PROCESS INDUSTRY PRACTICES

TECHNICAL REVISION
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Vessel

PIP VESBI002
Design and Fabrication of Bulk Solids Product Containers

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

July 2001 *Issued*
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Appendices

1. Scope

This Practice provides requirements for the construction of cylindrical atmospheric and low-pressure, welded, shop- and field-fabricated dry bulk solids containers (e.g., bins, hoppers, silos, and gravity blenders).

This Practice describes requirements for design, materials, fabrication, examination, testing, and shipping for cylindrical shell, single-wall containers for dry bulk solids (i.e., bins, hoppers, silos, and gravity blenders) having internal design pressures not exceeding 15 psig (103 kPa) and/or full vacuum external pressure at the top of the container in its normal operating position. Containers may be welded, shop- and field-fabricated, and shall generally be designed in accordance with the philosophy and requirements of the *ASME Boiler and Pressure Vessel Code*, Section VIII, Division 1, henceforth referred to as the *Code*. *Code* inspections and stamping are not required for these containers.

The following are not covered by this Practice:

a. Containers with nominal diameters 2 ft (0.6 m) or less

b. Containers with volumes less than 100 ft^3 (2.8 m^3)

c. Bolted containers operating at atmospheric conditions

d. Mechanically fastened shell or head courses with or without seal welding

e. Non-metallic material

f. Fluidized beds

g. Non-cylindrical shells

h. Containers requirements associated with mechanical agitation by motor-driven blade impellers

i. Portable transport containers

j. Containers containing "lethal substances" defined as poisonous gases, liquids, or solids of such nature that a very small amount of the gas, liquid, or solid mixed or unmixed with air is dangerous to life if inhaled or if contacting skin. See *Code* paragraph UW-2.

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 CTSE1000 – *Application of External Coatings*
- PIP VEDBI003 – *Documentation Requirements for Bulk Solids Product Containers*
- PIP VEFV1100 – *Vessel/S&T Heat Exchanger Details*
  (Applicable details are as follows:)
  - PIP VEFV1101 – *Vessel Nameplate Bracket*

  - PIP VEFV1102 – *Vessel Tolerances*
  - PIP VEFV1103 – *Vessel Grounding Lug*
  - PIP VEFV1116 – *Vessel Manway Hinges*
  - PIP VEFV1117 – *Vessel Manway Vertical Davit*
  - PIP VEFV1118 – *Vessel Manway Horizontal Davit*
  - PIP VEFV1128 – *Skirt Attachment*
  - PIP VEFV1130 – *Solids Product Container Blend Tube and Shell Interface*
  - PIP VEFV1131 – *Solids Product Container Flush-Mounted Side-Entry Manway*
- PIP VESV1003 – *Special Fabrication Requirements for Welded Vessels and Tanks to Be Lined*
- PIP STF05501 – *Fixed Ladders and Cages Details*
- PIP STF05520 – *Pipe Railing for Walking and Working Surfaces Details*
- PIP STF05521 – *Details for Angle Railing for Walking and Working Surfaces*
- PIP STF05535 – *Vessel Circular Platform Details*

2.2 Industry Codes and Standards

- American Institute of Steel Construction (AISC)
  - AISC Allowable Stress Design (ASD) – *Manual of Steel Construction*
- American Petroleum Institute (API)
  - API 650 – *Welded Steel Tanks for Oil Storage*
- American Society of Mechanical Engineers (ASME)
  - *ASME Boiler and Pressure Vessel Code*
    - *Section II – Materials, Parts A*
      - *SA-193 – Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications*
      - *SA-194 – Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both*
      - *SA-263 – Specification for Stainless Chromium Steel-Clad Plate*
      - *SA-264 – Specification for Stainless Chromium-Nickel Steel-Clad Plate*
      - *SA-265 – Specification for Nickel and Nickel-Base Alloy-Clad Steel Plate*
      - *SA-480 – Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip*
      - *SA-578 – Specification for Straight-Beam Ultrasonic Examination of Plain and Clad Steel Plates for Special Applications*
    - *Section VIII – Pressure Vessels, Division 1* (hereinafter noted as *Code*)
    - *Section IX – Welding and Brazing Qualifications*
  - ASME B16.5 – *Pipe Flanges and Flanged Fittings*
  - ASME B16.9 – *Factory-Made Wrought Steel Buttwelding Fittings*
  - ASME B16.21 – *Nonmetallic Flat Gaskets for Pipe Flanges*

