A Comparison:
ASME B31.1 Power Piping
versus
ASME B31.3 Process Piping

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Topics Discussed

- B31 History
- Scopes
- Organization of the Codes
- Bases for Allowable Stresses
- Piping Component Standards
- Fluid Service Requirements
- Material Requirements
- Pressure Design
- Flexibility Analysis
- Fabrication and Installation
- Inspection, Examination and Testing
Comparison: ASME B31.1 to ASME B31.3

B31 History

- In the mid 1800's, boiler explosions were occurring at the rate of one every four days.
- On April 27, 1865 the boiler explosion on the Sultana killed 1800 returning civil war soldiers.
- From 1898 to 1903, more than 1200 people were killed in the U.S. in 1900 separate boiler explosions. The catastrophic explosion of a fire tube boiler in a factory in Brockton, Massachusetts, in 1905 killed 58 people.

ASME formed a committee to address the boiler explosion problem - 1911.
ASME Boiler and Pressure Vessel Code (BPVC) was the first comprehensive standard for the design, construction, inspection, and testing of boilers and pressure vessels - 1915.
American Standards Institute initiated a project to develop a piping code - 1926.
American Tentative Standard code for Pressure Piping – 1935.
Separate sections were split off starting in 1955.
B31 Piping Codes

➢ Each Code provides a set of requirements for obtaining a safe, reliable and economical installation.
➢ The designer is cautioned that the Code is not a design handbook; it does not eliminate the need for the designer or for competent engineering judgment.

ASME Piping System Standards

BPE-1  Bioprocessing Equipment
PVHO-1  Pressure Vessels for Human Occupancy
B&PV Code, Section III for Nuclear Power Plants
Other USA Piping System Standards

NFPA 13 – Installation of Sprinkler Systems
NFPA 24 – Installation of Private Mains
NFPA 50 – Bulk Oxygen Systems
NFPA 54 – National Fuel Gas Code
CGA – Handling of Anhydrous Ammonia (K61.1)
Chlorine Institute #6 – Piping Systems for Chlorine

B31.1 and B31.3 Scopes

Rules have been developed considering piping typically found in

- electric power generating stations, industrial and institutional plants,
- geothermal heating systems and central and district heating and cooling systems. (100.1)
- petroleum refineries; chemical, pharmaceutical, textile, paper, semiconductor, and cryogenic plants; and related processing plants and terminals. (300.1)

ASME B31.1 ASME B31.3
**Comparison: ASME B31.1 to ASME B31.3**

## B31.1 and B31.3 Scopes

<table>
<thead>
<tr>
<th>Power piping systems ...include but are not limited to</th>
<th>This Code applies for all fluids, including:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- steam</td>
<td>(1) raw, intermediate, and finished chemicals;</td>
</tr>
<tr>
<td>- water</td>
<td>(2) petroleum products;</td>
</tr>
<tr>
<td>- oil</td>
<td>(3) gas, steam, air, and water;</td>
</tr>
<tr>
<td>- gas</td>
<td>(4) fluidized solids;</td>
</tr>
<tr>
<td>- air</td>
<td>(5) refrigerants;</td>
</tr>
<tr>
<td>[100.1.2]</td>
<td>(6) cryogenic fluids.</td>
</tr>
<tr>
<td></td>
<td>[300.1.1(b)]</td>
</tr>
</tbody>
</table>

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**Requirements**

<table>
<thead>
<tr>
<th>B31.1 provides requirements for types of piping</th>
<th>B31.3 provides requirements for fluid services</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Boiler External</td>
<td>- Category D (utility)</td>
</tr>
<tr>
<td>- Blowoff and Blowdown</td>
<td>- Category M (lethal)</td>
</tr>
<tr>
<td>- Instrument, Control and Sample</td>
<td>- Elevated Temperature (creep range)</td>
</tr>
<tr>
<td>- Spray Type Desuperheater</td>
<td>- High Pressure (above about 100 MPa)</td>
</tr>
<tr>
<td>- Pressure Relief</td>
<td>- High Purity</td>
</tr>
<tr>
<td>- Flammable or Combustible Liquids</td>
<td>- Normal (Process)</td>
</tr>
<tr>
<td>- Flammable Gases and Toxic Fluids</td>
<td>- Severe Cyclic Conditions</td>
</tr>
<tr>
<td>- Piping for Corrosive Fluids</td>
<td></td>
</tr>
<tr>
<td>- Temporary</td>
<td></td>
</tr>
<tr>
<td>- Steam Trap</td>
<td></td>
</tr>
<tr>
<td>- Pump Suction and Discharge</td>
<td></td>
</tr>
<tr>
<td>- District Distribution Systems</td>
<td></td>
</tr>
</tbody>
</table>

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Comparison: ASME B31.1 to ASME B31.3

Organization of the Codes

I Scope and Definitions
II Design
III Materials
IV Dimensional Requirements
V Fabrication, Assembly, and Erection
VI Inspection, Examination and Testing

