ASME B31.3 Process Piping

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Piping Development Process

1. Establish applicable system standard(s)
2. Establish design conditions
3. Make overall piping material decisions
   - Pressure Class
   - Reliability
   - Materials of construction
4. Fine tune piping material decisions
   - Materials
   - Determine wall thicknesses
   - Valves
5. Establish preliminary piping system layout & support configuration
6. Perform flexibility analysis
7. Finalize layout and bill of materials
8. Fabricate and install
9. Examine and test
17. High Pressure Piping

- General
- Materials
- Pressure Design
- Limitations
- Fabrication
- Examination
- Testing

The Material in This Section is Addressed by B31.3 in:

- Chapter IX - High Pressure Piping
- Appendix K - Allowable Stresses for High Pressure Piping
General

**High Pressure:** A service for which the owner specifies the use of Chapter IX [of B31.3] for piping design and construction… considered to be in excess of Class 2500 (6000 psi, 42 MPa).

There are no specified pressure limitations for application of these rules. [K300(a)]

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**General**

- Most applications are in the range of 20,000 psi (150 MPa) and higher
- Nonmetallic piping is excluded
- No provisions are made for Category M fluid service
- The temperature is required to be below the creep range
- Allowances for variations in pressure and temperature are not permitted
Materials

- Allowable stress for materials other than bolting
  - $\frac{2}{3}$ of specified minimum yield strength ($S_Y$)
  - $\frac{2}{3}$ of yield strength at temperature; except for austenitic stainless steels and nickel alloys with similar behavior, 90% of yield strength at temperature

<table>
<thead>
<tr>
<th>Material</th>
<th>Base Code (ksi)</th>
<th>High Pressure (ksi)</th>
<th>Base Code (MPa)</th>
<th>High Pressure (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A106 Gr B</td>
<td>20.0</td>
<td>23.3</td>
<td>138</td>
<td>161</td>
</tr>
<tr>
<td>API 5L X80</td>
<td>30.0</td>
<td>53.3</td>
<td>207</td>
<td>368</td>
</tr>
</tbody>
</table>

Materials

- Castings and welded components are required to be such that the quality factors are equal to 1.0
- Conformance of materials to the product analysis chemical requirements of the applicable specification shall be verified.
- Cast irons are not permitted
- Zinc coated materials are not permitted, nor are zinc coated materials permitted to be welded to pressure containing components
Materials

Impact Test Requirements

- Impact testing is required for all materials from which a suitable test specimen can be machined.
- The impact test temperature shall be no higher than the lowest temperature at which the piping is subjected to a stress greater than 6 ksi (41 MPa)...lower if subsize specimens are required.
- Minimum acceptable impact values are higher than for the base code.

Pressure Design – Straight Pipe

\[ t = \left( \frac{D}{2} \right) \left[ 1 - \exp\left( -1.155 \frac{P}{S} \right) \right] \]

Where:
- \( t \) = pressure design thickness
- \( D \) = outside diameter of pipe
- \( P \) = design pressure
- \( S \) = stress value for material from Appendix K (Autoclave Engineers)
Pressure Design – Straight Pipe

- The equation is based on through thickness yielding pressure as a basis for design
- The equation provides a factor of two on through thickness yielding

![Diagram]

Base Code, A106 Gr B
High Pressure, A106 Gr B
Base Code, API 5L X80
High Pressure, API 5L X80

(1 in. OD tubing)
Pressure Design – Straight Pipe

Pressure Design

Thread depth need not be subtracted from the pipe wall thickness when

- Thread depth does not exceed 20% of the wall thickness
- D/d is greater than 1.1
- The internally threaded attachment provides adequate reinforcement
- The thread undercut area does not extend beyond the reinforcement by a distance greater than the pipe wall thickness

(Autoclave Engineers)
Pressure Design [K304.7.2]

Components for which there are no specific rules require:

- Calculations consistent with the design philosophy of Chapter IX, and
- Substantiation of the calculations by
  - Extensive successful experience
  - Performance testing, or
  - Finite element stress analysis
- Interpolation between sizes & thicknesses allowed

Pressure Design

Fatigue Analysis

- Fatigue analysis in accordance with ASME B&PV Code, Section VIII, Div. 2 is required
- Pressure is the primary load, but alternating sustained loads and displacement loads must also be included
- High stresses at the inner surface of the pipe wall and stress concentrations must be considered
- An inelastic analysis is required if the stress on the inside surface of the pipe exceeds three times the allowable stress (twice yield)
Pressure Design

Fatigue Analysis

- Fatigue life may be demonstrated by destructive testing when the owner approves
- Fatigue life beyond that calculated via the Section VIII, Div. 2 method may be applied when
  - surface treatments or
  - prestressing methods
are used, and the component is qualified by
  - extensive successful service or
  - performance testing
in accordance with K304.7.2

Limitations

Not permitted

- Miter bends
- Fabricated branches
- Corrugated and creased bends
- Laps other than forged
- Slip-on flanges
Limitations

**Joints Not permitted**
- Ordinary threaded, except for instrumentation up to NPS ½
- Socket welding
- Expanded
- Solder
- Compression and flared tubing
- Caulked
- Bell type
- Adhesive

Fabrication

- Welder qualification is like for the base Code, except
  - Impact tests are required for all procedure and performance qualifications
  - More testing is required for weld procedure and performance qualifications
  - Performance and procedure qualification by others is not permitted
Fabrication

- Seal welds are not permitted
- Welded branch construction must provide for 100% interpretable radiographic examination

Examination Requirements - VT

<table>
<thead>
<tr>
<th>Metallic Piping</th>
<th>Normal</th>
<th>High Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials &amp; components</td>
<td>Random to extent needed to satisfy the examiner</td>
<td>100%</td>
</tr>
<tr>
<td>Fabrication, including welds</td>
<td>5% Random</td>
<td>100%</td>
</tr>
<tr>
<td>Longitudinal welds</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Bolted, threaded &amp; other joints</td>
<td>Random to extent needed…, except 100% for pneumatic test</td>
<td>100%, threads to be examined for finish and fit, and compliance with applicable standard</td>
</tr>
<tr>
<td>Supports, alignment, erected piping</td>
<td>Random</td>
<td>100%</td>
</tr>
</tbody>
</table>
Examination Requirements - Other

<table>
<thead>
<tr>
<th>Metallic Piping</th>
<th>Normal</th>
<th>High Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circumferential groove welds</td>
<td>5% Random RT or UT</td>
<td>100% RT</td>
</tr>
<tr>
<td>Longitudinal welds</td>
<td>100% RT</td>
<td></td>
</tr>
<tr>
<td>Branch connection welds</td>
<td></td>
<td>100% RT</td>
</tr>
</tbody>
</table>

- Neither ultrasonic examination nor in-process examination may be substituted for radiographic examination.
- Acceptance criteria are more stringent than the base Code.

Testing

- A hydrostatic or a pneumatic test at 1.5 times the design pressure corrected for temperature is required.
- Protection of people and property from missile fragments, shock waves and other consequences of failure must be provided.
- A leak test of the installed piping at 1.1 times the design pressure is required unless the main leak test was done on the installed piping.
- For all welded systems, the closing weld may be tested at 1.1 times the design pressure.