



**RECOMMENDED PRACTICE
FOR ANCHORING OF
STEEL UNDERGROUND STORAGE TANKS**

R011

**REVISED
JANUARY 2006**

STEEL TANK INSTITUTE
A DIVISION OF SFI/SPFA
944 DONATA COURT
LAKE ZURICH, IL 60047
847/438-8265
FAX: 847/438/8766

WWW.STEELTANK.COM

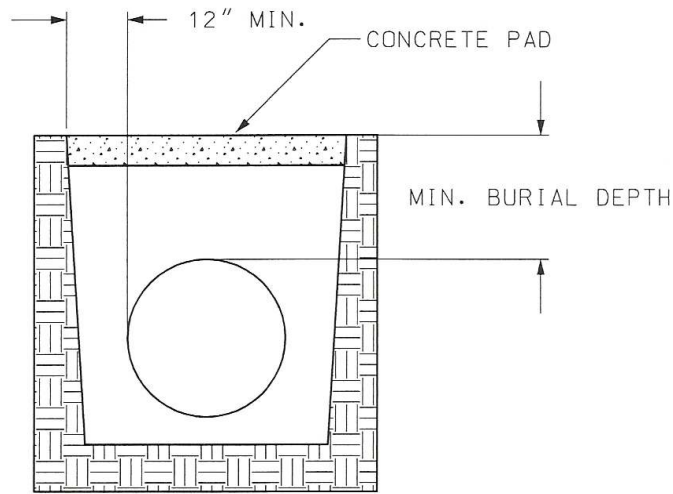
COPYRIGHT © 2001 BY STEEL TANK INSTITUTE

1.0 DETERMINATION OF NEED FOR ANCHORING

- 1.1 It is the responsibility of the tank owner or his technical representative to determine if mechanical anchoring is required for a specific job site.
- 1.2 All potential sources of water (underground water table, rain water run-off, etc.) should be considered.
- 1.3 If water could enter the hole, it is recommended the tanks be mechanically anchored unless the minimum burial depth from the top of the tank is in accordance with Table 1.3. (Note that at the burial depths given in Table 1.3, the overburden above the tank weighs more than the buoyancy of the empty tank with water to grade with a safety factor of 1.2.)
 - 1.3.1 When a concrete pad is supplied, it shall extend a minimum of 12" beyond the tank outline in all directions. Refer to Figure 1.3.1.
 - 1.3.2 When anchorage is required in accordance with Table 1.3, use deadman anchors or a reinforced concrete slab under the tank.
- 1.4 Refer to PEI RP100, "Recommended Practices for Installation of Underground Liquid Storage Systems", Appendix A for more information.

TABLE 1.3
MINIMUM BURIAL DEPTH

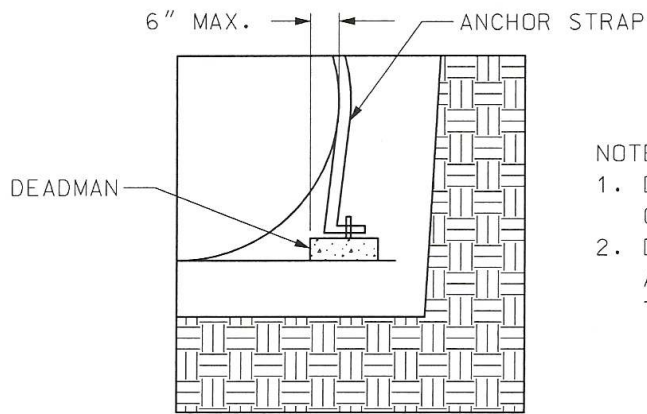
TANK DIAMETER	MINIMUM BURIAL DEPTH (NO CONCRETE SLAB)	MINIMUM BURIAL DEPTH (8" THICK CONCRETE SLAB)
4 feet (1.22 m)	26 inches (0.66 m)	24 inches (0.61 m)
6 feet (1.83 m)	45 inches (1.14 m)	39 inches (0.99 m)
8 feet (2.44 m)	63 inches (1.60 m)	58 inches (1.47 m)
10 feet (3.05 m)	84 inches (2.13 m)	79 inches (2.01 m)
12 feet (3.66 m)	REQUIRES ANCHORING	REQUIRES ANCHORING



