PIP STF05121
Anchor Fabrication and Installation into Concrete
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.

This Practice is subject to revision at any time.
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1. Scope

This Practice provides details and requirements for anchor fabrication and installation into concrete. Anchors are anchor rod assemblies that include a rod threaded at the two ends, nuts, washers, and anchor plates and/or sleeves if required. J-bolts and L-bolts are not included. Three standard lengths are shown for each diameter anchor rod in both U.S. Customary units and Metric (SI) units.

This Practice also provides requirements for non-standard anchor rod lengths.

The “Comments” shown in boxes in the Practice are provided for use by the anchor design engineer only.

2. References

Applicable requirements in the following Practices and industry codes and standards 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 STE05121 - Application of ASCE Anchorage Design for Petrochemical Facilities
- PIP STS03001 - Plain and Reinforced Concrete Specification

2.2 Industry Codes and Standards

- American Society of Testing and Materials (ASTM)
  - ASTM A36/A36M - Standard Specification for Carbon Structural Steel
  - ASTM A563 - Standard Specification for Carbon and Alloy Steel Nuts
  - ASTM F436/F436M - Standard Specification for Hardened Steel Washers Inch and Metric Dimensions
  - ASTM F1554 - Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength
  - ASTM F2329/ F2329M - Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners
- American Society of Mechanical Engineers (ASME)
  - ASME B1.13M - Metric Screw Threads: M Profile
  - ASME B18.2.1 - Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series)
  - ASME B18.2.3.6M - Metric Heavy Hex Bolts
3. Definitions

anchor: General term for the anchor bolt or anchor rod assembly. This does not include the concrete and rebar which are parts of the anchorage.

anchor plate: Circular plate bolted at the bottom of an anchor bolt or anchor rod to increase the pull out capacity of the anchor. Typically, this is required to make the anchorage ductile.

anchor rod assembly: Fabricated assembly that includes a rod threaded at the two ends, nuts, washers, and anchor plates if required. J-bolts and L-bolts are not included.

constructor: Party responsible for supplying materials, equipment, tools, supervision, and labor for installation of anchors in accordance with contract documents. The term constructor shall apply also to constructor’s subcontractor(s) and vendor(s).

contract documents: Any and all documents, including codes, studies, design drawings, specifications, sketches, practices, and data sheets, that purchaser or engineer of record has transmitted or otherwise communicated, either by incorporation or reference, and made part of the legal contract agreement or purchase order between purchaser and fabricator or constructor.

engineer of record: Purchaser’s authorized representative with overall authority and responsibility for engineering design, quality, and performance of civil works, structure, foundations, materials, and appurtenances described in contract documents. Engineer of record shall be licensed as defined by laws of the locality in which the work is to be constructed, and be qualified to practice in the specialty discipline required for the work described in contract documents.

fabricator: Party responsible for providing fabricated anchors in accordance with contract documents. The term fabricator shall apply also to fabricator’s subcontractor(s) and/or vendor(s).

4. Requirements

4.1 Anchor Dimensional Data and Details

4.1.1 Unless a non-standard anchor rod length is specified on design drawings, the anchors shall be provided in accordance with the dimensional requirements in Table 1 or Table 1M for U.S. Customary or Metric units, respectively.

Comment:

If practical, design engineer should preferentially specify one of the three standard length anchor rods shown in Table 1 or Table 1M. However, non-standard anchor rod lengths may be specified for the following reasons:

a. A longer than necessary anchor rod length causes the foundation to be deeper than practical.

b. A longer than necessary anchor rod length causes the anchor rod to project into the foundation (i.e., mat), increasing construction costs.

c. A longer anchor rod is needed to properly transfer load to the reinforcing steel.
Comment:
If a non-standard anchor rod length is required, the design engineer should specify the rod length as follows:

a. A whole number of inches for U.S. Customary units or a multiple of 10 mm for Metric units.

b. A minimum of 6 inches (150 mm) shorter or longer than the closest standard length anchor rod.

4.1.2 Anchor and sleeve configuration details shall be in accordance with drawing PIP STF05121-01.

4.1.3 Anchor types “A”, “B”, “C” and “N” shall consist of an anchor rod with a tack-welded nut at bottom and nut(s) and washer at top.

