.2  MAXIMUM ARC OF SHELL LEFT UNSUPPORTED BECAUSE OF GAP IN STIFFENING RING OF CYLINDRICAL SHELL UNDER EXTERNAL PRESSURE
FIG. UG-30 SOME ACCEPTABLE METHODS OF ATTACHING STIFFENING RINGS

- In-line Intermittent Weld
  - \( S \leq 8t \) external stiffeners
  - \( S \leq 12t \) internal stiffeners

- Staggered Intermittent Weld
  - 2 in. (50 mm) min.
  - 2 in. (50 mm) min.

- Continuous Fillet Weld
  - One Side, Intermittent Other Side
  - 2 in. (50 mm) min.
  - 24t max.
Part UW-Design

- UW-8 General
- UW-9 Design of Welded Joints
- UW-10 Postweld Heat Treatment
- UW-11 Radiographic and Ultrasonic Examination
- UW-12 Joint Efficiencies
- UW-13 Attachment Details
- UW-14 Openings in or Adjacent to Welds
- UW-15 Welded Connections
- UW-16 Minimum Requirements for Attachment Welds at Openings UW-17 Plug Welds
- UW-18 Fillet Welds
- UW-19 Welded Stayed Construction
- UW-20 Tube-to-Tubesheet Welds
- UW-21 Flange to Nozzle Neck Welds
UW-9 DESIGN OF WELDED JOINTS

(a) Permissible Types.
(b) Welding Grooves.
(c) Tapered Transitions.
(d) Vessels made up of two or more courses-
   Staggering of longitudinal joints
(e) Lap Joints.
(f) Welded Joints Subject to Bending Stresses
(g) Minimum Weld Sizes.
Fabrication

- UW-26 General
- UW-27 Welding Processes
- UW-28 Qualification of Welding Procedure
- UW-29 Tests of Welders and Welding Operators
- UW-30 Lowest Permissible Temperatures for Welding
- UW-31 Cutting, Fitting, and Alignment
- UW-32 Cleaning of Surfaces to Be Welded
- UW-33 Alignment Tolerance
- UW-34 Spin-Holes
- UW-35 Finished Longitudinal and Circumferential Joints
- UW-36 Fillet Welds
- UW-37 Miscellaneous Welding Requirements
- UW-38 Repair of Weld Defects
- UW-39 Peening
- UW-40 Procedures for Postweld Heat Treatment
- UW-41 Sectioning of Welded Joints
- UW-42 Surface Weld Metal Buildup.
Subsection C
ASME VIII Div.1

Requirements Pertaining to Classes of Materials
Subsection C of ASME VIII Div.1

- Part UCS
  Requirements for Pressure Vessels Constructed of Carbon and Low Alloy Steels

- Part UNF
  Requirements for Pressure Vessels Constructed of Nonferrous Materials

- Part UHA
  Requirements for Pressure Vessels Constructed of High Alloy Steel
Subsection C of ASME VIII Div. 1
Requirements Pertaining to Classes of Materials

- Part UCI
  Requirements for Pressure Vessels Constructed of Cast Iron

- Part UCL
  Requirements for Welded Pressure Vessels Constructed of Material With Corrosion Resistant Integral Cladding, Weld Metal Overlay Cladding, or With Applied Linings

- Part UCD
  Requirements for Pressure Vessels Constructed of Cast Ductile Iron
Subsection C
Cont.