**FIGURE 1.3.1
BURIAL DEPTH**

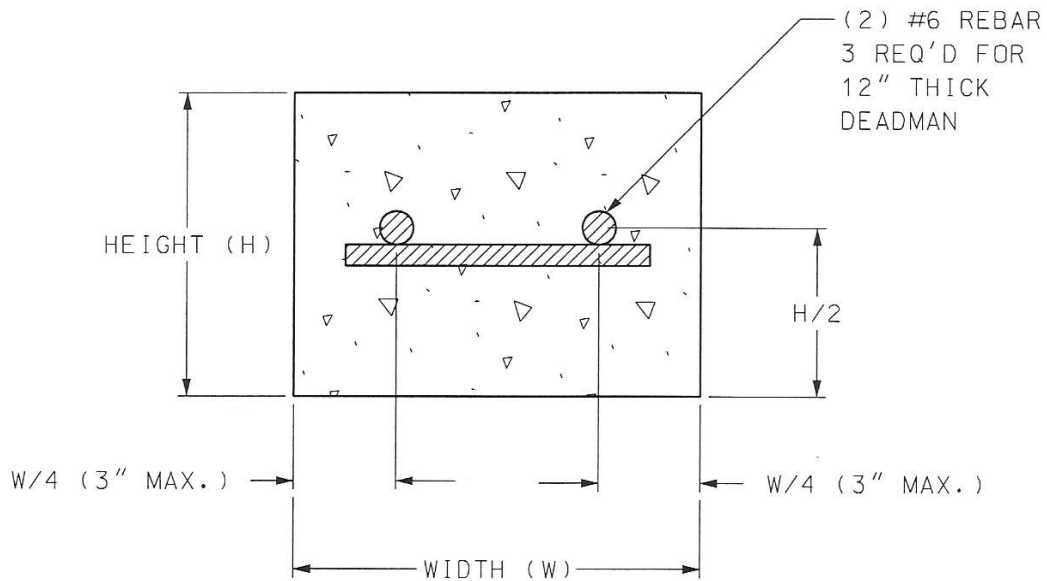
2.0 DEADMAN ANCHORS

- 2.1 The weight of overburden on top of the deadman and the tank provides the anchoring force.
 - 2.1.1 Lay deadman along each side and parallel to the tank. Deadman shall extend the full length of the tank.
 - 2.1.2 The bottom of the deadman shall be placed at least as deep as the bottom of the tank. The edge of the deadman shall not project more than 6 inches (0.15 m) under the outer edge of the tank. Refer to Figure 2.1.2.
- 2.2 Deadmen are made with reinforced concrete. Two #6 rebar shall be spaced per Figure 2.2. Deadmen 12 inches (0.30 m) high and greater shall have a third #6 rebar added midway between the other two rebars.
 - 2.2.1 A #6 rebar shall be placed at each anchor point across the width of the deadman and under the rebar that runs lengthwise of the deadman. See Figure 2.2.
- 2.3 When using deadman anchors, they shall meet the minimum sizes and maximum anchor spacings shown in Table 2.3.
 - 2.3.1 There must be a minimum of two anchor points per deadman section.
 - 2.3.2 For tanks requiring four or more anchor points per deadman, two deadman sections of equal length may be butted end to end.



