PROCESS INDUSTRY PRACTICES

**COMPLETE REVISION**
*June 2017*

***Structural***

# PIP STE05121
# Application of ASCE Anchorage Design for Petrochemical Facilities

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.



**PUBLISHING HISTORY**

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|---|---|
| *January 2003* | *Issued* |
| *October 2003* | *Technical Correction* |
| *October 2006* | *Technical Correction* |
| *June 2017* | *Complete Revision* |

Not printed with State funds

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## 1. Scope

This Practice provides guidelines for design engineers involved in design, fabrication, installation, and repair of anchorage for foundations and structures. This Practice supplements the *ASCE Anchorage Design for Petrochemical Facilities*, hereafter referred to as the *ASCE Anchorage Design Report*. The information on fabrication, installation, and repair of anchorages provided in this Practice is to be used by design engineers to develop specifications, drawings, scopes of work, etc. for fabricators, constructors, and maintenance personnel involved in fabrication, installation, and repair activities.

This Practice describes the design of anchorage based on the requirements in *ACI 318-11 / ACI 318M-11* and *ACI 318-14 / ACI 318M-14* including material selection, cast-in-place anchor design, post-installed anchor design, anchor installation and repair.

*Comment:* The information provided in the *ASCE Anchorage Design Report* is recommended for the design, fabrication, installation and repair of anchorage for foundations and structures. The *ASCE Anchorage Design Report* is in accordance with *ACI 318-08 / ACI 318M-08*. This Practice is in accordance with *ACI 318-11 / ACI 318M-11* and *ACI 318-14 / ACI 318M-14*. Differences with the *ASCE Anchorage Design Report* are noted in this Practice. Many anchor design tables that are not included in the *ASCE Anchorage Design Report* have been included in this Practice for use by engineers and designers.

*Comment:* The primary differences between *ACI 318-11 / ACI 318M-11* and *ACI 318-14 / ACI 318M-14* are as follows:

a. *ACI 318-14 / ACI 318M-14* have been reorganized so that all of the chapter, section, paragraph, equation, and table numbers have been changed.

b. The anchorage information that was in Appendix D of *ACI 318-11 / ACI 318M-11* is now in Chapter 17 of *ACI 318-14 / ACI 318M-14*.

c. *ACI 318-14 / ACI 318M-14* versions do not recognize the Alternative Load and Strength Reduction Factors shown in Appendix C of *ACI 318-11 / ACI 318M-11* and earlier *ACI 318 / ACI 318M* versions. The only Load Factors and Load Combinations that may now be used are those in what is now Chapter 5 of *ACI 318-14 / ACI 318M-14*.

d. When *ACI 318-14* or *ACI 318M-14* is the project standard, the user of the *ASCE Anchorage Design Report* should interpret "Appendix D" as "Chapter 17". Table 6 in this Practice, shows the new chapter, section, paragraph, equation, and table numbers in the *ASCE Anchorage Design Report* which should be used when using *ACI 318-14* or *ACI 318M-14* as the project standard. Table 6 does not show the change if the only difference is using "Chapter 17" instead of "Appendix D".

There are no other technical differences in regard to anchorage between the 2011 and 2014 versions of *ACI 318* / *ACI 318M*.

## 2. References

There is an extensive set of references at the end of each chapter in the *ASCE Anchorage Design Report*. These shall be considered part of this Practice. The references for the *ASCE Anchorage Design Report* and the revised *ACI 318* and *ACI 318M* are shown below.

### 2.1 Industry Codes and Standards

- American Concrete Institute (ACI)
  - ACI 318-08 - *Building Code Requirements for Structural Concrete and Commentary*
  - ACI 318-11 - *Building Code Requirements for Structural Concrete and Commentary*
  - ACI 318-14 - *Building Code Requirements for Structural Concrete and Commentary*
  - ACI 318M-11 - *Building Code Requirements for Structural Concrete and Commentary (Metric)*
  - ACI 318M-14 - *Building Code Requirements for Structural Concrete and Commentary (Metric)*
  - ACI 355.3R-11 - *Guide for Design of Anchorage to Concrete: Examples Using ACI 318 Appendix D*
- American Institute of Steel Construction (AISC)
  - *AISC Manual of Steel Construction*
- American Society of Civil Engineers (ASCE)
  - *Anchorage Design for Petrochemical Facilities*, Task Committee on Anchorage Design, 2013 [Short title used herein is *ASCE Anchorage Design Report*.]
- Portland Cement Association (PCA)
  - *PCA Notes on ACI 318-11 Building Code*

## 3. Definitions

An extensive set of definitions and notations are in the *ASCE Anchorage Design Report* and are considered part of this Practice.

*Comment:* Traditionally, "anchors" as defined in the *ASCE Anchorage Design Report* and in *ACI 318 / ACI 318M* have been called "anchor bolts". However, since there are many types of anchors that are not traditional bolts (i.e., bolts with a head on one end with a nut or nuts on the other end), the term "anchor" is used in this Practice to be consistent with the *ASCE Anchorage Design Report* and with recent versions of *ACI 318 / ACI 318M*. The definition of "anchor" in the *ASCE Anchorage Design Report* is "A rod element of the anchorage used to transmit components of the design force from a structure or equipment to the foundation. Anchor types include cast-in-place rods, welded studs, and manufactured post-installed elements."

Following are definitions used in this Practice for anchorage types:

*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 bolt:* Traditional bolt with a head on one end and a nut or nuts on the other end used for anchorage to concrete.

*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.

*anchorage: The complete system for anchoring into concrete. This includes the anchor, concrete into which the anchor is embedded, sleeves, and rebar transmitting the load from the anchor into the concrete.*

The following acronyms are used in this Practice but are not in the *ASCE Anchorage Design Report*:

| | |
|---|---|
| *AC* | Diameter of a circular pattern of anchors (i.e., anchor circle), inches (mm) |
| *AP* | Anchor Plate (see definition above) |
| $A_{Vc}$ | Projected concrete failure area in shear for a single anchor in an octagon foundation, inches (mm) |
| $c_a$ | Distance from center of an anchor to the edge of concrete, inches (mm) |
| *D* | Face to face dimension of an octagon, inches (mm) |
| $D_o$ | Octagon equivalent circle diameter equal to 1.03D, inches (mm) |
| *P* | Anchor rod projection above concrete (see Figure 1), inches (mm) |
| *TB1* | Thread length at bottom of anchor rod with no anchor plate and dimension from bottom of anchor to top of bottom nut (see Figure 1, Type 2), inches (mm) |
| *TB2* | Thread length at bottom of anchor rod with anchor plate and dimension from bottom of anchor to top of upper bottom nut (see Figure 1, Type 2), inches (mm) |

## 4. Materials

4.1 Recommendations for materials for anchor bolts, studs, anchor rods, washers, nuts, and sleeves are included in *ASCE Anchorage Design Report,* Chapter 2. Recommendations for anchor material fabrication, corrosion protection, and considerations for extreme temperatures are also included in *ASCE Anchorage Design Report,* Chapter 2. These recommendations are considered part of this Practice with the following exceptions:

a. Section 2.2.1, delete the note in the box under the Section.

*Comment:* *ASTM F1554* Grade 105 material can be used for ductile anchors. Even though Table 3 of *ASTM F1554* shows a minimum of 12 percent elongation using an 8 in (203 mm) specimen (*ACI 318* requires 14 percent elongation for ductile connections); Table 3 requires a minimum