• Part UHT
  Requirements for Pressure Vessels Constructed of Ferritic Steels With Tensile Properties Enhanced by Heat Treatment

• Part ULW
  Requirements for Pressure Vessels Fabricated by Layered Construction

• Part ULT
  Alternative Rules for Pressure Vessels Constructed of Materials Having Higher Allowable Stresses at Low Temperature
Part UCS

Requirements for Pressure Vessels Constructed of Carbon and Low Alloy Steels
Two important issues for carbon and low alloy steels:

- Post weld heat treatment
- Impact test
• **Temperatures to Consider**
• Minimum Design Metal Temperature (MDMT)
• Lowest temperature at which component has adequate fracture toughness
PWHT
(stress relieving at around 600 centigrade)
• Postweld heat treatment is mandatory under the following conditions:
  
  • (a) for welded joints over 11/2 in. (38 mm) nominal thickness;
  
  • b) for welded joints over 11/4 in. (32 mm) nominal thickness through 11/2 in. (38 mm) nominal thickness unless preheat is applied at a minimum temperature of 200°F (95°C) during welding;
TABLE UCS-56
POSTWELD HEAT TREATMENT IS REQUIRED AS THE THICKNESS OR ALLOYING ELEMENTS INCREASE

<table>
<thead>
<tr>
<th>Material</th>
<th>Normal Holding Temperature, °F (°C), Minimum</th>
<th>Minimum Holding Time at Normal Temperature for Nominal Thickness [See UW-40(f)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-No. 1 Gr. Nos. 1, 2, 3</td>
<td>1100 (593)</td>
<td>Up to 2 in. (51 mm): 1 hr/in. (25 mm), 15 min minimum</td>
</tr>
<tr>
<td>Gr. No. 4</td>
<td>NA</td>
<td>None</td>
</tr>
</tbody>
</table>
### QW/QB-422  FERROUS/NONFERROUS P-NUMBERS (CONT’D)