- NOTES:
1. DEADMAN TO BE FULL LENGTH OF TANK ON BOTH SIDES
 2. DEADMAN TO BE AT LEAST AS DEEP AS THE BOTTOM OF THE TANK

**FIGURE 2.1.2
DEADMAN POSITION**

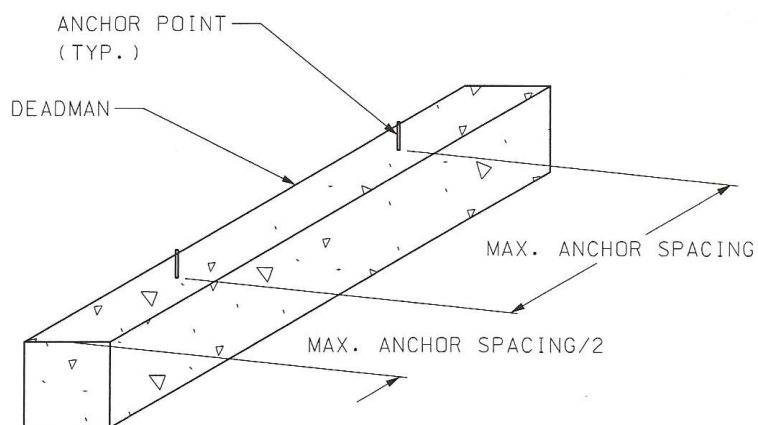


**FIGURE 2.2
REBAR DETAIL**

**TABLE 2.3
DEADMAN DESIGN**

TANK DIAMETER (FEET)	MINIMUM BURIAL DEPTH (INCHES)	DEADMAN MINIMUM HEIGHT (INCHES)	DEADMAN MINIMUM WIDTH (INCHES)	MAXIMUM ANCHOR SPACING (INCHES)	MAXIMUM ANCHOR POINT LOAD (POUNDS)	MINIMUM ANCHOR BOLT DIAMETER (INCHES)
4 (1.22 m)	36 (0.91 m)	6 (0.15 m)	6 (0.15 m)	96 (2.44 m)	1800 (816.47 kg)	1/2 (0.01 m)
6 (1.83 m)	36 (0.91 m)	6 (0.15 m)	6 (0.15 m)	96 (2.44 m)	1800 (816.47 kg)	1/2 (0.01 m)
8 (2.44 m)	36 (0.91 m)	12 (0.30 m)	12 (0.30 m)	96 (2.44 m)	6000 (2721.55 kg)	7/8 (0.02 m)
10 (3.05 m)	36 (0.91 m)	12 (0.30 m)	21 (0.30 m)	72 (1.83 m)	8000 (3628.74 kg)	1 (0.03 m)
12 (3.66 m)	36 (0.91 m)	12 (0.30 m)	30 (0.76 m)	45 (1.14 m)	8000 (3628.74 kg)	1 (0.03 m)

- 2.3.3 An anchor point shall be located a maximum of one half of the maximum anchor spacing from each end of the deadman. Refer to Figure 2.3.3.
- 2.4 The maximum anchor point load is the load applied to each anchor point on each deadman. If anchor bolts are used, they shall have a minimum pull out strength at least equal to the maximum anchor point load.
 - 2.4.1 Anchor straps shall be designed to meet the requirements of the maximum anchor point load applied to each end of the straps. If turnbuckles are used they shall meet the anchor point load requirement.
 - 2.4.2 Attachments to the deadman shall meet the loading requirements of the maximum anchor point load.



**FIGURE 2.3.3
DEADMAN DETAIL**

3.0 CONCRETE SLAB ANCHORS

- 3.1 The weight of overburden on top of the concrete slab and the tank provides the anchoring force. Sufficient backfill is needed under the tank. Refer to Figure 3.1.
- 3.1.1 Concrete slabs shall be a minimum of 2 feet (0.61 m) wider and longer than the tank. The tank shall be centered on the concrete slab.
- 3.1.2 The top of the concrete slab shall be placed at least 6 inches (1.83 m) below the bottom of the tank with suitable backfill material placed between the tank and concrete slab.
- 3.2 Rebar shall be placed 3 inches (0.08 m) from the top of the concrete slab and 3 inches (0.08 m) from the bottom of the slab per the sketch and table. Two additional #6 rebars shall be placed both top and bottom running the length of the concrete slab by each row of anchor bolts to distribute the anchor bolt loads. See Figure 2.2.

