Recommended Practice for
Home Heating Oil Tank Flood Resistance

During severe flood events, such as those occurring from Hurricane Irene and Super-Storm Sandy, many coastal and low elevation inland areas were subjected to high water conditions. As a result, a number of outdoor above-ground home heating oil tanks were dislodged and, in some cases, caused property damage.

In response to the combined effects of these events, the Oil Heat Institute of Long Island (OHILI) and the National Oilheat Research Alliance (NORA), in collaboration with local government agencies and oil heat industry experts, have developed this ***Recommended Practice*** *(RP) in an effort to mitigate these problems in future flood events.*

The research, testing and approval of this RP went through the National Fire Protection (NFPA) 31 Technical Committee and was balloted successfully for publication as a reference document.

This RP should be used as guidance when installing new tanks or upgrading existing installations.

This RP is intended to provide recommended installation guidelines for small heating oil tanks to resist floating and mitigate spills under severe static flood conditions. Guidance information of what tank owners should do before and after flood events occur is also provided.

This RP is intended for use by homeowners, businesses, oil tank installers, regulators or others who either have small heating oil tanks on their property, may install or maintain these tanks or have various government or regulatory responsibilities for such tanks.

This RP was developed around the most common types of heating oil tanks typically used in small heating systems, and reflects practical solutions using widely available construction components. This RP may also be used for similar tanks storing similar Class II liquids.

Design Parameters

The following are the heating oil tank and system details upon which this RP was developed. For tank types, foundations, hold-downs and flood conditions that differ from these parameters, a professional engineer should be consulted to design equivalent flood resistant solutions.

Tank Types:

- Steel UL80 or UL142 obround shapes, max 330 gal.
- Tanks located above ground outdoors or indoors.
- Welded supports or attached legs of min. 1.25" sch 40 steel pipe.

Tank Foundations:

- Existing concrete slabs or structures, such as garages or patios.
- Concrete slabs designed in accordance with this RP per (Figure 1).
- Structural steel floors meeting applicable building code requirements.

Tank Hold-Downs:

- Foot flanges in combination with pipe legs per (Design A1 or A2).
- Concrete anchor (Design B1 or B2) in combo with hold-down (Design D1 or D2).
- Earth auger ure(Design C1 or C2) in combo with hold-down (Design D1 or D2).

Fig. 1 – *General photo of assembled tank and slab before anchoring - Note all photos are of ½ size horizontal obrounds tested, but the hold down methods apply to vertical obrounds.*

Flood Conditions:

- Still water in Flood Zones 1-4 with tank at 40% fill level.
- Flood height of 2.0' above tank shell top for Flood Zone 1.
- Two day submersion in fresh or salt water.

Miscellaneous Assumptions:

- The tank and supports are in good condition without damage or corrosion.
- Annual damage and corrosion check of the flood resistant components used.
- Maintenance or repair of the flood resistant components if needed.
- All work is done by a licensed contractor.

Disclaimers

Please be aware that the following tanks, installations or flood conditions are not specifically covered by this RP:

- Underground tanks of any type, material or size.
- Rectangular steel tanks, and any nonmetallic tanks (plastic or fiberglass).
- Installations above 1st floor levels or basements one level below grade.
- Dynamic flood conditions, such as wave action, storm surge or river flows.
- Excessive wind loads, such as those from tornadoes or hurricanes.

- Impacts from large debris driven by high winds or water flows.

Prior to selecting and installing a suitable design to prevent tank uplifting, the following are minimum requirements for different types of common tank supports and surfaces upon which the tank shall be placed.

- **Tank Supports** – Tank supports shall be either (a) types that are included under the tank Listing (steel saddles welded to tank), or (b) 1.25" diameter Schedule 40 steel pipe legs <= 12" long with threaded ends connected to leg brackets (welded to the tank shell). Any supports not structurally connected to the tank (welded, bolted, threaded) are not suitable.

- **Existing Surfaces** – Existing concrete foundations (such as garage floors or patio slabs) are suitable provided they at least (a) extend 3' beyond the tank footprint or have a minimum weight to resist the tank buoyant force (Table 2) and (b) are of 4" thick structural concrete with metal reinforcement (wire or bars). The concrete shall be free of cracks.