**Grouping of Base Metals for Qualification**

#### Ferrous (CONT’D)

<table>
<thead>
<tr>
<th>Spec. No.</th>
<th>Type or Grade</th>
<th>UNS No.</th>
<th>Minimum Specified Tensile, ksi (MPa)</th>
<th>Welding</th>
<th>Brazing</th>
<th>ISO 15608 Group</th>
<th>Nominal Composition</th>
<th>Product Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 514</td>
<td>E</td>
<td>K21604</td>
<td>110 (760)</td>
<td>11B</td>
<td>2</td>
<td>102</td>
<td>3.1</td>
<td>1.75Cr-0.5Mo-Cu</td>
</tr>
<tr>
<td>A 514</td>
<td>P</td>
<td>K21650</td>
<td>100 (690)</td>
<td>11B</td>
<td>8</td>
<td>102</td>
<td>3.1</td>
<td>1.25Ni-1Cr-0.5Mo</td>
</tr>
<tr>
<td>A 514</td>
<td>P</td>
<td>K21650</td>
<td>110 (760)</td>
<td>11B</td>
<td>8</td>
<td>102</td>
<td>3.1</td>
<td>1.25Ni-1Cr-0.5Mo</td>
</tr>
<tr>
<td>A 514</td>
<td>Q</td>
<td>...</td>
<td>100 (690)</td>
<td>11B</td>
<td>9</td>
<td>102</td>
<td>3.1</td>
<td>1.3Ni-1.3Cr-0.5Mo-V</td>
</tr>
<tr>
<td>A 514</td>
<td>Q</td>
<td>...</td>
<td>110 (760)</td>
<td>11B</td>
<td>9</td>
<td>102</td>
<td>3.1</td>
<td>1.3Ni-1.3Cr-0.5Mo-V</td>
</tr>
<tr>
<td>SA-515</td>
<td>60</td>
<td>K02401</td>
<td>60 (415)</td>
<td>1</td>
<td>1</td>
<td>101</td>
<td>1.1</td>
<td>C</td>
</tr>
<tr>
<td>SA-515</td>
<td>65</td>
<td>K02800</td>
<td>65 (450)</td>
<td>1</td>
<td>1</td>
<td>101</td>
<td>11.1</td>
<td>C-Si</td>
</tr>
<tr>
<td>SA-515</td>
<td>70</td>
<td>K03101</td>
<td>70 (485)</td>
<td>1</td>
<td>2</td>
<td>101</td>
<td>11.1</td>
<td>C-Si</td>
</tr>
<tr>
<td>SA-516</td>
<td>55</td>
<td>K01800</td>
<td>55 (380)</td>
<td>1</td>
<td>1</td>
<td>101</td>
<td>1.1</td>
<td>C-Si</td>
</tr>
<tr>
<td>SA-516</td>
<td>60</td>
<td>K02100</td>
<td>60 (415)</td>
<td>1</td>
<td>1</td>
<td>101</td>
<td>1.1</td>
<td>C-Mn-Si</td>
</tr>
<tr>
<td>SA-516</td>
<td>65</td>
<td>K02403</td>
<td>65 (450)</td>
<td>1</td>
<td>1</td>
<td>101</td>
<td>1.1</td>
<td>C-Mn-Si</td>
</tr>
<tr>
<td>SA-516</td>
<td>70</td>
<td>K02700</td>
<td>70 (485)</td>
<td>1</td>
<td>2</td>
<td>101</td>
<td>11.1</td>
<td>C-Mn-Si</td>
</tr>
<tr>
<td>SA-517</td>
<td>F</td>
<td>K11576</td>
<td>115 (795)</td>
<td>11B</td>
<td>3</td>
<td>101</td>
<td>3.1</td>
<td>0.75Ni-0.5Cr-0.5Mo-V</td>
</tr>
<tr>
<td>SA-517</td>
<td>B</td>
<td>K11630</td>
<td>115 (795)</td>
<td>11B</td>
<td>4</td>
<td>101</td>
<td>3.1</td>
<td>0.5Cr-0.2Mo-V</td>
</tr>
<tr>
<td>SA-517</td>
<td>A</td>
<td>K11856</td>
<td>115 (795)</td>
<td>11B</td>
<td>1</td>
<td>101</td>
<td>3.1</td>
<td>0.5Cr-0.25Mo-Si</td>
</tr>
<tr>
<td>SA-517</td>
<td>E</td>
<td>K21604</td>
<td>105 (725)</td>
<td>11B</td>
<td>2</td>
<td>102</td>
<td>3.1</td>
<td>1.75Cr-0.5Mo-Cu</td>
</tr>
<tr>
<td>SA-517</td>
<td>E</td>
<td>K21604</td>
<td>115 (795)</td>
<td>11B</td>
<td>2</td>
<td>102</td>
<td>3.1</td>
<td>1.75Cr-0.5Mo-Cu</td>
</tr>
<tr>
<td>SA-517</td>
<td>P</td>
<td>K21650</td>
<td>105 (725)</td>
<td>11B</td>
<td>8</td>
<td>102</td>
<td>3.1</td>
<td>1.25Ni-1Cr-0.5Mo</td>
</tr>
<tr>
<td>SA-517</td>
<td>P</td>
<td>K21650</td>
<td>115 (795)</td>
<td>11B</td>
<td>8</td>
<td>102</td>
<td>3.1</td>
<td>1.25Ni-1Cr-0.5Mo</td>
</tr>
<tr>
<td>A 519</td>
<td>1018 HR</td>
<td>G10180</td>
<td>...</td>
<td>1</td>
<td>1</td>
<td>101</td>
<td>1.1</td>
<td>C</td>
</tr>
<tr>
<td>A 519</td>
<td>1018 CW</td>
<td>G10180</td>
<td>...</td>
<td>1</td>
<td>2</td>
<td>101</td>
<td>1.1</td>
<td>C</td>
</tr>
<tr>
<td>A 519</td>
<td>1020 HR</td>
<td>G10200</td>
<td>...</td>
<td>1</td>
<td>1</td>
<td>101</td>
<td>1.1</td>
<td>C</td>
</tr>
<tr>
<td>A 519</td>
<td>1020 CW</td>
<td>G10200</td>
<td>...</td>
<td>1</td>
<td>2</td>
<td>101</td>
<td>1.1</td>
<td>C</td>
</tr>
<tr>
<td>A 519</td>
<td>1022 HR</td>
<td>G10220</td>
<td>...</td>
<td>1</td>
<td>1</td>
<td>101</td>
<td>1.1</td>
<td>C</td>
</tr>
</tbody>
</table>
Impact Testing
at minimum design temperature

NOTE:
(1) See UG-84(c) for thickness of reduced size specimen.

