MWPS-74303
Liquid Manure Tanks

CAUTION!

Additional professional services will be required to tailor this plan to your situation, including but not limited to: assurance of compliance with codes and regulations; review of specifications for materials and equipment; supervision of site selection, bid letting and construction; and provision for utilities, waste management, roads or other access. **Furthermore, any deviation from the given specifications may result in structural failure, property damage, and personal injury including loss of life.**

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Cooperative Extension Work in Agriculture and Home Economics and Agricultural Experiment Stations of North Central Region - USDA Cooperating
Liquid Manure Tanks
Title Page
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A liquid manure storage tank must support soil loads which tend to push the walls in. The walls are reinforced to prevent them from breaking, and are keyed to the floor and top to prevent them from falling over.

Partitions can have liquid on either or both sides, and so must be doubly reinforced. See Detail, page 3.

If possible, locate the tank so that tractors, wagons, or other vehicle traffic cannot be on the tank top. If traffic cannot be avoided, select a top design from Table 4.

Tank tops also have to support livestock, people, and snow. If the tank is to be outdoors, or is to support livestock, select a top design from Table 3. If indoors, and livestock can be fenced away, use Table 2.

Construct end walls the same as the side walls.

The 6 steps below will help you use this plan.

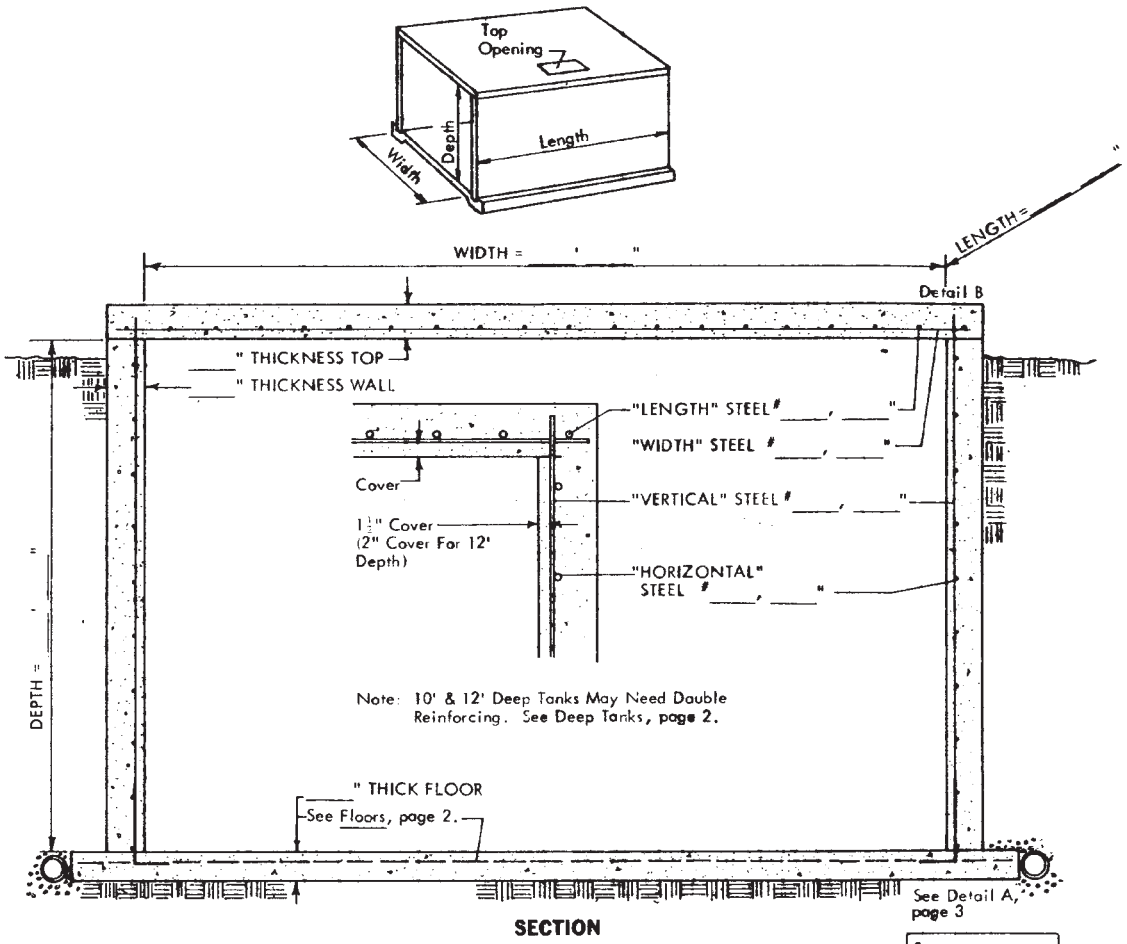
1. Select depth of tank required.
2. From Table 1, select wall thickness and reinforcing:
   "Horizontal" steel depends on wall thickness.
   "Vertical" steel depends on tank depth.
   Use "100 psf surcharge" if heavy vehicles can drive near the tank walls.
   See also back page 4.

