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
12. Fabrication and Installation

- Welder/Brazer Qualification
- Welding Processes
- Weld Preparation
- Typical Welds
- Preheating & Heat Treatment
- Typical Owner Added Requirements
- Installation
- Flange Joints

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

Chapter V - Fabrication, Assembly, and Erection
Welder Qualification

Welders are required to use an approved procedure in accordance with B&PV Code Section IX

- Prepare the welding procedure specification (WPS)
  - Essential variables (P-no., thickness, PWHT, etc.)
  - Nonessential variables (Groove design, position, technique, etc)
- Procedure Qualification Test – to determine that weldment is capable of having required properties
- Test of procedure, not welder (normally done by good welders)
- Must pass tensile test and bend test
- May be required to pass supplemental tests (e.g. impact)
- The test record is documented as Procedure Qualification Record (PQR), which is retained by the employer

Welder Qualification

Welders are required to be qualified by test in accordance with B&PV Code Section IX

- Performance Qualifications Test – to determine that the welder is capable of depositing sound weld metal
- Additional essential variables, e.g. position, pipe diameter
- The test record is documented as Welder Performance Qualification (WPQ), which is retained by the employer
- Need to weld with manual (or automatic) process periodically, if not for 6 months, re-qualification required (could be on production weld that is X Rayed)
- Procedure and performance qualifications may be by other than the employer under certain conditions if the Inspector approves.
**Brazer Qualification**

**Brazers** are required to use an approved procedure and be qualified by test, also in accordance with B&PV Code Section IX

- Prepare the brazing procedure specification (BPS)
- The procedure test record is documented as Procedure Qualification Record (PQR), which is retained by the employer
- The performance test record is documented as Brazer Performance Qualification (BPQ), which is retained by the employer
- The owner may waive these qualifications for Category D Fluid Service.

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**Welding Processes – Fusion Weld**

Characteristics of the fusion weld joint

(Manufacturing Engineering and Technology: p820)
Welding Processes – Electric Arc

- Shielded Metal Arc Welding (SMAW), a.k.a. stick welding
- Gas Metal Arc Welding (GMAW), a.k.a. MIG
- Flux Cored Arc Welding (FCAW)
- Gas Tungsten Arc Welding (GTAW), a.k.a. TIG
Shielded Metal Arc Welding

- Suitable for windy, outdoor conditions
- Low cost equipment
- All position capabilities
- Good choice for on-site welding

Gas Metal Arc Welding
Gas Metal Arc Welding

- Not suitable for windy, outdoor conditions
- Moderate cost equipment
- All position capabilities
- Fast welding speeds possible
- No slag to clean

Flux Cored Arc Welding
Flux Cored Arc Welding

- Suitable for windy, outdoor conditions
- Same equipment as for GMAW
- Out of position capabilities
- High metal deposition rate

Gas Tungsten Arc Welding
Gas Tungsten Arc Welding

- Not suitable for windy, outdoor conditions
- Moderate cost equipment
- All position capabilities
- Low metal deposition rate
- No slag to clean
- Highest quality, most precise welds

Welding Processes

<table>
<thead>
<tr>
<th>Process</th>
<th>Materials</th>
<th>Skill Level Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMAW</td>
<td>Steel, Stainless Steel</td>
<td>Moderate</td>
</tr>
<tr>
<td>GMAW</td>
<td>Steel, Stainless Steel, Aluminum</td>
<td>Low</td>
</tr>
<tr>
<td>FCAW</td>
<td>Steel, Stainless Steel</td>
<td>Moderate</td>
</tr>
<tr>
<td>GTAW</td>
<td>Steel, Stainless Steel, Aluminum, Titanium, Nickel Alloys</td>
<td>High</td>
</tr>
</tbody>
</table>
Welding Processes Accepted

<table>
<thead>
<tr>
<th>Process</th>
<th>Generally Accepted for</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMAW</td>
<td>Most fluid services with GTAW root. Sometimes restricted to larger sizes.</td>
</tr>
<tr>
<td>GMAW</td>
<td>Like SMAW, but approval of specific process may be required.</td>
</tr>
<tr>
<td>FCAW</td>
<td>Like SMAW, but approval of specific process may be required.</td>
</tr>
<tr>
<td>GTAW</td>
<td>Everything</td>
</tr>
</tbody>
</table>

Weld Preparation

- Surfaces to be welded are required to be clean
- End preparation required to meet WPS, ASME B16.25 is accepted practice
Weld Preparation

- Use of backing rings is permitted
- Alignment is required to be in accordance with the WPS

Typical Welds

- Slip-on Flange
- Socket Welding Flange

The lesser of T or 6 mm (\(\frac{1}{4}\) in.) approx. gap before welding
Typical Welds

Socket Weld

$C_x \geq 1.25r$ but not less than 3 mm ($\frac{1}{8}$ in.)

$1.5$ mm ($\frac{1}{16}$ in.) approx. gap before welding

Typical Welds

Unreinforced Stub on

Reinforced Stub on

Unreinforced Stub in

Reinforced Stub in

$0.5r$
Preheating

Preheating:
- Prevents cracking caused by differential thermal expansion in the area of the weld
- Drives off moisture that could contribute to hydrogen in the welds
- Slows the cooling rate for the deposited weld metal

The Code:
- Recommends preheat to 50°F (10°C) for most carbon steels and stainless steels
- Requires preheat to 300°F (150°C) or more for low alloy steels

No welding is permitted if water is present in the weld area or if there is excessive wind. See Table 330.1.1.