4.1.4 Anchor types “ASL”, “BSL”, “CSL,” and “NSL” shall consist of an anchor rod with a tack-welded nut at bottom and sleeve, nut(s), and washer at top.

4.1.5 Anchor Plates

4.1.5.1 If an “AP” is added to the end of the anchor type designation, an anchor plate is required.

4.1.5.2 Anchors having the “AP” suffix shall include components specified in Section 4.1.3 or 4.1.4 of this Practice as applicable, plus an anchor plate and an additional nut above the anchor plate.

4.1.5.3 Example designations for these types of anchors are “AAP” for a type “A” anchor with an anchor plate, and “ASLAP” for a type “ASL” sleeved anchor with an anchor plate.

4.2 Anchor Callout

4.2.1 Anchors with U.S. Customary units are identified in anchor callouts on design drawings as shown in the following example:

| Quantity | 8          | Anchor rod diameter | 1 1/4”ø | Anchor type: NSLAP | P = 5 3/4” | W/2 Nuts | L = 4’ – 0” |

Comment:
If required for record purposes, anchor rod lengths of standard length anchors should be specified by the design engineer either in the anchor callout or in notes on design drawings. The design engineer may duplicate Table 1 or Table 1M and drawing PIP STF05121-01 on design drawings.
4.2.2 Anchor callouts for anchors with Metric units are identified on design drawings similar to the example above, but with metric dimensions for anchor rod diameter, projection, and length.

4.3 Materials

4.3.1 Unless otherwise specified on design drawings, anchor rods shall be in accordance with ASTM F1554, Grade 36. The substitution of ASTM F1554, weldable Grade 55 anchors for Grade 36 anchors, as allowed by ASTM F1554 Section 6.4, is not permitted unless approved by the engineer of record.

4.3.2 Components of U.S. Customary unit dimensioned anchors shall be as follows:
   a. Unless otherwise specified on design drawings, anchor rods shall have UNC-Class 2A threads.
   b. Unless otherwise specified on design drawings, nuts shall have a proof load greater than the minimum tensile strength specified for the anchor and shall be in accordance with ASTM A563 Grade A, heavy hex with UNC-2B threads.
   c. Washers shall be in accordance with ASTM F436. If plate washers are specified on design drawings, they shall be in accordance with ASTM A36 (see drawing STF05121-01).

4.3.3 Components of Metric unit dimensioned anchors shall be as follows:
   a. Unless otherwise specified on design drawings, anchor rods shall have coarse metric thread form in accordance with ASME B1.13M, Class 6g.
   b. Unless otherwise specified on design drawings, nuts shall have a proof load greater than the minimum tensile strength specified for the anchor and shall be in accordance with ASTM A563M, Property Class 9, heavy hex thread class 6AX. Thread form shall be consistent with the anchor rod specification.
   c. Washers shall be in accordance with ASTM F436M. If plate washers are specified on design drawings, they shall be in accordance with ASTM A36M (see drawing STF05121-01).

4.3.4 Headed bolts, in accordance with Section 4.3.1, equal to the length of anchor rods above the bottom nut (see drawing PIP STF05121-01) may be provided as a substitution for anchor rods. Bolt head style shall be heavy hex in accordance with ASME B18.2.1 or ASME B18.2.3.6M for U.S. Customary or Metric units, respectively. Thread length at the top of the bolt (TT) shall be exactly the same as shown in Table 1 or 1M.

4.3.5 Anchor Sleeves

4.3.5.1 Anchor sleeves shall be molded from black polyethylene.

4.3.5.2 Sleeves shall be formed with a self-threading neck on one end to match the thread size of the anchor.

4.3.5.3 Sleeves shall have V-shaped ribs around the body diameter to provide structural strength.

4.3.6 Anchor plates shall be circular discs in accordance with ASTM A36/A36M, with a center hole, 1/16 inch (1.5 mm) greater in diameter than the anchor rod.
4.4 Fabrication

4.4.1 Unless otherwise specified on design drawings, all anchor rods (i.e., total anchor rod length), anchor plates, nuts, and washers shall be hot-dip galvanized after fabrication in accordance with ASTM F2329/F2329M.

4.4.2 Excess galvanizing material shall be removed from threaded portions of anchor rods and nuts by use of a centrifuge or by mechanical chasing of the threads.