- ASME B16.47 - *Large Diameter Steel Flanges (NPS 26–NPS 60)*
- ASME B46.1 – *Surface Texture, Surface Roughness, Waviness and Lay*
- ASME PCC-2 – *Repair of Pressure Equipment and Piping*

- American Welding Society (AWS)
  - AWS A2.4 – *Standard Symbols for Welding, Brazing, and Non-Destructive Examination*
- American Society of Civil Engineers (ASCE)
  - ASCE 7 – *Minimum Design Loads for Buildings and Other Structures*
- Standard Association of Australia
  - AS 3774 and Supplements 1 and 2 – *Loads on Bulk Solids Containers*
- British Standards Institute and the British Materials Handling Board
  - *Draft Design Code for Silos, Bins, Bunkers, and Hoppers*
- Deutsches Institut fur Normung (DIN)
  - DIN 1055, Part 6 – *Design Loads for Buildings, Loads in Silo Bins [German Standard]*
- International Conference of Building Officials (ICBO)
  - *Uniform Building Code (UBC)*
- Manufacturer's Standardization Society (MSS)
  - MSS SP-6 – *Standard Finishes for Contact Faces of Pipe Flanges and Connecting End Flanges of Valves and Fittings*
- National Association of Corrosion Engineers (NACE)
  - NACE SP0178 – *Standard Recommended Practice - Fabrication Details, Surface Finish Requirements and Proper Design Considerations for Tanks and Vessels to Be Lined for Immersion Service*
- Welding Research Council (WRC)
  - WRC Bulletin 537 – *Precision Equations and Enhanced Diagrams for Local Stresses in Spherical and Cylindrical Shells Due to External Loadings for Implementation of WRC Bulletin 107*

2.3 Other References

- ASCE Task Committee on Wind-Induced Forces, Wind Loads and Anchor Bolt Design for Petrochemical Facilities [ISBN-0-7844-0262-0]
- Buzek, J. R., *Useful Information on the Design of Steel Bins and Silos*, American Iron and Steel Institute and Steel Plate Fabricators Association, Inc., 1989
- Galletly, G. D., *Design Equations for Preventing Buckling in Fabricated Torispherical Shells Subjected to Internal Pressure*, Proceedings, Institution of Mechanical Engineers, London, Vol. 200, No A2, pp. 127-139, 1986
- *Process Equipment Design*, Brownell and Young, Wiley and Sons Publishers, 1959

- Jenike, A. W., Johanson, J. R., and Carson, J. W., Journal of Engineering for Industry, Transaction ASME, Series B Vol. 95, No. 1, Feb. 1973, pp. 1-16
- Vellozzi, Joseph, *Dynamic Response to Wind Loading*, U.S. Dept. of Standards

2.4 Government Regulations

- U.S. Environmental Protection Agency (EPA)
  - *Clean Air Act Amendments of 1990*
- U.S. Department of Labor, Occupational Safety and Health Administration (OSHA)
  - OSHA 29 CFR 1910.106(b)(5)(ii) – *Flammable and Combustible Liquids*
  - OSHA 29 CFR 1910.119 – *Process Safety Management of Highly Hazardous Chemicals*
  - OSHA 29 CFR 1910.146, (K)(3)(ii) – *Permit-Required Confined Spaces for General Industry*

3. Definitions

angle of repose (poured): The slope of the surface of bulk solids when formed as a pile by pouring solids onto a horizontal plane. The angle is measured from the horizontal plane. This angle is not a flow property.

angle of repose (drained): The slope of the top surface of bulk solids when formed by discharging a container that holds the bulk solid. This angle is not a flow property.

arching: A no-flow condition in which the bulk solid forms a stable arch across a solids product container. Typically, this arch forms at the bottom outlet opening, but may form at a higher location in the hopper or bin. At a sufficiently large discharge opening, a stable arch cannot be sustained. The terms "bridge" and "dome" are also used to describe this condition.

bulk density: Weight per unit volume of a material including voids within the particle structure and also including voids between individual particle masses. The bulk density of a material can vary, depending on over-pressurization, vibration, time consolidation, etc.