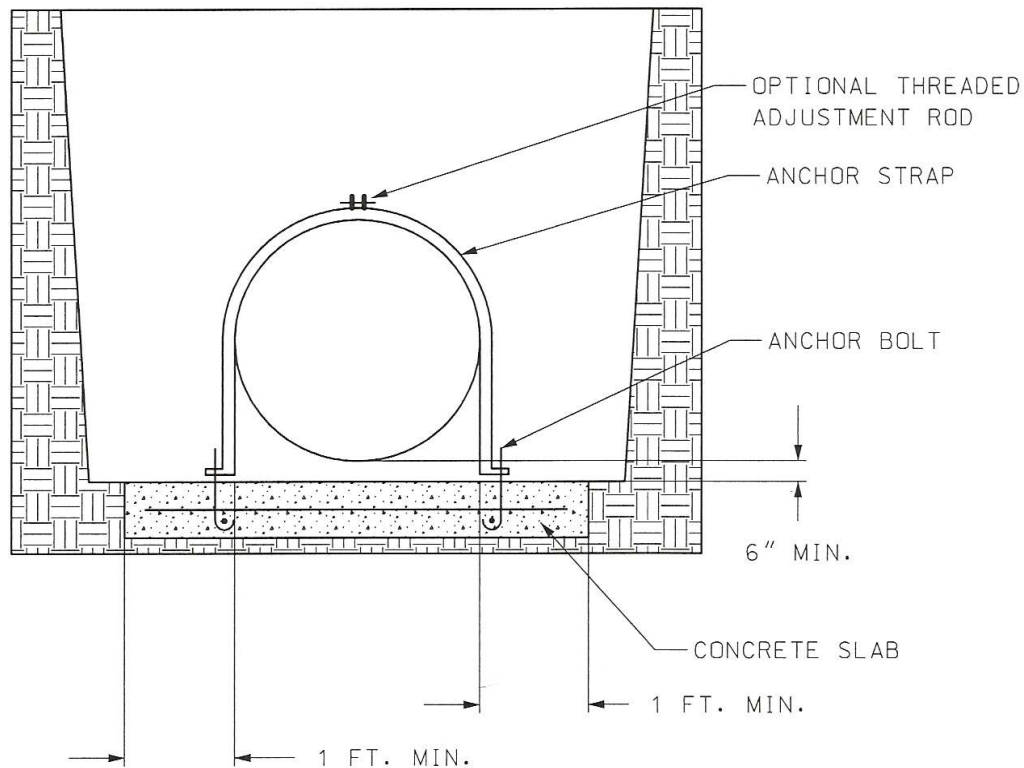
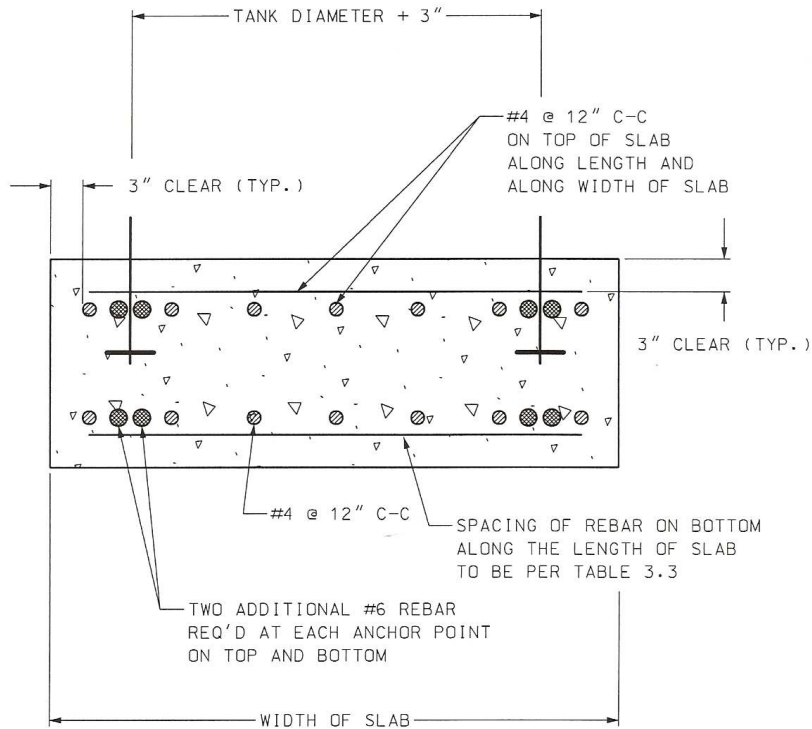


FIGURE 3.1
BACKFILL FOR CONCRETE SLAB DETAIL



**FIGURE 3.2
CONCRETE SLAB REBAR DETAIL**

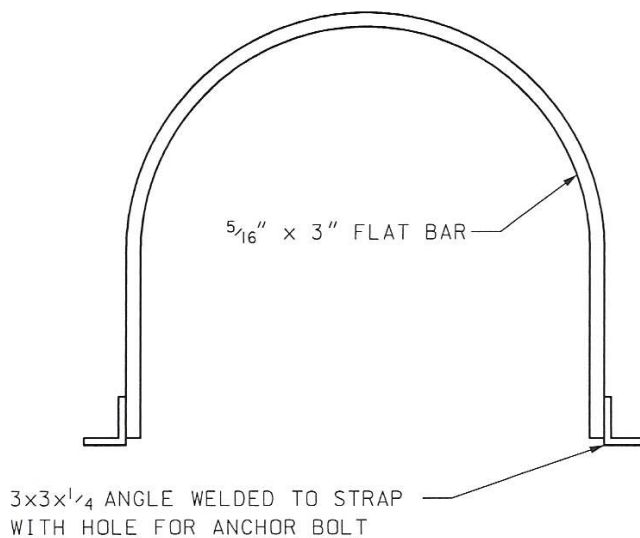
- 3.3 When using concrete slabs, the slabs and anchors shall meet the minimum sizes and maximum anchor spacings shown in Table 3.3.
- 3.4 Anchor bolts shall be evenly spaced. The distance from the end of the tank to the first anchor point shall not be more than $\frac{1}{2}$ the anchor spacing shown in Table 3.3. See Figure 2.3.3.
 - 3.4.1 The maximum anchor point load is the load applied to each anchor point.
 - 3.4.2 Anchor bolts can be of any type desired (cast in place headed anchors, cast in place bent anchors, or drilled after pouring concrete). However, they shall have a pull out strength equal to at least the maximum anchor point load.
 - 3.4.3 Anchor straps shall be designed to meet the requirements of the maximum anchor point load applied to each end of the straps. If turnbuckles are used, they shall meet the anchor point load requirement.
 - 3.4.4 Attachments to the concrete slab shall meet the loading requirements of the maximum anchor point load.