Table 1. Wall Reinforcing
(Wall pressure = 60 lb/sq ft per ft depth)

Tank Depth	Wall Thickness	Reinforcing Steel "Horizontal"	"Vertical"	"Vertical", 100 psf surcharge
Up to 6'	6"	#3,7.3" o.c.	#3,12.1" o.c.	#3,8.1" o.c.
8'	6"	#3,7.3"	#4,9.4"	#5,10.2"
10'	8"	#4,10.0"	#5,10.8"	#6,10.5"
12'	8"	#4,10.0"	#7,10.7"	#8,11.0"
	10"	#4,8.0"	#6,10.8"	#7,11.5"

#4, 13.3" may replace #3, 7.3"
#4, 18.0" may replace #3, 9.9" or more

3. Select tank width.
4. From Table 2, 3, or 4, select top thickness and reinforcing:
   "Width" steel depends on span and design load.
   "Length" steel depends on top thickness.
   If your tank will be under slotted floors, see page 2.
5. Record your selections on the drawings to the right.
6. If column and girder system will support solid or slotted tank lid, review TR-3 "Concrete Manure Tank Design" by the Midwest Plan Service, and consult an engineer.



SECTION

See CONSTRUCTION on page 2.

Table 2. Top Reinforcing
(live load = 40 lb/sq ft)

INDOOR TANKS TO SUPPORT HUMANS OR POULTRY
(No livestock, snow or tractor loads)

Tank Width	Top Thickness	Top Reinforcing Steel "Width"	"Length"
6'	4"	#3,12.8" o.c.	#3,13.8" o.c.
8'	4"	#3,8.7"	#3,13.8"
10'	4"	#4,9.9"	#3,13.8"
12'	5"	#4,8.6"	#3,11.0"
16'	8"	#5,10.6"	#3,6.9"
20'	10"	#6,10.0"	#4,10.0"
24'	10"	#7,10.4"	#4,8.3"

Table 3. Top Reinforcing
(live load = 150 lb/sq ft)

TANKS TO SUPPORT LIVESTOCK
(No tractor loads)

Tank Width	Top Thickness	Top Reinforcing Steel "Width"	"Length"
6'	4"	#4,11.7" o.c.	#3,13.8" o.c.
8'	5"	#4,8.8"	#3,11.0"
10'	6"	#5,10.7"	#3,9.2"
12'	8"	#5,9.9"	#3,6.9"
16'	10"	#6,8.8"	#4,10.0"
20'	12"	#8,11.7"	#4,8.3"
24'	12"	#9,10.0"	#4,8.3"

Table 4. Top Reinforcing
(live load = 2 - 5000 lb wheels 4' o.c.)

TANKS TO SUPPORT TRACTORS OR MANURE TANK WAGONS

Tank Width	Top Thickness	Top Reinforcing Steel "Width"	"Length"
6'	6"	#5,10.1" o.c.	#3,9.2"o.c.
8'	8"	#5,10.9"	#3,6.9"
10'	8"	#6,11.2"	#3,6.9"
12'	8"	#6,9.0"	#3,6.9"
16'	10"	#7,10.9"	#4,10.0"
20'	10"	#8,10.4"	#4,10.0"
24'	12"	#9,11.7"	#4,8.3"

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Rectangular, Below-Ground

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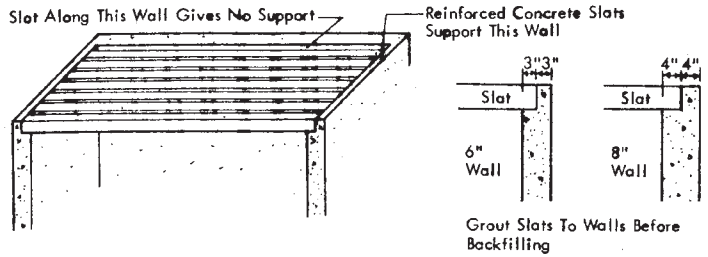
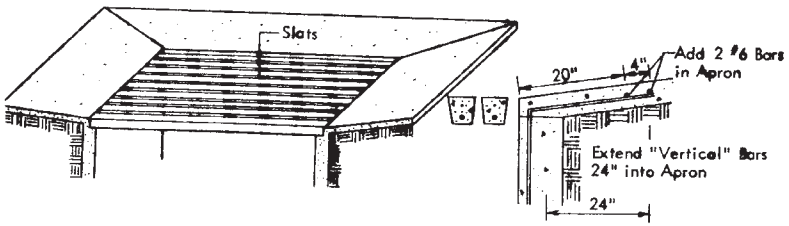
TANKS UNDER SLOTTED FLOORS

The Tanks In This Plan Are Designed To Have The Walls Supported By The Top. Special Provisions Must Be Made For Tanks Under Slotted Floors.

