PIP VESV1003
Special Fabrication Requirements for Welded Vessels and Tanks to Be Lined
PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

In an effort to minimize the cost of process industry facilities, this Practice has been prepared from the technical requirements in the existing standards of major industrial users, contractors, or standards organizations. By harmonizing these technical requirements into a single set of Practices, administrative, application, and engineering costs to both the purchaser and the manufacturer should be reduced. While this Practice is expected to incorporate the majority of requirements of most users, individual applications may involve requirements that will be appended to and take precedence over this Practice. Determinations concerning fitness for purpose and particular matters or application of the Practice to particular project or engineering situations should not be made solely on information contained in these materials. The use of trade names from time to time should not be viewed as an expression of preference but rather recognized as normal usage in the trade. Other brands having the same specifications are equally correct and may be substituted for those named. All Practices or guidelines are intended to be consistent with applicable laws and regulations including OSHA requirements. To the extent these Practices or guidelines should conflict with OSHA or other applicable laws or regulations, such laws or regulations must be followed. Consult an appropriate professional before applying or acting on any material contained in or suggested by the Practice.

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1. Introduction

1.1 Purpose
This Practice provides fabrication requirements for equipment to be internally lined, supplementing PIP VECV1001, PIP VESV1002, PIP VESSM001 and PIP VESLP001.

1.2 Scope
This Practice describes fabrication requirements for welded vessels, tanks, bins and silos that are to be lined with nonmetallic linings including liquid-applied and sheet linings. Provisions of this Practice are intended to apply only to surfaces to be lined.

2. References
Applicable parts of the following Practices, industry codes and standards, and references shall be considered an integral part of this Practice. The edition in effect on the date of contract award shall be used, except as otherwise noted. Short titles are used herein where appropriate.

2.1 Process Industry Practices (PIP)
- PIP VECV1001 - Design Criteria and Purchasing Requirements for Vessels
- PIP VEDV1003 - Documentation Requirements for Vessels, ASME Code Section VIII, Divisions 1 and 2
- PIP VEFV1100 - Vessel/S&T Heat Exchanger Standard Details
- PIP VESSM001 - Specification for Small Pressure Vessels and Heat Exchangers with Limited Design Conditions
- PIP VESLP001 - Low-Pressure, Welded Vessel Specification
- PIP VESV1002 - Design and Fabrication Specification for Vessels, ASME Code Section VIII, Divisions 1 and 2

2.2 Industry Codes and Standards
- ASME
  - ASME Section VIII, Div. 1 - Rules for the Construction of Pressure Vessels
- NACE International
  - NACE Standard Practice SP0178 - Design, Fabrication and Surface Finish Practices for Tanks and Vessels to Be Lined for Immersion Service

3. Requirements

3.1 Welded Joints to Be Lined
3.1.1 For in-plane joints, buttweld joints shall be used.
3.1.2 Continuous lap welds may be used for liquid applied linings in accordance with Table 1, but are not preferred because of the difficulty in obtaining acceptable radii for the welds.
3.1.3  Misalignment of plate edges shall not be greater than the limits permitted by the applicable code or standard, but in any case shall not be greater than the lesser of 1/8 inch (3 mm) or 25 percent of the plate thickness.

3.1.4  Mismatched edges shall be blended into the adjacent surfaces by grinding. Minimum required wall thickness shall be maintained.

3.1.5  Grinding shall be held to the minimum necessary to provide a minimum radius of 1/4 inch (6 mm) for a smooth surface for the lining.

3.1.6  The use of caulking compounds and putties shall not be permitted.

3.2  Welds

3.2.1  Welds shall be prepared in accordance with NACE Weld Preparation Designation C for liquid-applied linings and Weld Preparation Designation A for rubber and sheet linings.

3.2.2  See NACE Standard Practice SP0178, Appendix C for details of NACE Weld Preparation Designations.

3.3  Surface Contours

3.3.1  Particular care shall be given to corners and edges over which the lining is to be applied. All outside corners and edges shall be ground to a radius of 1/4 inch (6 mm) or greater.

3.3.2  See Figure 1 for typical details for surface contours. See NACE Standard Practice SP0178, Appendix A for additional details.

![Figure 1. Surface Contours](image)

3.4  Surface Finish

Weld surface finish shall be in accordance with NACE Standard Practice SP0178, Section 5.
3.5 Attachments

3.5.1 Interior Structural Members

3.5.1.1 Partitions, braces, supports, or other attachments on the lined side of the vessel shall be fitted flat against the vessel surface and continuously welded around the entire perimeter.

3.5.1.2 See Figure 2 for typical details for internal attachments.

3.5.1.3 Pockets or crevices that cannot drain or be abrasive-blast cleaned shall not be permitted.

3.5.1.4 Internal attachment configurations shall be in accordance with NACE Standard Practice SP0178, Section 3, Paragraph 3.4.

3.5.1.5 Avoid the use of bolt holes that must be lined. However, if lined bolt holes are required, bolt holes shall be drilled oversized as required for the lining. All edges shall be rounded to 1/4-inch (6-mm) radius by grinding.

3.5.2 External Attachments

Lifting lugs shall be designed and located so that lining cannot be damaged during lifts.