- **New Pads** – New concrete pads shall be monolithic (single unbroken) types that at least (a) extend 6" beyond the tank footprint, and (b) are made of structural concrete with metal reinforcement (wire or bars) in the thickness necessary to resist the tank buoyant forces per Table 2, but not less than 6". Extension of new pads over old ones is permitted if the design is engineered to resist separating under the expected forces.

- **Undersized Pads** – Undersized concrete pads may be used provided the pad is no less than ½ the required minimum weight to resist the tank buoyant force per Table 2 and is used in combination with the earth auger or stake design as described in the tank securement methods.

- **Steel Surfaces** - For steel floors of substantial construction (structural grating or min. 0.93 in thick plate) used in commercial shops or pre-fabricated buildings, integral tank supports and legs with or without foot flanges shall be welded to these surfaces.

Notes- 1. For outdoor constructions, the surface of the concrete pad shall have a crown or slope to prevent water from collecting around the supports and other securement components at grade.

2. For new constructions, at least twenty one days between pouring any concrete and installation of the tank is recommended to ensure high strength and crack resistance.

Tank Securement Methods

After determining that the tank support and concrete pad surface meets the minimum criteria above, one of the following pre-engineered designs to prevent tank uplifting should be installed based on the combination of tank support and surface. (See Figure 1 and specific Designs for details.)

The following applies to steel UL 80 and UL 142 tanks only. See manufacturer's instructions for other tanks.

- **Foot Flanges** – For tanks with pipe legs on new or existing surfaces without the need for hold-down straps, foot flanges with threaded ends shall be connected to mating pipe end. Each foot shall then be secured to the supporting surface with concrete bolts or screws. See Designs A1 or A2 for details of the minimum specs for foot flanges and concrete bolts or screws.

- **Concrete Anchors** – For tanks with saddles or pipe legs for new surfaces in combination with hold-down straps, concrete anchors with a means for attaching the strap end shall be cast in the concrete. The anchors shall be positioned at +/- 4" of the tank support centerline and +/- 4" of the tank width or diameter centerline. See Design B1 or B2

Table 1.
Flood Zones Table

Flood Zones	FEMA Hurricane Storm Surge Zones	Flooding Potential (*)
0		Water below any recognized flood zones
1	Category 1	Water 1-2 ft above grade (approx 1/4 tank height)
2	Category 2	Water 2-3 ft above grade (approx 1/2 tank height)
3	Category 3	Water 3-4 ft above grade (approx 3/4 tank height)
4	Category 4	Water 4-5 ft above grade (water at/above tank top)

* based on 275 gal vertical obround tank with 12" legs at ground level.

Table 2.
Pad Size Requirements
(Vertical Obround Steel Tanks)

Tank capacity & Size	Flood Zone #	Pad Size	Bouy-ancy Force
120g 30" x 23" x 46"	0	48" x 35" x 6"	-499
	1	48" x 35" x 6"	-293
	2	48" x 35" x 6"	17
	3	48" x 35" x 6"	326
	4	48" x 35" x 9"	532
130g 30" x 27" x 44"	0	48" x 39" x 6"	-544
	1	48" x 39" x 6"	-317
	2	48" x 39" x 6"	38
	3	48" x 39" x 6"	394
	4	48" x 39" x 10"	631
220g 49" x 27" x 44"	0	61" x 39" x 6"	-850
	1	61" x 39" x 6"	-472
	2	61" x 39" x 6"	95
	3	61" x 39" x 7"	662
	4	61" x 39" x 11"	1041
230g 60" x 22" x 44"	0	72" x 34" x 6"	-896
	1	72" x 34" x 6"	-501
	2	72" x 34" x 6"	92
	3	72" x 34" x 6"	685
	4	72" x 34" x 11"	1080
240g 60" x 23" x 46"	0	72" x 35" x 6"	-935
	1	72" x 35" x 6"	-523
	2	72" x 35" x 6"	96
	3	72" x 35" x 7"	715
	4	72" x 35" x 11"	1127
275g 60" x 27" x 44"	0	72" x 39" x 6"	-1042
	1	72" x 39" x 6"	-568
	2	72" x 39" x 6"	138
	3	72" x 39" x 8"	848
	4	72" x 39" x 12"	1320
330g 72" x 27" x 44"	0	84" x 39" x 6"	-1236
	1	84" x 39" x 6"	-669
	2	84" x 39" x 6"	182
	3	84" x 39" x 8"	1032
	4	84" x 39" x 12"	1599

for additional details and minimum specs for anchor types, and information below for hold-down strap options.