1. Use Slats To Support Walls If Possible. Reinforced Concrete Slats Can Provide Adequate Support For Sidewalls. See 2 and 3 Below For Endwalls.



2. Or, Use A Paved Apron Along The Wall To Provide Adequate Support.



3. Or, The Top Of The Wall Can Be Reinforced Between Supports With A Beam Cast As Part Of The Top Of The Wall.

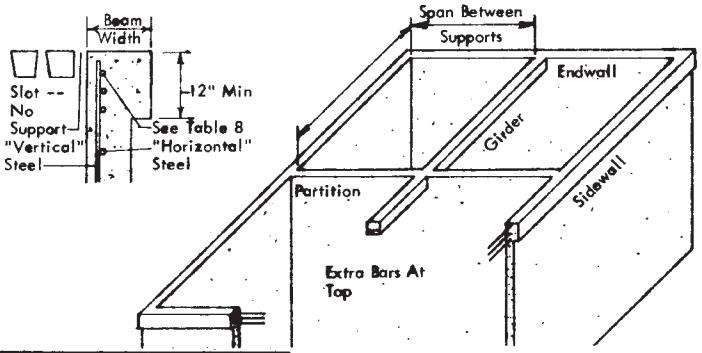


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Table 8. Extra Bars Required At The Top of Unsupported Walls.

Beam Width	Tank Depth	Length Of Span Between Supports 8'	12'	16'	20'	24'
8"	6'	1-#5	2-#6	--	--	--
10"	6'	1-#5	2-#5	2-#6	--	--
	8'	2-#4	2-#6	--	--	--
12"	6'	1-#5	1-#6	2-#6	2-#8	--
	8'	1-#5	2-#6	2-#8	--	--
	10'	2-#5	2-#7	--	--	--
	12'	2-#6	3-#7	--	--	--

GENERAL RECOMMENDATIONS*

Obtain approval by appropriate regulatory agencies prior to starting construction.

To avoid pollution of water supply and surface runoff:

- Locate the storage tank as far as feasible and downhill from the water supply, and so that leakage or spillage will not adversely affect water supplies. The minimum distance should = 100 ft.
- Avoid creviced limestone, shale, and bedrock sites which might allow direct ground water pollution.
- Avoid constructing tanks below the high-water table or in flood plains to prevent tank floatation and flooding.

Design against accidents, asphyxiation, and possible over-exposure to toxic gases.

Protect necessary tank openings with grills and/or covers to prevent children, animals, equipment and other objects from accidentally falling into storage tanks. Provide removable grills in only those openings used for stirring and pumping equipment. Design removable covers and grills to prevent their accidental loss into the tank and their unintentional removal, but for simple removal and replacement to encourage their use. Round openings are suggested.

Covers for tank openings should be non-floating, and weigh at least 40 lb, or otherwise be protected from accidental removal.

Provide a permanent ladder or steps below all openings that have a least dimension of 15 in., or larger, for emergency escape in case of accidental entry. Enclose open-top tanks with a fence about 6 ft high constructed to prevent humans, livestock, or equipment from accidentally entering the tank.

Where gases may discharge into a building provide necessary ventilation. Evacuate the building if practical during agitation prior to cleaning.

External hydrostatic pressures cause uplifting forces on the tank. The tank is vulnerable to these uplifting forces when empty, particularly during construction. Water may be added to counteract bouyancy effects.

No person should enter a storage tank. However, if it is essential to enter, other persons should be present outside the tank with immediate means of removing the victim in case of any possible effect of dangerous gases. The person entering the tank should wear self-contained breathing equipment (chemical reaction filter mask is not sufficient protection) and have one end of a rope secured around his body just below the arms, with the other end secured outside the tank.

Periodic inspection should be made of the tank and its surroundings for: leaks; vertical separation between ground and tank cover; deterioration of grills, covers, and ladders; and adequacy of the roof.

*From Recommendation R-345, "Design of Farm Waste Storage Tanks", American Society of Agricultural Engineers.

CONSTRUCTION

Concrete:

Air-entrained, 3500 psi min. 28-day strength.
Maximum aggregate size = 3/4"

Steel:

Deformed reinforcing steel, f_y = 40,000 psi min.

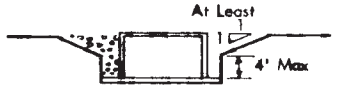
Locate steel accurately in forms; hold firmly in place with wire ties, and with accessories such as slab bolsters and spacers.

Excavation and backfill:

Slope excavations over 4' deep no steeper than 1:1 above the 4' level.

Provide wall support before backfilling -- reinforced concrete top or grouted slats.

