

SCOPE

- I 1.1 This practice covers the design and construction of foundations for atmospheric storage tanks, refrigerated storage tanks, and carbon steel tanks in sulfuric acid service.
- I 1.2 **An asterisk (*) indicates that additional information is required. If a job is contracted, this information is furnished in the Job Specification.**

SUMMARY OF ADDITIONAL REQUIREMENTS

- I 2.1 **Table 1** lists the practice which shall be used as specified in this practice.
- I 2.2 **Table 2** lists the practices and standards which shall be used with this practice as applicable.

TABLE 1

PRACTICE	
IP 4-9-1	Site Preparation and Earthwork

TABLE 2

PRACTICES			
IP 4-1-1	Concrete Design and Construction	IP 4-7-1	Pile Foundations
IP 4-6-1	Reinforced Concrete Foundations and Anchor Bolts	IP 9-6-1	Refrigerated Storage Tanks
		IP 19-5-1	Cathodic Protection
STANDARDS			
ASTM Standards		ASTM Standards (Cont)	
B418	Cast and Wrought Galvanic Zinc Anodes	D2922	Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
C192	Making and Curing Concrete Test Specimens in the Laboratory	D2937	Density of Soil in Place by the Drive-Cylinder Method
D448	Sizes of Aggregate for Road and Bridge Construction	ACI Standards	
D1556	Density and Unit Weight of Soil in Place by the Sand-Cone Method	318	Building Code Requirements for Reinforced Concrete
D1557	Laboratory Compaction Characteristics of Soil Using Modified Effort	API Standards	
D2167	Density and Unit Weight of Soil in Place by the Rubber-Balloon Method	650	Welded Steel Tanks for Oil Storage - Appendix B

- 2.3 If local codes and standards exist for the materials, design and test methods covered in **Table 1**, which yield comparable quality, they may be substituted if approved by the Owner's Engineer.

GENERAL

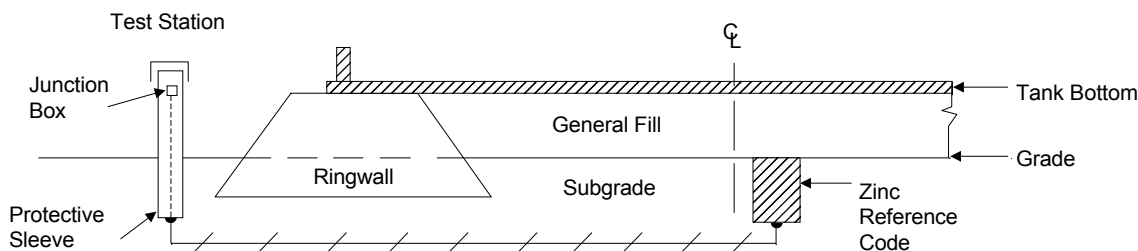
- R 3.1 **Earth subgrade** preparation, placement of fill, and compaction requirements shall be per [IP 4-9-1](#).
- R ↕ 3.2 **Where concrete ringwalls are provided under the shell**, they shall be designed in accordance with API-650 Appendix B and ACI 318, taking into consideration predicted settlements.

PAD CONSTRUCTION FOR ATMOSPHERIC STORAGE TANKS

- O,R 4.1 **Pad construction** shall be per [Figure 1, 2](#) or [3](#). If Flush Type Nozzles are used, there shall be a minimum 2 in. (50 mm) clearance beneath the flange of the nozzle.
- I * 4.2 **Predicted settlement to be used in establishing foundation pad height** will be specified.
- R 4.3 Pads equipped with a ringwall are required for the following conditions:
- Tanks larger than 120 ft (36.5 m) in diameter.
 - Tanks higher than 48 ft (14.6 m) with diameters of 100 ft (30 m) or larger.
 - When a cohesionless soil will be used as general fill, the minimum size tank requiring a ringwall will be specified.