Appendices covering:
- Nonmetallic Piping and Piping Lined with Nonmetals
- Design of Safety Valve Installations
- Corrosion Control
- Restrained Underground Piping

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What's Different in B31.1 -
Comparison: ASME B31.1 to ASME B31.3

Bases for Design Stresses

**B31.1** – The lowest of

- the specified minimum tensile strength divided by 3.5
- tensile strength at temperature divided by 3.5
- 2/3 of specified minimum yield strength
- 2/3 of yield strength at temperature; except for austenitic stainless steels, 90% of yield strength at temperature
- Creep strength criteria

**B31.3** – The lowest of

- the specified minimum tensile strength divided by 3
- tensile strength at temperature divided by 3
- 2/3 of specified minimum yield strength
- 2/3 of yield strength at temperature; except for austenitic stainless steels, 90% of yield strength at temperature
- Creep strength criteria

ASTM A106 Grade B Carbon Steel (US Customary Units)
Piping Component Standards

- **Standard Components**: Those listed by standard number in Table 126.1, which lists material specifications (ASTM) as well as component standards.
- **Listed Components**: Those listed by standard number in Table 326.1 and Appendix A.
- **Unlisted Components**: Those not so listed.

Nonstandard/Unlisted Components

- Can be used if they:
  - “adherence to dimensional standards of ANSI and ASME is strongly recommended when practicable”, and
  - Meet the pressure design formulas and procedures given in para. 104
  
  [104, 126.2]

- Can be used if they:
  - “are checked for adequacy of mechanical strength under applicable loadings…”, and
  - “composition, mechanical properties, method of manufacture, and quality control are comparable to listed components”, and
  - Have pressure-temperature ratings that conform with para. 304

[302.2.3, 326.1.2]
Comparison: ASME B31.1 to ASME B31.3

Selected Fluid Service Requirements

- Furnace butt welded pipe is not permitted for flammable, combustible or toxic fluids
- Furnace butt welded pipe is permitted only for Category D fluid service (utility)
- Soldered joints may not be used for flammable or toxic fluids
- Soldered joints may be used only for Category D fluid service (utility)

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What's Different in B31.1 - 19

Selected Fluid Service Requirements

- Brazed joints may not be used for flammable or toxic fluids in fire hazard areas
- Brazed joints are permitted for fluids that are flammable, toxic or damaging to human tissue only if safeguarded
- Threaded joint size limited by temperature and pressure; example max. pressure NPS 3 (DN 80) joint is 400 psi (2750 kPa)
- NPS 1-1/2 (DN 40) and smaller tapered joints must be Sch 80 for notch sensitive material in Normal Service
- Pipe thinner than STD WT may not be thr’d'd

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What's Different in B31.1 - 20
Material Requirements

- **Listed Material:** a material that conforms to a specification in Appendix A or to a standard in Table 126.1 – may be used (123.1.1)

- **Unlisted Material:** a material that is not so listed – may be used under certain conditions (123.1.2)

- **Unknown Material:** may not be used (123.1.3)

An unlisted material may be used if (123.1.2)
- It conforms to a published specification covering chemistry, mechanical properties, etc.
- Otherwise meets the requirements of the Code
- Allowable stresses are determined in accordance with Code bases, and
- Qualified for service…at all temperatures

An unlisted material may be used if (323.1.2)
- It conforms to a published specification covering chemistry, mechanical properties, etc.
- Otherwise meets the requirements of the Code
- Allowable stresses are determined in accordance with Code bases, and
- Qualified for service…at all temperatures (323.2.4)
Material Requirements

- Materials for BEP must be ASME B&PV Code materials
- Use at temperatures above maximum in the stress tables is generally not permitted
- No rules for use at temperatures below -20°F (-29°C)
- Use at temperatures above maximum in the stress tables is generally permitted
- Extensive rules for use at temperatures below -20°F (-29°C)

Cast Iron Fluid Service Limits

<table>
<thead>
<tr>
<th>Material</th>
<th>Service Limits</th>
<th>Temperature Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gray Iron</td>
<td>Generally limited to 250 psi (1725 KPa) saturated steam service</td>
<td>May not be used in flammable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>service above 150 psi (1035 KPa)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>May not be used in other services above 400 psi (2760 kPa)</td>
</tr>
<tr>
<td>Malleable Iron</td>
<td>Limited to 350 psi (2415 kPa) and 450°F (230°C)</td>
<td>Limited to -20°F to 650°F (-29°C to 343°C)</td>
</tr>
<tr>
<td>Ductile Iron</td>
<td>Generally limited to temperature of 450°F (232°C) and B16.42 ratings</td>
<td>Generally limited to temperature range of -20°F to 650°F (-29°C to 343°C) and B16.42 ratings</td>
</tr>
</tbody>
</table>
Pressure Design

The rules for pressure design are essentially the same in B31.1 and B31.3, but they are not identical.