Backfill with free-draining, non-cohesive, granular materials.



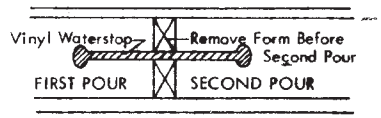
Floors:

5" thick, min., over 2" sand.
4" thick, min., over 4 mil polyethylene over 2" sand.
Variations in floor thickness must be above these minimums.
6"x6" 10 gage in floors of tanks up to 8' deep. Install construction joints 50' o.c.
6"x6" 6 gage in floors of tanks up to 12' deep. Install construction joints not more than 100' o.c.
Footings — see Detail A, page 3.

Construction joints:

In long tanks, install vertical construction joints in the walls about 100' o.c. to avoid problems of differential settlement. Do not extend horizontal steel through the construction joint; insert a waterstop -- one type is illustrated.

Install construction joints in the floor 50' o.c. with 10 gage steel mesh, or 100' o.c. with 6 gage mesh.



Wall support:

If the top of the tank is to be above grade:
Not more than 2-1/2 ft for 6" thick walls, nor more than 3 ft for thicker walls, reinforcing on the inside face only is adequate.

If the top of the tank is to be further above grade than 2-1/2 or 3':
The upper portion of the wall must be double reinforced. In the outside face extend vertical steel (same size and spacing as in inside face) from the top to one foot below grade; in the inside face use full-length bars. Half the horizontal steel in the upper portion of the wall should be moved to the outside face. See Partition Detail, page 3.

Deep tanks -- over 8' deep:

For tanks over 8' deep constructed where the nature of the soil or the quality of backfilling may not provide solid lateral bearing for the walls, walls should be reinforced in the outside face to resist hydraulic pressure from liquids stored in the tank.

Walls should be built as partition walls, sheet 2, and where top beams are needed they should be reinforced against bending in both directions.

Design tables:

Design data for other loads and tank sizes are available in: "Reinforced Concrete Manure Tanks, Slats, & Beams", TR-3; Midwest Plan Service, Ames, Iowa 50011.

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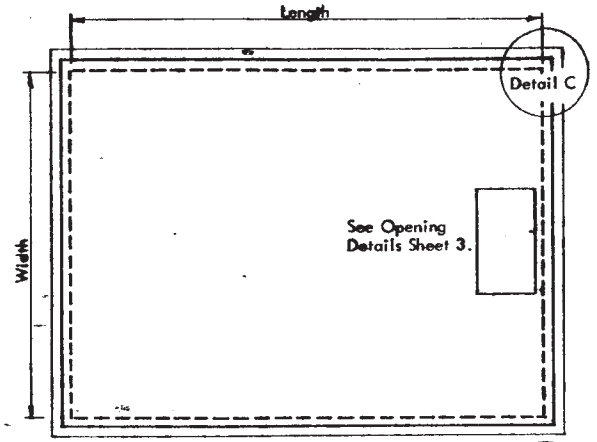
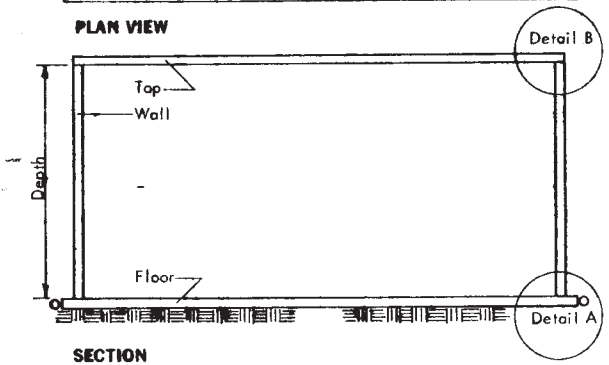
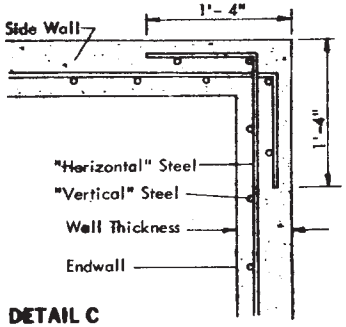


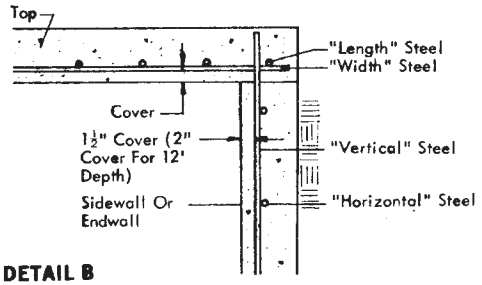
PLAN VIEW



SECTION



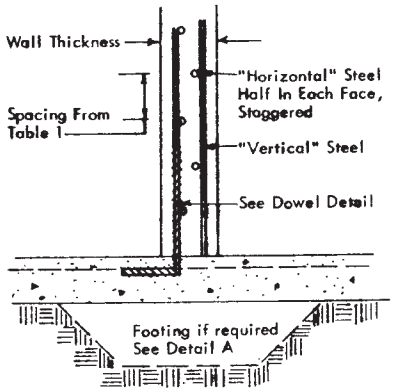
DETAIL C
TOP VIEW OF CORNER



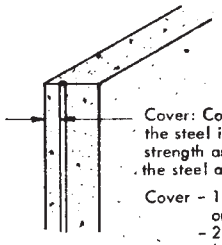
DETAIL B

Note: "Length" Steel In Top Are Above "Width" Steel.