FIG. UG-84 SIMPLE BEAM IMPACT TEST SPECIMENS (CHARPY TYPE TEST)
GRAPH UCS-66:

IMPACT TEST IS REQUIRED BELOW THE CURVE.

AS THE SERVICE TEMPERATURE DECREASE OR THICKNESS INCREASE

Minimum Design Metal Temperature
## Material Groups

<table>
<thead>
<tr>
<th>MATERIAL GROUP</th>
<th>APPLICABLE MATERIALS</th>
</tr>
</thead>
</table>
| Curve A        | • All carbon and low alloy steel plates, structural shapes, and bars not listed in Curves B, C & D  
• SA-216 Gr. WCB & WCC, SA-217 Gr. WC6, if normalized and tempered or water-quenched and tempered |
| Curve B        | • SA-216 Gr. WCA, if normalized and tempered or water-quenched and tempered  
• SA-216 Gr. WCB & WCC for maximum thickness of 2 in., if produced to fine grain practice and water-quenched and tempered  
• SA-285 Gr. A & B  
• SA-414 Gr. A  
• SA-515 Gr. 60  
• SA-516 Gr. 65 & 70, if not normalized  
• Except for cast steels, all materials of Curve A if produced to fine grain practice and normalized which are not included in Curves C & D  
• All pipe, fittings, forging, and tubing which are not included in Curves C & D |
## Material Groups, cont’d

<table>
<thead>
<tr>
<th>MATERIAL GROUP</th>
<th>APPLICABLE MATERIALS</th>
</tr>
</thead>
</table>
| Curve C        | SA-182 Gr. 21 & 22, if normalized and tempered  
|                | SA-302 Gr. C & D    
|                | SA-336 Gr. F21 & F22, if normalized and tempered  
|                | SA-387 Gr. 21 & 22, if normalized and tempered  
|                | SA-516 Gr. 55 & 60, if not normalized  
|                | SA-533 Gr. B & C    
|                | SA-662 Gr. A        
|                | All material of Curve B if produced to fine grain practice and normalized which are not included in Curve D |
| Curve D        | SA-203               
|                | SA-508 Cl. 1        
|                | SA-516, if normalized  
|                | SA-524 Cl. 1 & 2    |
|                | SA-537 Cl. 1, 2 & 3  
|                | SA-612, if normalized  
|                | SA-662, if normalized  
|                | SA-738 Gr. A        |
Energy Requirement in Impact Testing

- Minimum specified yield strength:
  - 65 ksi (448 MPa)
  - 55 ksi (380 MPa)
  - 50 ksi (345 MPa)
  - 45 ksi (310 MPa)
  - ≤38 ksi (262 MPa)

- Graph showing energy requirement vs. maximum nominal thickness of material or weld.
### TABLE A2.15

**GENERALLY AVAILABLE GRADE-THICKNESS-MINIMUM TEST TEMPERATURE COMBINATIONS MEETING CHARPY V-NOTCH REQUIREMENTS INDICATED (NORMALIZED OR QUENCHED AND TEMPERED CONDITION) (CONT’D)**