4.4.3 Hot-dip galvanized nuts shall be tapped oversize in accordance with ASTM A563 / ASTM A563M.

4.4.4 Fit of nuts on threads of anchor rods shall be verified before shipment.

4.4.5 Certified mill test reports shall be submitted to the engineer of record or his designee for all parts of the anchor rod assemblies.

4.5 Installation

4.5.1 Unless otherwise specified on design drawings, installation tolerances shall be as specified in PIP STS03001.

4.5.2 Anchors shall be securely tied in position so as not to be dislodged during concrete installation. Tack welding of anchor bolts for securing is strictly forbidden.

4.5.3 If specified on design drawings, anchor rod shall be wrapped with non-bonding tape for the required length and location shown on design drawings.

4.5.4 The top of anchor sleeves shall be cut off at the bottom of the structure or equipment base / top of grout elevation after concrete is placed and before setting the base of the structure or equipment and grouting.

4.5.5 Filling of Sleeves

4.5.5.1 Unless otherwise specified on design drawings, anchor sleeves shall be filled with one of the following materials after concrete is placed and before setting the structure or equipment base and grouting:

   a. Nonbonding moldable material (e.g., silicone based compound of heavy consistency)

   b. Elastomeric moldable non-hardening material (e.g., acrylic roof coating)

4.5.5.2 Water or other loose particles shall not be permitted to collect in sleeves before sleeves are filled.

4.5.6 Threads at top of anchor rods shall be covered with duct tape or other suitable means to keep them clean and to prevent any damage that might occur during concrete placement, preparation of the foundation for grouting, and grouting.

4.5.7 Unless otherwise specified on design drawings, nuts at top of anchors shall be tightened to a snug-tight condition, defined as the tightness that is attained with a few impacts of an impact wrench or with the full effort of a man using an ordinary spud wrench.
4.5.8 For anchors at locations specified on design drawings that require the structure or equipment base to slide for expansion and/or contraction purposes, the anchors shall be installed as follows:

a. Two top nuts shall be provided at the top of anchor.

b. Lower top nut shall be hand tightened and then backed off a half turn leaving approximately 1/16-inch (1.5 mm) clearance between lower top nut and structure or equipment base.

c. Upper top nut shall then be installed and jammed against lower top nut.
Notes for design engineer:

1. It is intended that type "A" and "ASL" anchors be used unless a longer anchor rod length is required. If a longer anchor rod length is required, use type "B" and "BSL" anchors, or "C" and "CSL" anchors. Types "C" and "CSL" anchors are intended if vessel or column chairs or base rings are used. If none of these lengths is suitable, designate the anchor as type "N" (i.e., non-standard anchor rod length with no sleeves required) or as type "NSL" (i.e., non-standard anchor rod length with sleeves required), and specify the required anchor rod length in the anchor callout on the design drawing.

2. Sleeves used for the purpose of anchor alignment are not recommended for anchors rods with diameters greater than 1 inch.

3. Anchor plates are sized for ductile anchors using $f_c = 4,000$ psi. These plates can be used for higher strength concrete but may not be needed and can be made smaller. See "PIP STE05121, Table 4. "NR" shown in Table 1 means anchor plates are not required for a ductile connection.

4. If ASTM A36 plate washers are required in addition to ASTM F436 washers, they should be specified on design drawings along with corresponding revised N1 or N2 dimensions.

Table 1. Anchor Dimensional Data – U.S. Customary Units

<table>
<thead>
<tr>
<th>Anchor Rod Diameter (in)</th>
<th>Allowance for Nuts (inch)</th>
<th>Sleeve Size (inch)</th>
<th>Anchor Plate Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>d&lt;sub&gt;N&lt;/sub&gt; (Anchor Rod Diameter (inch))</td>
<td>N&lt;sub&gt;1&lt;/sub&gt; (1 nut) (See Note 2)</td>
<td>N&lt;sub&gt;2&lt;/sub&gt; (2 nuts) (See Note 2)</td>
<td>TB1 (Thread Length at Bottom with No AP)</td>
</tr>
<tr>
<td>--------------------------</td>
<td>---------------------------</td>
<td>--------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>5/8</td>
<td>1 1/2</td>
<td>2 1/4</td>
<td>1 1/4</td>
</tr>
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<td>7 1/2</td>
<td>4</td>
</tr>
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</table>

Note 1: Type "N" and "NSL" anchors have non-standard anchor rod lengths. See anchor callout on design drawings for anchor rod length.