"Horizontal" Steel In Walls Are Outside "Vertical" Steel.

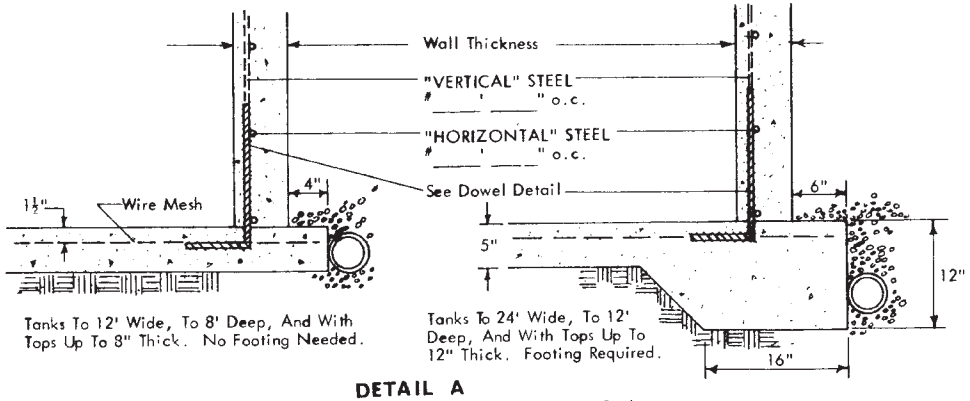


Reinforcing Is Required Near Both Faces Of Partitions And Some Deep Tanks. See "Deep Tanks", page 2.



Cover: Concrete around the steel is required for strength and to protect the steel against corrosion.

Cover - 1½" over #5 bars or smaller.
- 2" over #6 bars or larger.

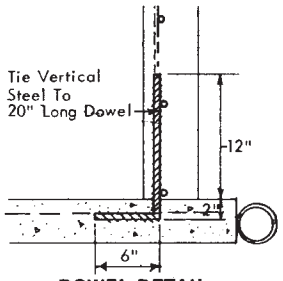


Tanks To 12' Wide, To 8' Deep, And With Tops Up To 8" Thick. No Footing Needed.

Tanks To 24' Wide, To 12' Deep, And With Tops Up To 12" Thick. Footing Required.

DETAIL A

Provide 4" Perimeter Tile To Adequate Outlet If Water Table Can Rise Above Floor Level.



DOWEL DETAIL

Walls to 8' deep: #4, 16" o.c.
or #3, 9" o.c.
12' deep: #4, 7" o.c.
or #5, 13" o.c.

Dowels at top of wall, to apron or top, may be spaced twice as far apart. Or, extend vertical steel into top or apron.

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TANK DESIGN MODIFICATIONS

The following two modifications may be used where good construction practices are assured, and where all minimums will be met or exceeded. The modifications may not meet code or governmental requirements.

REDUCING VERTICAL STEEL FOR VERY GOOD DRAINAGE

Where drainage is very good, tank walls may be designed for 30 pcf, or 30 pcf + 100 psf vehicle load.

Very good drainage means: no surface drainage toward the tank site; coarse granular backfill that drains well near tanks walls; tile around the tank floor perimeter that drains freely to an outlet. Where well-drained soils surround a tank, and where the tank walls are at least tank depth in from building walls, drain tile may not be needed.

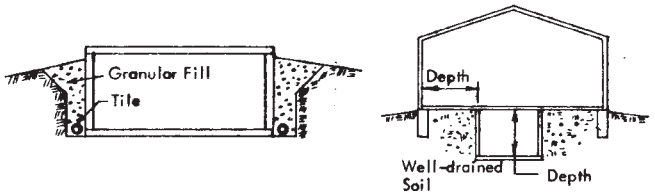

Table 9. Wall designs for very good drainage. Table entries are vertical steel; use horizontal steel from Table 1 sheet 1, or Table 10.

30 pcf Hydrostatic load.