<table>
<thead>
<tr>
<th>Acceptance criteria Charpy V-Notch</th>
<th>Energy Absorption</th>
<th>Test Temperature, °C, for Plate Thicknesses (Unless Otherwise Agreed Upon)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>25 mm and Under</td>
</tr>
<tr>
<td>Class A</td>
<td>Minimum Average For 3 Specimens $^8$, J</td>
<td>Minimum for 1 Specimen $^8$, J</td>
</tr>
<tr>
<td>V</td>
<td>27</td>
<td>20</td>
</tr>
<tr>
<td></td>
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<tr>
<td>VI</td>
<td>0.38</td>
<td>...</td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Lateral Expansion mm, Minimum Each Specimen Transverse Test**
<table>
<thead>
<tr>
<th>P-No. &amp; Gr. No. Classification of Material</th>
<th>Nominal Thickness Above Which Butt Welded Joints Shall Be Fully Radiographed, in. (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Gr. 1, 2, 3</td>
<td>$1\frac{3}{4}$ (32)</td>
</tr>
<tr>
<td>3 Gr. 1, 2, 3</td>
<td>$\frac{3}{4}$ (19)</td>
</tr>
<tr>
<td>4 Gr. 1, 2</td>
<td>$\frac{5}{8}$ (16)</td>
</tr>
<tr>
<td>5A, 5B Gr. 1</td>
<td>0 (0)</td>
</tr>
<tr>
<td>9A Gr. 1</td>
<td>$\frac{5}{8}$ (16)</td>
</tr>
<tr>
<td>9B Gr. 1</td>
<td>$\frac{5}{8}$ (16)</td>
</tr>
<tr>
<td>10A Gr. 1</td>
<td>$\frac{3}{4}$ (19)</td>
</tr>
<tr>
<td>10B Gr. 2</td>
<td>$\frac{5}{8}$ (16)</td>
</tr>
<tr>
<td>10C Gr. 1</td>
<td>$\frac{5}{8}$ (16)</td>
</tr>
<tr>
<td>10F Gr. 6</td>
<td>$\frac{3}{4}$ (19)</td>
</tr>
</tbody>
</table>
Sample Problem 1 – Design for Internal Pressure

- The geometry and design data of a vertical cylindrical pressure vessel are specified in next Figure Cost estimates are being prepared for this vessel. It is your job to estimate the required component thicknesses.

- A. What are the minimum required thicknesses for the two cylindrical sections?
DESIGN INFORMATION
Design Pressure = 250 psig
Design Temperature = 700° F
Shell and Head Material is SA-515 Gr. 60
Corrosion Allowance = 0.125"
Both Heads are Seamless
Shell and Cone Welds are Double Welded and will be Spot Radiographed
The Vessel is in All Vapor Service
Cylinder Dimensions Shown are Inside Diameters
Sample Problem 2 - External Pressure Calculation

- The vendor has proposed that the wall thickness of the tower shown in next slide be 7/16 in., and no stiffener rings have been specified. Is the 7/16 in. thickness acceptable for external pressure? If it is not acceptable, what minimum thickness is required? Round your answer upward to the nearest 1/16 in.
DESIGN INFORMATION
Design Pressure = Full Vacuum
Design Temperature = 500° F
Shell and Head Material is
SA-285 Gr. B, Yield Stress = 27 ksi
Corrosion Allowance = 0.0625"
Cylinder Dimension Shown
is Inside Diameter
Sample peoblem 3

- **Required Thickness for Internal Pressure**
- Determine the minimum required thickness for the cylindrical shell and heads of the following pressure vessel:
  - Inside Diameter - 10’ - 6”
  - Design Pressure - 650 psig
  - Design Temperature - 700°F
  - Shell & Head Material - SA-516 Grade 70
  - Corrosion Allowance - 0.125”
  - 2:1 Semi-Elliptical heads, seamless
  - 100% radiography of cylindrical shell welds
  - The vessel is in an all vapor service (i.e., no liquid loading)
Reinforcement of opening

To determine whether an opening is adequately reinforced, it is first necessary to determine whether the areas of reinforcement available will be sufficient without the use of a pad.

- the total cross-sectional area of reinforcement required (in square inches) is indicated by the letter $A$, which is equal to the diameter (plus C.A.) times the required thickness. The area of reinforcement available without a pad includes:

1. The area of excess thickness in the shell or head, $A_1$
2. The area of excess thickness in the nozzle wall, $A_2$
3. The cross-sectional area of welds, $A_3$. 
If $A_1 + A_2 + A_3 = A$, the opening is adequately reinforced.