**TABLE 3.3
CONCRETE SLAB DESIGN**

TANK DIAMETER (FEET)	MINIMUM BURIAL DEPTH (INCHES)	CONCRETE SLAB MINIMUM THICKNESS (INCHES)	BOTTOM REBAR SIZE AND SPACING	MAXIMUM ANCHOR SPACING (INCHES)	MAXIMUM ANCHOR POINT LOAD (POUNDS)	MINIMUM ANCHOR BOLT DIAMETER (INCHES)
4 (1.22 m)	36 (0.91 m)	12 (0.30 m)	#4 @ 12" c-c	96 (2.44 m)	1800 (816.47 kg)	1/2 (0.01 m)
6 (1.83 m)	36 (0.91 m)	12 (0.30 m)	#4 @ 12" c-c	96 (2.44 m)	1800 (816.47 kg)	1/2 (0.01 m)
8 (2.44 m)	36 (0.91 m)	12 (0.30 m)	#4 @ 12" c-c	96 (2.44 m)	6000 (2721.55 kg)	7/8 (0.02 m)
10 (3.05 m)	36 (0.91 m)	12 (0.30 m)	#5 @ 12" c-c	72 (1.83 m)	8000 (3628.74 kg)	1 (0.03 m)
12 (3.66 m)	36 (0.91 m)	16 (0.41 m)	#4 @ 6" c-c	45 (1.14 m)	8000 (3628.74 kg)	1 (0.03 m)

4.0 ANCHOR STRAPS

- 4.1 Anchor straps shall be adequate to withstand the loads.
- 4.2 Follow applicable installation instructions when installing tank and anchor straps. Refer to Figure 4.2. The anchor strap shown is for reference only and may not be adequate for the particular installation. Adequate means for tightening the anchor strap shall be provided.



**FIGURE 4.2
ANCHOR STRAP**

5.0 TECHNICAL NOTES AND RESTRICTIONS

- 5.1 These are general guidelines and are to be used only as a reference. They may be used in determining the anchorage requirements of the tank installation. It is the customers responsibility to determine the actual anchorage requirements based on each individual tank installation, site requirements, site conditions, and local codes.
- 5.2 The following assumptions concerning materials have been used in the designs:
 - 5.2.1 Tank is completely backfilled with suitable material in accordance with STI standards
 - 5.2.2 2000 psi concrete is used.
 - 5.2.3 Concrete weighing 150 pounds (2403 kg/m³) per cubic foot is used.
 - 5.2.4 Backfill material weighing 120 pounds (1922 kg/m³) per cubic foot is used.
 - 5.2.5 Anchor bolt material A36 is used.
 - 5.2.6 Anchor strap material A36 is used.

DISCLAIMER

Although the information in this pamphlet is believed accurate and reliable, STI makes no warranties, express or implied, including NO IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, as to any of the ideas, information or guidance in this Recommended Practice. This is not a "how-to" book for non-experts. STI warns that the types of work described herein should be left to trained professionals. Federal, state and municipal laws, regulations and ordinances should be consulted. STI shall not be liable in the event of any conflict between this Recommended Practice and such laws, regulations and ordinances. In no event, whether as a result of breach of warranty, breach of contract, negligence or otherwise, shall STI be liable for any loss or damage, including without limitation, any special, incidental, indirect or consequential damage resulting from the use of or reliance on this Recommended Practice.

This Recommended Practice may be revised or withdrawn at any time without prior notice. This practice does not necessarily address all of the applicable health and safety risks and precautions with respect to particular materials, conditions or procedures. Information concerning safety and health risks and precautions should be obtained from the applicable standards, regulations, suppliers of materials or material safety data sheets.