Wall Thickness	Tank Depth 6'	7'	8'	9'	10'
6"	#3, 12.2"	#3, 12.2"	#3, 10.5"	#3, 7.3"	#4, 9.6"
7	#3, 10.5	#3, 10.5	#3, 10.5	#3, 9.0	#4, 11.9
8	#3, 9.2	#3, 9.2	#3, 9.2	#3, 9.2	#3, 7.8
9	#3, 8.2	#3, 8.2	#3, 8.2	#3, 8.2	#3, 8.2
10	#3, 7.3	#3, 7.3	#3, 7.3	#3, 7.3	#3, 7.3
12	#4, 11.1	#4, 11.1	#4, 11.1	#4, 11.1	#4, 11.1
30 pcf + 100 psf Vehicle load.					
6"	#3, 12.0"	#3, 8.1"	#4, 10.4"	#5, 11.8"	#6, 11.0"
7	#3, 10.5	#3, 10.0	#3, 7.1	#4, 9.5	#5, 11.0
8	#3, 9.2	#3, 9.2	#3, 8.4	#4, 11.3	#4, 8.5
9	#3, 8.2	#3, 8.2	#3, 8.2	#3, 7.2	#4, 9.9
10	#3, 7.3	#3, 7.3	#3, 7.3	#3, 7.3	#4, 11.2
12	#4, 11.1	#4, 11.1	#4, 11.1	#4, 11.1	#4, 11.1

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REDUCING HORIZONTAL STEEL IN TANK WALLS

Tank walls are designed with the main reinforcing steel vertical. Horizontal steel controls cracking due to shrinkage during concrete curing, and due to length changes during temperature changes. Horizontal steel also prevents cracking that might permit corrosion of vertical bars.

Where vertical cracking is controlled, and where minor seepage can be tolerated, horizontal steel can be reduced below the minimums specified on page 1.

- Interrupt horizontal steel no further apart than 20'. Position the interruptions under floor-support girders. Position the interruptions between vertical steel bars.
- Provide horizontal steel spaced no further apart than 18" vertically.

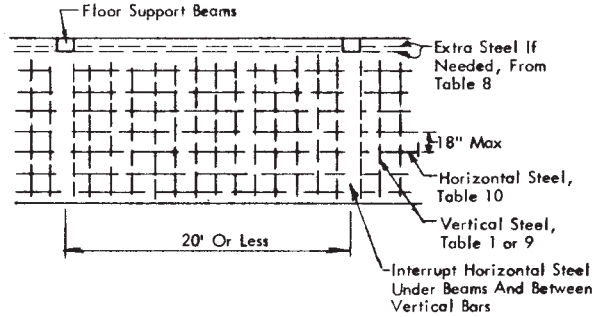
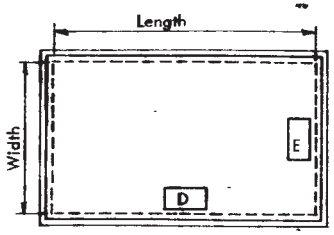


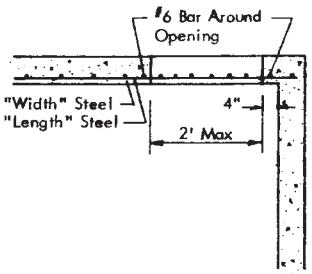
Table 10. Horizontal steel* permitting some vertical cracking.

Wall Thickness	Welded wire mesh size:	Maximum vertical spacing of re-bars #3	#4	#5
6"	4x4, 10g or 6x6, 8g	18"	18"	18"
7"	6x6, 6g	16"	18"	18"
8"	6x6, 6g	13"	18"	18"
9"	6x6, 4g	12"	18"	18"
10"	6x6, 4g	11"	18"	18"
12"	4x4, 6g	9"	17"	17"

*Welded mesh assumed 60 grade; re-bars assumed 40 grade. Horizontal steel is about 0.001 bt for 40 grade.

SLOT OPENINGS FOR SCRAPING



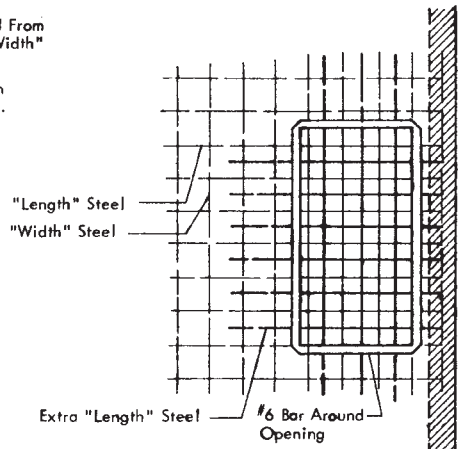


Reinforcing Steel Is Carried Across Opening To Provide Protective Grill.

Add Extra "Length" Steel Both Ways, And 16" Longer Than Opening So That No Space Between Bars Exceeds 6". Weld Bar Intersections.

Reinforce Tank Top With Steel Selected From Tables 2, 3, or 4. The "Length" And "Width" Are Shown In Light Lines.