Code: The *ASME Boiler and Pressure Vessel Code*, Section VIII, Division 1

construction: An all-inclusive term comprising materials, design, fabrication, examination, and testing

fabrication: The actual making and assembling of the container and container components from specified materials

fluidization: The use of gas flow to permeate the interstitial spaces in bulk solids, making bulk solids act more like a liquid

Manufacturer: The party responsible for the construction of a solids product container in accordance with the requirements in this Practice

owner: The party who owns the facility wherein the solids product container will be installed and used

Purchaser: The party responsible for establishing construction criteria (e.g., selection of the geometry, loads, etc.) consistent with the philosophy and service hazards, for defining and specifying the mechanical design requirements, and for contracting with the Manufacturer for the fabrication of the container or container components. The Purchaser is also required to assure that all owner requirements are fulfilled.

*solids product container (*or *container):* Bin, hopper, silo, or blender used to store bulk solids

4. Requirements

4.1 General

4.1.1 Overall Responsibilities

4.1.1.1 A solids product container and associated chutes, supports, and internal/external assemblies as specified in the contract documents shall be provided in accordance with this Practice and the following if applicable:

a. *PIP VEDBI003* including Purchaser's *PIP VEDBI003-D* Data Sheet

b. The Code

c. *PIP VEFV1100* details: VEFV1101, VEFV1102, VEFV1103, VEFV1116, VEFV1117, VEFV1118, VEFV1128, VEFV1130, VEFV1131

d. *PIP STF05501*, *PIP STF05520*, *PIP STF05521*, and *PIP STF05535*

e. Other codes and standards referenced in this Practice

f. Local requirements

g. Other contract documents furnished by the Purchaser

4.1.1.2 If a conflict is identified between this Practice, the design drawings, data sheets, referenced codes and standards, or any supplementary specification, written clarification shall be obtained from the Purchaser before proceeding with any work.

4.1.1.3 If this Practice and any datasheets and Purchaser's specifications do not provide enough information to design and construct a complete solids product container, requirements necessary to make the container complete shall be provided by the Manufacturer.

4.1.1.4 Licensing and licensing fees associated with the design, fabrication, and/or use of the container shall be provided.

4.1.1.5 Before any welding or preparation for welding is subcontracted to another shop or fabricator, approval for subcontracted fabrication work shall be obtained from Purchaser. The Manufacturer shall be responsible for assuring that subcontracted fabrication work is in accordance with this Practice and the contract documents.

4.1.1.6 Solids product container and associated chutes, supports, and internal assemblies shall be identified and labeled, e.g., for item numbers or

nameplate content, in accordance with designations furnished by the Purchaser.

4.1.2 Jurisdictional Compliance

4.1.2.1 The requirements in this Practice and the *Code* may be substituted by other requirements only by written agreement with the Purchaser.

4.1.2.2 All aspects of the work shall be in accordance with the applicable local, county, state, and federal rules and regulations, including but not limited to the rules and standards established by EPA and OSHA, if applicable. See Purchaser's *PIP VEDBI003-D* Data Sheet.

4.1.2.3 Laws, rules, and regulations specific to the site where the solids product container is to be installed shall be considered for all criteria and shall be noted on data sheets, in engineering notes, or in specific site specifications.

4.1.2.4 All references to EPA and OSHA may be replaced with national equivalent references that apply at the solids product container installation site.

4.1.3 Documentation Responsibilities

4.1.3.1 Solids product container documentation shall be provided in accordance with Purchaser's *PIP VEDBI003-R* Documentation Requirements Sheet.

4.1.3.2 Fabrication drawings shall be prepared in accordance with Appendix A.

4.1.3.3 Design calculations shall include information in accordance with Appendix B.

4.1.3.4 Manufacturer's Data Package shall include the information shown in Appendix C.

4.2 Process Design Effects on Components of Bulk Solids Product Container

4.2.1 Types of Flow

4.2.1.1 The type of flow required for the bulk solids container shall be as specified on Purchaser's *PIP VEDBI003-D* Data Sheet.

4.2.1.2 This Practice provides requirements for solids product containers that have only symmetrical flow of solids. Symmetrical flow is the flow pattern that results from a center discharge nozzle with no obstructions that can cause preferential flow from one side of the outlet or from one side of the container.

4.2.1.3 Graphical representations of the four major symmetrical flow types are shown in Figure 1.