Heat Treatment

Heat treatment
- Relieves residual stresses caused by welding, bending and forming
- Facilitates diffusion of hydrogen out of the weld

The Code requires heat treatment for:
- Carbon steels thicker than ¾ in. (19 mm)
- Most low alloy steels thicker than ½ in. (13 mm)

See Table 331.1.1.
Typical Owner Added Requirements

- Requirements on use of particular welding processes
- Restrictions on the use of repairs
- Requirements for traceability
- Requirements for marking of piping
  - Stamping not permitted on certain materials
  - Inks containing low melting point metals not permitted on certain materials
- Specific end preparation and alignment requirements

Typical Owner Added Requirements (Continued)

- Requirements for socket welds
- Prohibition of the use of single welded slip-on flanges
- Prohibition on the use of backing rings
- Requirements for fabricated branches
- Bolt hole orientation for flanges
- Dimensional tolerances
- Additional heat treatment requirements
Typical Owner Added Requirements
(Continued)

- Requirements for flow meter runs
- Cleaning requirements
- Shipping and storage requirements
- Requirements for records

Installation

Code Requirements

- Detrimental distortion of piping to bring it into alignment is prohibited
- Examination of installation for errors prior to cold spring is required.
- Flange faces are required to be parallel to design plane within ½% prior to bolt up.
- Flanges are required to be properly tightened
- No more than one gasket can be used
- Bolts can be one thread short of a full nut
- Thread sealant shall be suitable for the service
**Installation**

**Code Requirements**
- Threaded joints to be seal welded shall be made up without thread compound.
- Threaded joints that leak during testing may be seal welded provided compound is removed from exposed threads.
- Seal welds shall cover all exposed threads.

**Installation**

**Typical Owner Added Requirements**
- Maximum distance a bolt can extend through a nut.
- Requirements for connecting to in-service piping.
- Cleanliness requirements.
- Requirements for installation of isolation kits.
- Require threads to conform to ASME B1.20.1.
- Requirements for thread sealant(s).
- Prohibition of the use of seal welds.
- Prohibit use of gasket compounds.
Installation

Typical Owner Added Requirements (cont.)

- Requirements for use of bolt lubricants
- Requirements for use (or not) of washers
- Requirements for flanged joint tightening
- Requirements for valve orientations
- Requirements for alignment by heating (rose budding)
- Requirements for bolting to rotating equipment; e.g., in accordance with API 686

Typical Owner Added Requirements (cont.)

- Requirements for support, including prohibition of supporting piping from other piping
Typical Owner Added Requirements (cont.)

- Clearance from obstructions such as support steel

Flange Joints

Guidelines for installation are provided in ASME PCC-1 – Guidelines for Pressure Boundary Bolted Flange Joint Assembly. Topics addressed include:

- Qualification of assemblers
- Gasket contact surfaces
  - Correct facing finish
  - Good condition
- Flange alignment
- Correct gasket type, size & placement
Flange Joints

More topics addressed:

- Lubrication of bolting, back facing
- Numbering of bolts
- Tighten bolting uniformly in criss-cross pattern is small steps
- Target bolt stress is typically 50 ksi (340 MPa)

Elastic Interaction
(WRC Bulletin 408)

BECHT ENGINEERING COMPANY, INC.  Fabrication and Installation - 37
Flange Joints

ASME PCC-1 describes bolt-up procedure using torque to gage bolt tension

- Snug up bolting
- Tighten to 20% of target torque using cross pattern
- Tighten to 50 to 70% of target torque using cross pattern
- Tighten to 100% of target torque using cross pattern
- Continue tightening to 100% target torque using rotational pattern until no movement
- Wait 4 hours or longer and repeat rotational pattern to 100% target torque until no movement
**Flange Joint**

Target torque for 50 ksi (345 MPa) bolt stress:

<table>
<thead>
<tr>
<th>Bolt Size</th>
<th>Non-Coated Bolts (in-lb – N-m)</th>
<th>Coated Bolts (in-lb – N-m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>60 – 80</td>
<td>45 – 60</td>
</tr>
<tr>
<td>5/8</td>
<td>120 – 160</td>
<td>90 – 120</td>
</tr>
<tr>
<td>3/4</td>
<td>210 – 280</td>
<td>160 – 220</td>
</tr>
<tr>
<td>7/8</td>
<td>350 – 470</td>
<td>250 – 340</td>
</tr>
<tr>
<td>1</td>
<td>500 – 680</td>
<td>400 – 540</td>
</tr>
<tr>
<td>1-1/8</td>
<td>750 – 1000</td>
<td>550 – 750</td>
</tr>
<tr>
<td>1-1/4</td>
<td>1050 – 1400</td>
<td>800 – 1100</td>
</tr>
<tr>
<td>1-3/8</td>
<td>1400 – 1900</td>
<td>1050 – 1400</td>
</tr>
<tr>
<td>1-1/2</td>
<td>1800 – 2450</td>
<td>1400 – 1900</td>
</tr>
</tbody>
</table>