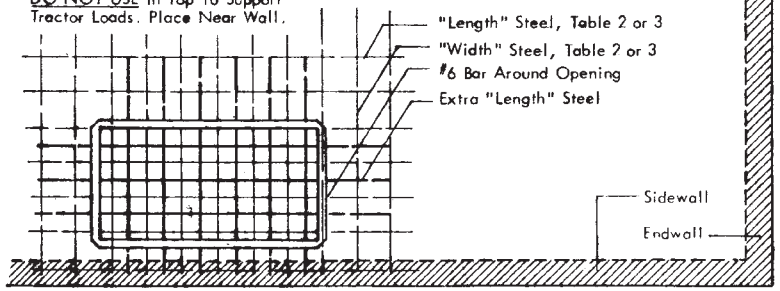
Additional Reinforcing Is Needed At An Opening, And Is Shown In Heavy Lines.



E ACROSS WIDTH

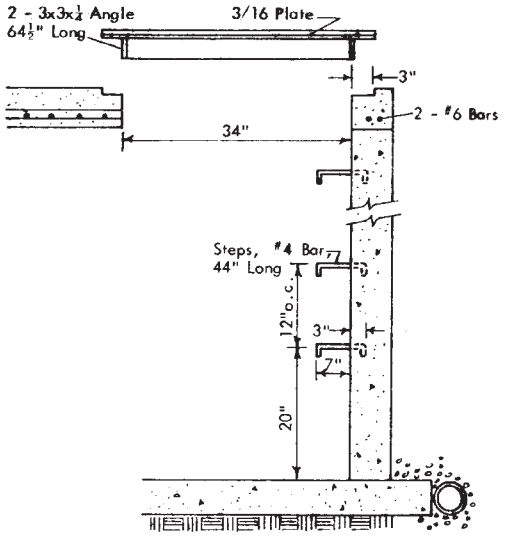
D ALONG LENGTH

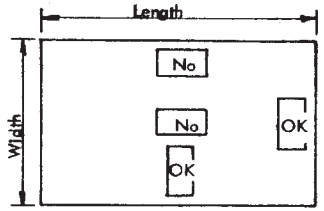
DO NOT USE In Top To Support Tractor Loads. Place Near Wall.



Tractor (Prevent Driving On Cover)

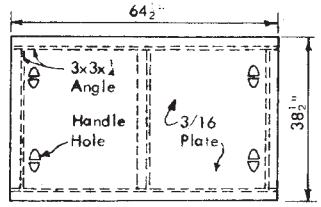
PUMP AND AGITATOR OPENINGS





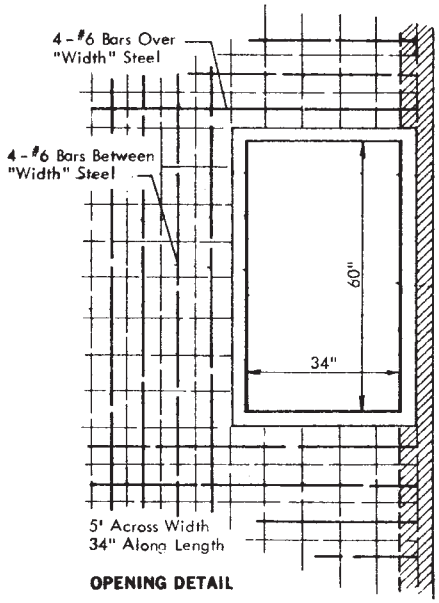
LOCATING OPENING

Main Reinforcing Steel Is The "Width" Steel. In Tops Which Must Support Tractor Or Machinery, Locate Openings To Cut As Few "Width" Bars As Possible. Reinforce Around The Opening With "Extra" Bars Shown In Dark Lines.



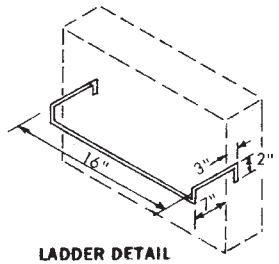
COVER DETAIL

Cover Weighs About 250 lbs. Size Is Adequate For Large Agitator Pump. Use Smaller Opening (Manhole) If Possible.