IP 4-8-1		Tank Foundations	
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- R 4.4 **Acceptable materials for stone ringwall construction**, below the top 4 in. (100 mm) zone of graded crushed stone or crushed gravel, include any crushed stone or crushed gravel size numbers 2, 24, 3, 357, 4 or 467 (ASTM D448) which meets the requirements of ASTM D693 for crushed aggregate. Proposals to use other gradations or materials shall be approved by the Owner's Engineer. Crushed slag shall not be used.
- R 4.5 A **reinforced concrete ringwall** is acceptable provided a tank shell settlement of 2 in. (50 mm) or less is expected, and details in [Figure 3](#) are applied. If site-specific experience has demonstrated satisfactory performance of concrete ringwalls for larger shell settlements, then the use of concrete in lieu of crushed stone can be considered in these cases as well.
- O,R 4.6 The average **elevation of finished pads**, measured at the tank shell, shall be within a tolerance of 1 in. (25 mm) of that shown on the construction drawings.
- O,R 4.7 **Tank pad elevation differences**, measured at the shell, shall not exceed any of the following:
- 1:720 in any distance of 30 ft (10 m) or more.
 - 1 in. (25 mm) between the highest and lowest elevation points.
 - To achieve these tolerances, it may be helpful to either choke surface voids in a crushed stone ringwall with fine aggregate of gradation Size No. 10 (ASTM D448), or excavate a portion of the crushed stone and place a layer of unreinforced or fiber-reinforced mortar having maximum dimensions of 1 ft (300 mm) wide by 2 in. (50 mm) thick.
- O,R 4.8 Deviations from the specified **slope of the pad** within the tank shell shall not exceed 1:720 in a horizontal distance of 30 ft (10 m) or more.
- O 4.9 **Apex-down cone bottom tanks** shall have a drain pipe installed to remove rainwater during construction. The pipe shall empty into a water drawoff manhole, rain water sump, or other location as specified. The inlet to the drain shall be per [Figure 4](#).
- O,E 4.10 **Bottom leak detection facility**. All new tank pads shall be equipped with a bottom leak detection facility consisting of a synthetic membrane, a collection sump, and a drain pipe. See [Figure 4](#). A detail for connecting the membrane to the sump is provided in Section III of the Civil Engineering Design Guide.
- The requirement for a leak detection system may be waived if the tank contains clean water, a product not fluid at ambient temperature, or if the temperature of the tank is sufficiently high to jeopardize the integrity of the membrane.
 - The membrane shall be High Density Polyethylene sheet, 80 mils thickness, unless the stored product necessitates the use of another material.
 - The membrane shall be furnished with factory sealed seams if practical. If field seams are used, these shall be made using the extrusion welding or hot wedge methods. Seams shall be 100% tested using the vacuum box method, and any leaks shall be repaired.
- R 4.11 If use of an impermeable membrane is contemplated without an apex drain, a cathodic protection system shall be installed between the membrane and the tank bottom.
- R 4.12 **Permanent zinc reference electrode**. All tanks shall be provided with a permanent zinc reference electrode installed per the sketch below. The zinc anode shall be per ASTM B418, Type II composition. Where an impermeable membrane is used per **Par. 4.10** above, the electrode shall be installed above the membrane.



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FOUNDATIONS FOR REFRIGERATED STORAGE TANKS

- R 5.1 **Refrigerated storage tanks** shall be supported on either a ringwall foundation per [Figure 5](#), or an elevated pile supported foundation per [Figure 6](#). Proposals to use alternative foundation design shall be submitted to the Purchaser for approval by the Owner's Engineer.
- S,R 5.2 **Foundations** shall be designed:
- To restrain the tank shell against lifting forces resulting from internal pressures.
 - For full hydrostatic testing, in which the fill height equals the design liquid height.
- S,R 5.3 For **pile supported foundations**:
- The pile cap shall be designed to withstand the total loss of any single pile.
 - Supports shall be designed to withstand thermal effects of a spill of the full tank contents.
- R * 5.4 **Heating and/or insulation systems** shall be designed to prevent ground freezing if specified.
- R,M 5.5 If specified, ringwall foundations shall be provided with electrical heating systems - either: (1) electrical resistance coils with separate temperature sensing elements and controls, or (2) self-limiting heater cables. All heating elements and temperature sensing elements shall be installed in conduits and be readily accessible for inspection and replacement.
- R 5.6 **Tank bottom settlement criteria** shall be as specified in [IP 9-6-1](#).

FOUNDATIONS FOR CARBON STEEL TANKS IN SULFURIC ACID SERVICE

- M 6.1 Special requirements for the design of foundations shall be per [Figure 7](#).
- M 6.2 **Drain requirements.** Drains shall consist of an elbow set flush in the concrete and piped to an acid sump or sewer. Each drain shall be equipped with a strainer. Elbow, pipe and strainer shall be of an acid resistant material.
- R,M 6.3 **Protection of concrete against acid spillage** shall be per the following:
- Two coats of Coal Tar Epoxy or Epoxy Mastic applied on all exposed concrete surfaces after suitable surface preparation, including the outer vertical surface of the foundation extending about 12 in. (300 mm) below finished grade.
 - When specified, areas around connections (e.g., takeoff, sampling) shall be faced with acid resistant tile and mortar.

Revision Memo

9/68	Original Issue of Basic Practice
1/75	Revision 1
12/90	Revision 2
6/96	Revision 0 - Original Issue of International Practice
3/98	Revision 1

Complete editorial revision to rationalize this practice with the referenced standards and other IPs. This practice combines pertinent requirements of [IP 4-8-1](#) (Tank Foundations for Carbon Steel Tanks in Acid Services), [BP 4-8-2](#) (Foundation Pads, Atmospheric Tanks), and [BP 4-8-3](#) (Foundations for Refrigerated Storage Tank). [IP 4-8-1](#) has been retitled to Tank Foundations, and [BP 4-8-2](#) and [BP 4-8-3](#) have been withdrawn.

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NOTES FOR FIGURES 1 AND 2:

- For tanks not requiring ringwalls, all other details remain the same, except general fill replaces the ringwall material and starts at pit grade level.
- For tanks less than 30 ft diameter and 30 ft high, the Berm width shall be decreased to 2 ft.
- Specified bottom plate slope (1.48) does not apply for tanks less than 20 ft in diameter.
- The crushed stone or gravel (2 in Legend) should extend outward past the annular ring through water test. The necessary amount may be removed to apply the impermeable sand-asphalt mix after the water test.