Note 2: If an ASTM A36 plate washer in addition to the ASTM F436 washer is specified on design drawings, corresponding revised N1 or N2 dimensions will also be specified on design drawings.
Table 1M. Anchor Dimensional Data – Metric (SI) Units

Anchor Types “A”, “B”, “C”, “N” (see Note 1), “ASL”, “BSL”, “CSL”, and “NSL” (see Note 1)
(Anchors with Anchor Plates have an "AP" at end of Anchor Type Designation.)
(See drawing PIP STF05121-01 for anchor and sleeve details showing locations of dimensions.)

<table>
<thead>
<tr>
<th>Anchor Rod Diameter (mm)</th>
<th>Allowance for Nuts (mm)</th>
<th>&quot;A&quot; &amp; &quot;ASL&quot; Anchors</th>
<th>&quot;B&quot; &amp; &quot;BSL&quot; Anchors</th>
<th>&quot;C&quot; &amp; &quot;CSL&quot; Anchors</th>
<th>Anchor Plate (AP) Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>dₐ (Anchor Rod Diameter)</td>
<td>N1 (1 nut)</td>
<td>N2 (2 nuts)</td>
<td>TB1 (Thread Length at Bottom with No AP)</td>
<td>TB2 (Thread Length at Bottom with AP)</td>
<td>TT (Thread Length at Top)</td>
</tr>
<tr>
<td>16</td>
<td>40</td>
<td>55</td>
<td>30</td>
<td>75</td>
<td>50 x 175</td>
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<tr>
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<td>72</td>
<td>110</td>
<td>180</td>
<td>90</td>
<td>185</td>
<td>200</td>
</tr>
</tbody>
</table>

Note 1: Type “N” and “NSL” anchors have non-standard anchor rod lengths. See anchor callout on design drawings for anchor rod length.

Note 2: If an ASTM A36M plate washer in addition to the ASTM F436M washer is specified on design drawings, corresponding revised N1 or N2 dimensions will also be specified on design drawings.

Notes for design engineer:
1. It is intended that type “A” and “ASL” anchors be used unless a longer anchor rod length is required. If a longer anchor rod length is required, use type “B” and “BSL” anchors or “C” and “CSL” anchors. Types “C” and “CSL” anchors are intended if vessel or column chairs or base rings are used. If none of these lengths is suitable, designate the anchor as type “N” (i.e., non-standard anchor rod length with no sleeves required) or as type “NSL” (i.e., non-standard anchor rod length with sleeves required), and specify the required anchor rod length in the anchor callout on the design drawing.

2. Sleeves used for the purpose of anchor alignment are not recommended for anchor rods with diameters greater than 24 mm.

3. Anchor plates are sized for ductile anchors using f’c = 28 Mpa. These plates can be used for higher strength concrete but may not be needed and can be made smaller. See PIP STE05121, Table 4M. “NR” shown in Table 1M means anchor plates are not required for a ductile connection.

4. If ASTM A36M plate washers are required in addition to ASTM F436M washers, they should be specified on design drawings along with corresponding revised N1 or N2 dimensions.
ANCHOR AND SLEEVE DETAILS

Provide one nut at top of anchor unless anchor callout on design drawings indicates two nuts are required.

- ASTM F436 / F436M WASHER
- ASTM A36 / A36M WASHER (IF SPECIFIED ON DESIGN DRAWINGS)

Structure/equipment base

Bottom of structure/equipment base and top of grout & sleeve

Top of concrete

Sleeve (see detail below)

Non-bonding tape (if specified on design drawings, see PIP STF05121, Section 4.5.3)

Nut (if AP required)

AP (if required)

Cut off top of sleeve after concrete is placed and prior to setting structure/equipment base and grouting. Fill sleeve with a non-bonding moldable material or an elastomeric moldable non-hardening material unless otherwise specified on design drawings (see PIP STF05121, Sections 4.5.5.1a or 4.5.5.1b)

Note: Sleeve detail is shown prior to grouting