OPENING DETAIL

HANDLE HOLE DETAIL



LADDER DETAIL

MIDWEST PLAN SERVICE

Cooperative Extension & Research in Agriculture & Home Economics in the 12 North Central Universities—USDA Cooperating

LIQUID MANURE TANKS
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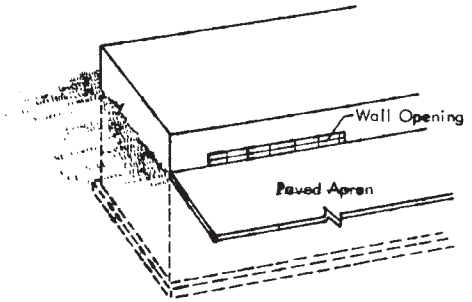
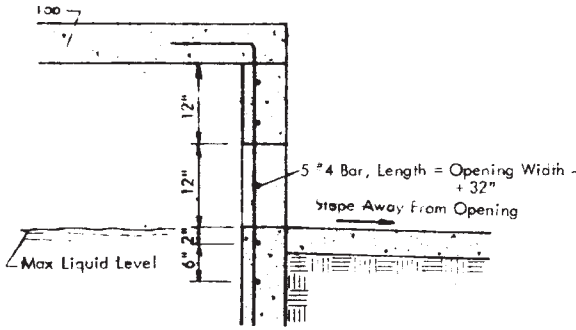
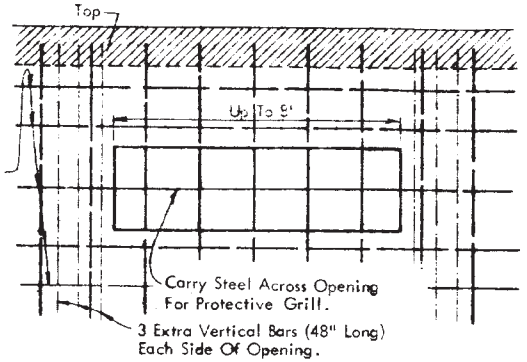
When Tank Is Raised To Prevent Traffic On The Top, Wall Opening Can Be Provided For Scrapping.



SCRAPING OPENING IN WALL



SECTION



FRONT VIEW

Table 5. Waste Tank Capacities, Per 10' Length
(Filled to 1' less than maximum depth)

	Capacity In Cubic Feet					Capacity In Gallons				
	Depth					Depth				
Width	4'	6'	8'	10'	12'	4'	6'	8'	10'	12'
4'	120	200	280	360	440	900	1500	2100	2700	3300
6'	180	300	420	540	660	1350	2250	3150	4050	4950
8'	240	400	560	720	880	1800	3000	4200	5400	6600
10'	300	500	700	900	1100	2250	3750	5250	6750	8250
12'	360	600	840	1080	1320	2700	4500	6300	8100	9900
16'	480	800	1120	1440	1760	3600	6000	8400	10800	13200
20'	600	1000	1400	1800	2200	4500	7500	10500	13500	16500
24'	720	1200	1680	2160	2640	5400	9000	12600	16200	19800

Table 7. Approximate Materials In Top and Floor, Per 10' Tank Length

	TANK TOP DESIGNED FOR							
	Indoors, Humans		Livestock		Tractor		4" Floor*	
Width	Concrete cu yd	Steel lb	Concrete cu yd	Steel lb	Concrete cu yd	Steel lb	Concrete cu yd	Steel lb
6'	.74	46	.74	84	1.11	162	0.74	12.6
8'	.99	92	1.23	140	1.98	185	0.99	16.8
10'	1.23	164	1.85	216	2.47	295	1.23	21.0
12'	1.85	219	2.96	321	2.96	416	1.48	25.2
16'	3.95	409	4.94	577	4.94	629	1.98	33.6
20'	6.17	738	6.17	1054	6.17	1054	2.47	42.0
24'	7.41	1081	8.89	1550	8.89	1550	2.96	50.4

*4" floor, no wall footings, see Detail A; 6" x 6" 10 gage steel for depths to 8'; 21 lb/100 sq ft.

Table 6. Approximate Materials In Sidewalls and Endwalls
Walls without 100 psf surcharge; 8" wall used for 12' deep tanks.

Sidewalls, 2-10' lengths

Tank Depth ft	Wall Thickness in	Concrete cu yd	Steel lb
6'	6"	2.22	132
8'	6"	2.96	279
10'	8"	4.94	459
12'	8"	5.93	777

Endwalls - 2 Widths

Tank Width ft	Tank Depth ft	Concrete cu yd	Steel lb
6'	6'	1.33	74
	8'	1.78	151
	10'	2.96	252
	12'	3.56	480
8'	6'	1.78	98
	8'	2.37	191
	10'	3.95	334
	12'	4.74	639
10'	6'	2.22	123
	8'	2.96	252
	10'	4.94	418
	12'	5.93	799
12'	6'	2.67	147
	8'	3.56	302
	10'	5.93	502
	12'	7.11	959
16'	6'	3.56	196
	8'	4.74	403
	10'	7.90	669
	12'	9.48	1279
20'	6'	4.44	245
	8'	5.93	503
	10'	9.88	837
	12'	11.85	1599
24'	6'	5.33	314
	8'	7.11	604
	10'	11.85	1004
	12'	14.22	1918

NOTE: In double-reinforced 10' and 12' deep tanks lbs steel will be nearly doubled.

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