If $A_1 + A_2 + A_3 < A$, a pad is needed.

If the reinforcement is found to be inadequate, then the area of pad needed ($A_4$) may be calculated as follows:

$$A_4 = A - (A_1 + A_2 + A_3)$$

- If a pad is used, the factor (2.5N) in the equation for A2 (see slide 253) is measured from the top surface of the pad and therefore becomes: 2.5N + Tp. The area A2 must be recalculated on this basis and the smaller value again used. Then:

  If $A_1 + A_2 + A_3 + A_4 = A$, the opening is adequately reinforced.

- All values except E are in inches.
Corrosion allowance

Limit of reinforcement
(use smaller value)

Nozzle wall inside shell can be used as reinforcement

2.5t or 2.5N

2.5N

Limit of reinforcement
(use greater value)
Cross-Sectional View of Nozzle Opening

2.5t or 2.5\(t_n\) + \(t_e\)
Use smaller value

2.5t or 2.5\(t_n\)
Use smaller value

d or \(R_n + t_n + t\)
Use larger value

For nozzle wall inserted through the vessel wall

For nozzle wall abutting the vessel wall
\( d \) = diameter in the plane under consideration of the finished opening in its corroded condition
\( t \) = nominal thickness of shell or head, less corrosion allowance
\( t_r \) = required thickness of shell or head as defined in Code Par. UG-37
\( t_{rn} \) = required thickness of a seamless nozzle wall
\( T_p \) = thickness of reinforcement pad
\( W_p \) = width of reinforcement pad
\( N \) = nominal thickness of nozzle wall, less corrosion allowance
\( W_1 \) = cross-sectional area of weld
\( W_2 \) = cross-sectional area of weld
\( E \) = 1 when an opening is in the solid plate or passes through a circumferential joint in a shell or cone

= the longitudinal joint efficiency when any part of the opening passes through any other joint
<table>
<thead>
<tr>
<th>SHELL OR HEAD DATA</th>
<th>NOZZLE DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$P =$ pressure, psi</td>
</tr>
<tr>
<td></td>
<td>$S =$ allowable stress, psi</td>
</tr>
<tr>
<td></td>
<td>$r =$ inside radius of nozzle, in.</td>
</tr>
<tr>
<td></td>
<td>$E =$ joint efficiency, per cent</td>
</tr>
<tr>
<td>$t =$ actual thickness of shell or head (minus corrosion)</td>
<td>$N =$ actual thickness of nozzle (minus corrosion)</td>
</tr>
<tr>
<td>$t_r =$ calculated thickness of shell or head</td>
<td>$t_{rn} =$ calculated thickness of nozzle</td>
</tr>
<tr>
<td>$Et - t_r =$ excess thickness in shell or head</td>
<td>$N - t_{rn} =$ excess thickness in nozzle</td>
</tr>
</tbody>
</table>

$$t_{rn} = \frac{Pt}{SE - 0.6P}$$
Area of reinforcement required

\[ A = dt_r \]

Area of reinforcement available without pad

\[ (A_1 + A_2 + A_3) \]

Area of excess thickness in shell or head (use greater value)

\[ A_1 = (Et - t_r)d \]
\[ \text{or } A_1 = 2(Et - t_r)(t + N) \]

Area of excess thickness in nozzle wall (use smaller value)

\[ A_2 = 2(2.5N)(N - t_{rn}) \]
\[ \text{or } A_2 = 2(2.5t)(N - t_{rn}) \]

Cross-sectional area of welds

\[ A_3 = 2 \left( \frac{(W_1)^2 + (W_2)^2}{2} \right) \]

Area in pad

\[ A_4 = 2W_p T_p \]

Total area available

* If reinforcing pad is used, the factor \((2.5N)\) becomes \((2.5N + T_p)\)
Sample problem 4