Design Pressure & Temperature

*allowance for pressure and temperature variation:* The Codes allow the design pressure to be set below the most severe coincident pressure and temperature for the following variations:

- Can exceed allowable by 20% for no more than 1 hr/event and no more than 80 hr/year
- Can exceed allowable by 15% for no more than 8 hr/event and no more than 800 hr/year
- Can exceed allowable by 33% for no more than 10 hr/event and no more than 100 hr/year
- Can exceed allowable by 20% for no more than 50 hr/event and no more than 500 hr/year
## Flexibility Analysis

### Acceptance Criteria for Sustained Loads

<table>
<thead>
<tr>
<th>Component</th>
<th>Dead Loads</th>
<th>Live Loads</th>
<th>Wind</th>
<th>Earthquake</th>
<th>Water Hammer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$S_L \leq S_h[W]$</td>
<td>$S_L \leq S_h[W]$</td>
<td>$S_L \leq 1.2S_h$ or $S_L \leq 1.15S_h$</td>
<td>$S_L \leq 1.33S_h(E_c)$, or $S_L \leq 0.90S_{yt}X(E_c)$</td>
<td></td>
</tr>
</tbody>
</table>

### Flexibility Analysis

#### Acceptance Criteria for Displacement Loads

\[ S_E \leq S_A = f \left[ 1.25(S_c + S_h) - S_L \right] \]

- Max. value of $f$ is 1.0
- Use single Stress Intensification Factor
- Provides SIF’s for buttwelds, tapered transitions & reducers
- Max. value of $f$ is 1.2
- Use in-plane and out-of-plane Stress Intensification Factors
Comparison: ASME B31.1 to ASME B31.3

Fabrication

- Welder & brazer qualification and bending & forming requirements are very similar but not identical
- Preheating and post weld heat treatment requirements are different, for example
  - B31.1 requires preheating to 200°F (95°C) or post weld heat treatment for carbon steel with thickness less than or equal to 3/4 in. (19.0 mm)
  - B31.3 requires neither preheating nor post weld heat treatment for the same thickness range

Installation

- Bolts must be threaded through the nut
- Threaded joints that are intended to be seal welded should be made up without any thread compound.
- Bolts may be one thread short of a full nut
- Threaded joints that are intended to be seal welded shall be made up without any thread compound.
Comparison: ASME B31.1 to ASME B31.3

**Inspection and Examination**

- Authorized inspector required for boiler external piping, ASME B&PV Code, Section I
- Owner’s Inspector is required to verify examination and testing was done correctly
- Does not include the concept of random with progressive examination... either 100% or none
- Does include the concept of random with progressive examination... e.g. 5% random RT

**Examination**

Examination required by Table 136.4:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Examination Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over 750°F (400°C)</td>
<td>Visual plus</td>
</tr>
<tr>
<td>For NPS ≤ 2 (DN ≤ 50), MP/LP</td>
<td></td>
</tr>
<tr>
<td>Over 1025 psig (70 bar) and 350 to 750°F (175 to 400°C)</td>
<td>Visual plus</td>
</tr>
<tr>
<td>For NPS &gt; 2 (DN &gt; 50), 100% radiography</td>
<td></td>
</tr>
<tr>
<td>All Others</td>
<td>Visual only</td>
</tr>
</tbody>
</table>
Examination

Examination required by para. 341:

<table>
<thead>
<tr>
<th>Category &amp; Condition</th>
<th>Examination Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category D (utility)</td>
<td>Visual Only</td>
</tr>
<tr>
<td>Normal (Process)</td>
<td>Visual plus 5% radiography</td>
</tr>
<tr>
<td>Category M (lethal)</td>
<td>Visual plus 20% radiography</td>
</tr>
<tr>
<td>Elevated Temperature (creep range)</td>
<td>Visual plus 5% radiography, 100% LP/MP of fillet welds</td>
</tr>
<tr>
<td>High Pressure (above about 100 MPa)</td>
<td>Visual plus 100% RT</td>
</tr>
</tbody>
</table>

Leak Testing

- BEP requires hydrotest in accordance with ASME B&PV Code, Section I
- Non BEP requires hydrotest or, at the owner’s option, pneumatic, sensitive leak or initial service leak testing
- Insulated systems may be tested by fluid loss over time method
- Category D Fluid Service may be initial service leak tested
- All other fluid services require hydrostatic or pneumatic testing
- Category M Fluid Service requires a sensitive leak test in addition to the hydrostatic or pneumatic test
Comparison: ASME B31.1 to ASME B31.3

<table>
<thead>
<tr>
<th>Leak Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hydrostatic test</strong> is at 1.5 times design pressure</td>
</tr>
<tr>
<td><strong>Pneumatic test</strong> is at 1.2 to 1.5 times design pressure</td>
</tr>
<tr>
<td>Hydrostatic test pressure must be held a minimum of 10 minutes, and then may be reduced to design pressure for leak examination period</td>
</tr>
</tbody>
</table>

| **Hydrostatic test** is at 1.5 times design pressure corrected for temperature |
| **Pneumatic test** is at 1.1 to 1.33 times design pressure |
| Hydrostatic test pressure must be held a minimum of 10 minutes, and may not be reduced for leak examination period |