3.6 Connections

3.6.1 All nozzles and outlets shall be flanged or pad type.

3.6.2 Nozzles and manways shall be flush on the lining side with all corners rounded to a radius of 1/4 inch (6 mm).

3.6.3 See Figure 3 for typical details for nozzles and outlets.

3.6.4 Minimum nozzle size for lining shall be NPS 2 (DN 50) nominal size. Manways shall be 24-inch (DN 600) nominal size.

3.6.5 For connections less than NPS 2 (DN 50), the use of a reducing flange should be considered.

3.6.6 Flat face flanges are preferred, to allow lining of the flange face (see Figure 3). For rubber or sheet lining, if flange faces are to be lined, flat face flanges shall be used.
3.6.7 If raised face flanges are required by design, the lining shall extend only to the outside of the raised face.

3.6.8 Maximum nozzle lengths are shown in Table 1.

3.6.9 To facilitate ventilation and heat curing, vertical tanks shall have a minimum of one 12-inch (DN 300) diameter nozzle in the top head or roof, and horizontal tanks shall be designed with one 6-inch (DN 150) diameter nozzle at each end. If Table 1 requires two manways, the manways shall be located approximately 180 degrees apart.

![Figure 3. Outlets](image)

**Figure 3. Outlets**

### 3.7 Tests and Inspections

3.7.1 Before the application of any lining, all equipment shall be inspected to verify conformance to the provisions of this Practice.

3.7.2 After the vessel has been prepared for the lining, acceptability of surface preparations shall be evaluated by the purchaser’s representative, using the approved weld samples specified in Section 3.8.

3.7.3 The lining applicator shall inspect the vessel and certify that it is suitable for lining.

3.7.4 All vessels, tanks, or other equipment shall be hydrotested after the final grinding of all welds and prior to the final surface preparation of the vessel before the application of a lining.

### 3.8 Weld Quality Samples

3.8.1 Representative weld samples, 6 inches (150 mm) long, with grinding if required, shall be submitted representing each of the following welds:

a. Tank bottom welds. These can be either butt welds or fillet welds depending upon the type applied.

b. Vertical shell welds

c. Horizontal shell welds

d. Roof welds
3.8.2 The samples shall represent the different types of welds present in the vessel, tank, or equipment and shall be in accordance with the surface preparation requirements of Sections 3.1 through 3.4 and Table 1.

3.8.3 The samples shall be submitted with drawings, for approval both by the purchaser and the lining applicator, and used as standards to determine acceptance in accordance with Section 3.7.1.

3.8.4 If the samples submitted are not approved, the purchaser and/or lining applicator shall furnish a detailed written explanation of the reason for rejection. Additional samples shall be submitted for approval.

3.9 Requirements for Vertical Tank Foundations

3.9.1 Except as specified in Section 3.9.2, the bottom of all field-erected, flat-bottom tanks shall be fully supported before application of a lining to prevent deflection that could damage the integrity of the lining when the tank is filled.

3.9.2 Section 3.9.1 shall not apply to tanks to be lined with an elastomeric lining. However, the bottom of these tanks shall be sloped to permit removal of all steam condensate, resulting from steam curing.

Comment: If this condensate is not removed, the result can be incomplete curing of the elastomer.

3.9.3 For heat-cured plastic linings applied in the field, the tank foundation shall possess adequate insulating properties, (e.g. a structural lightweight aggregate concrete).

Comment: Insulation is necessary to reduce the heat loss through the foundation to ensure that the lining on the tank bottom reaches the required cure temperature.
### Table 1. Special Requirements for Lining Systems

<table>
<thead>
<tr>
<th>Specification</th>
<th>Liquid Applied Linings</th>
<th>Sheet linings (adhesively bonded) (Note 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rubber linings</td>
<td>Thin Film linings</td>
</tr>
<tr>
<td>Butt welds permitted</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Lap welds permitted</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Welds shall be flush</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Welds shall be smooth</td>
<td>Yes</td>
<td>Yes (Note 2)</td>
</tr>
<tr>
<td>Weld spatter permitted</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Maximum nozzle length NPS 2 (DN-50) NPS 3 (DN-80) NPS 4 (DN-100)</td>
<td>6 in. (150 mm) 12 in. (300 mm) 24 in. (600 mm)</td>
<td>Not Permitted 4 in. (100 mm) 8 in. (200 mm)</td>
</tr>
<tr>
<td>Minimum number of manways in tanks for application of lining</td>
<td>1</td>
<td>2 (heat cured) or 1 (chemically cured)</td>
</tr>
<tr>
<td>Grout tank bottom to minimize deflection or “oil-canning” (see Section 3.9 for flat bottom tanks)</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Use insulating or structural lightweight aggregate concrete for tank foundation (see Section 3.9.3)</td>
<td>No</td>
<td>Yes (heat cured) No (chemically cured)</td>
</tr>
</tbody>
</table>

Notes:
1. Maximum height of any weld bead shall be in accordance with ASME Code or 1/8 inch (3 mm), whichever is less. Welds shall blend into the adjacent surface so that the glass fabric saturated with resin is able to follow this contour and not leave a gap or an air space.
2. Weld ripples are acceptable if they are shallow enough so that crevices and depressions can be cleaned by sandblasting to remove slag and oxides.
3. Typically, 60 mils thick or greater.
4. Use insert linings. If loose linings are used for nozzles, venting is required.