You are reviewing the nozzle design details that are proposed by a vendor for a new drum and have selected an NPS 8 nozzle into the shell for detailed evaluation. The vendor has not provided any reinforcement for this nozzle, and he has not provided any calculations to verify that use of the nozzle without reinforcement is acceptable. Determine if this nozzle requires additional reinforcement. If it does, assume that a 0.5 in. thick reinforcement pad of SA-516, Gr. 60 material is used. What must the minimum pad diameter be? Neglect any contribution of weld areas in these calculations since they are insignificant. The information that is needed to perform your evaluation is next slide.
DESIGN INFORMATION
Design Pressure = 300 psig
Design Temperature = 200°F
Shell Material is SA-516 Gr. 60
Nozzle Material is SA-53 Gr. B, Seamless
Corrosion Allowance = 0.0625"
Vessel is 100% Radiographed
Nozzle does not pass through Vessel Weld Seam

NPS 8 Nozzle
(8.625" OD)
0.5" Thick

0.5625" Thick Shell, 48" Inside Diameter
امکان جدا کردن قطعات از یکدیگر به منظور تعمیر، تعویض و تغییرات در سیستم را می‌دهد. همچنین باعث تسهیل در مونتاژ مجموعه می‌شوند.

مهمترین انواع فلنج:

- Welding neck
- Slip – on/lap joint
- Blind
- Socket weld
- threded
Table 8  Dimensions of Class 150 Flanges

<table>
<thead>
<tr>
<th>Type</th>
<th>Diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threaded</td>
<td><img src="threadedDiagram.png" alt="Threaded Diagram" /></td>
</tr>
<tr>
<td>Slip-On Welding</td>
<td><img src="slipOnWeldingDiagram.png" alt="Slip-On Welding Diagram" /></td>
</tr>
<tr>
<td>Socket Welding</td>
<td><img src="socketWeldingDiagram.png" alt="Socket Welding Diagram" /></td>
</tr>
<tr>
<td>Lapped</td>
<td><img src="lappedDiagram.png" alt="Lapped Diagram" /></td>
</tr>
<tr>
<td>Blind</td>
<td><img src="blindDiagram.png" alt="Blind Diagram" /></td>
</tr>
<tr>
<td>Welding Neck</td>
<td><img src="weldingNeckDiagram.png" alt="Welding Neck Diagram" /></td>
</tr>
</tbody>
</table>

Notes:
1. [Note 1] Indicates specific dimensions or notes related to each type of flange.
Sample Problem 4

- Determine Required Flange Rating
- Pressure Vessel Data:
  - Shell and Heads: SA-516 Gr.70
  - Flanges: SA-105
  - Design Temperature: 375°C
  - Design Pressure: 19 bar
Horizontal Drum on Saddle Supports
Vertical Drum on Leg Supports
Spherical Pressurized Storage Vessel
Vertical Reactor

- Inlet Nozzle
- Head
- Upper Catalyst Bed
- Support Grid
- Lower Catalyst Bed
- Outlet Collector
- Outlet Nozzle
- Support Skirt
- Shell
Vertical Vessel on Lug Supports
Fabrication

- Head Forming
Fabrication

- Shell Forming

- Dimension control with meter
Fabrication

- Welding of shell sections
- Fixing with fixture
Fabrication
Fabrication

- Shell sections assembling
- Welding
- Back gouging
- Back weld
- PT
Fabrication

- Head to shell attachment
- Welding
- Back gouging
- Back weld
- PT
Fabrication

- Head to shell attachment
- Welding
- Back gouging
- Back weld
- PT
Fabrication

- Welding of nozzles sections
- 9) Flange to nozzle welding
- 10) Nozzle place cutting in shell
- Oxygen cutting
- Grinding
Fabrication

- Nozzle to shell assembling
- 12) Nozzle to shell welding
- Welding
- Back gouging
- Back weld
- PT
Fabrication
Fabrication

- Transferring the vessel to the site