- **Earth Augers** - For tanks with saddles or pipe legs for undersized pads in combination with hold-down straps, earth augers with a means for attaching the strap end shall be installed under the concrete slab. The augers shall be positioned at +/- 4" of the tank support centerline and +/- 4" of the tank width or diameter centerline. See Design C1 or C2 for additional details and minimum specs for auger types, and information below for hold-down strap options.

- **Hold-Down Straps** – Hold-down straps for use with concrete anchor or earth auger designs shall have a means at each end to connect to fixed attachment points and shall have a means to tighten the strap, such as a turnbuckle. The straps shall be positioned over the tank at the anchor points, but shall not interfere with used openings. (See Design D1 or D2 for additional details, options and minimum specs for wire rope and metal strap options).

- **Tank Saddles** – When tank saddles are provided with the tank, either the tank manufacturer or a mechanical engineer shall be consulted to provide a recommended method of securing the saddle to the supporting surface that is suitable for the installation type, and sufficient to resist the buoyant forces with a safety factor of at least 1.15.

Notes – 1. Threaded connections between the pipe leg, tank bracket and/or foot flange shall be fully engaged without stripping. All bolts, screws or similar hardware shall use the manufacturers recommended torque or other assembly specifications.

2. Only stainless, galvanized, or similar corrosion resistant metal types should be used for all hardware components. Concrete adhesives shall be used in tap holes for screws.

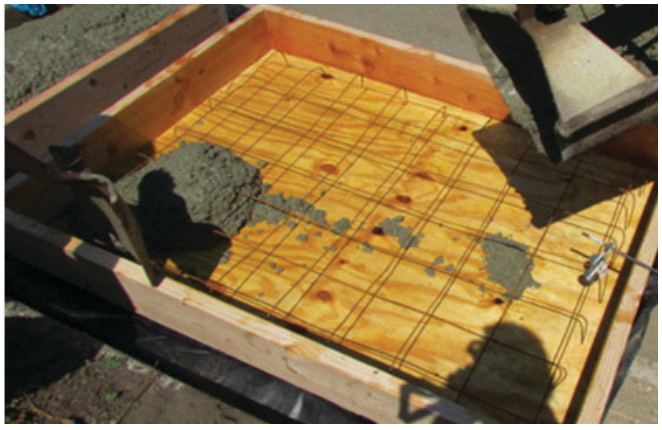

Fig. 2. Concrete slab remesh

Fig. 3. Concrete slab

3. To prevent accelerated corrosion in pipe legs, installers should NOT seal the foot; they should, however, cap the top ends or create a weep hole in the concrete under the foot.

When pouring a new slab

Remesh (Fig. 2) - Grade 40 Steel wire mesh min. 0.1" diameter x max 6.0" squares. See Design C1 or C2 details for any other components intended to be imbedded in the remesh and slab before pouring. Note cast in anchor in mesh.

Concrete (Fig. 3) - Single slab sized per Table 2 for tank dimensions & capacity using Sakrete (or equivalent) standard 4000 psi compression strength mix with remesh cut to slab size and centered in form.

Tank Securement Designs

CR = Corrosion Resistant, such as stainless steel or plated steel rated for outdoor use.

Fig. 4. Adding adhesive to the drilled hole

Designs A1 and A2 (Fig. 4) – Details of foot flange with bolt or screw options using similar flange, hole drilling and hole preparation. There is a difference with the anchoring method (bolt or screw).

Design A1 (Fig. 5) – Foot Flange & Concrete Bolt Photo detail of small diameter flange and one bolt combo for new or existing slabs before and after assembly:

Foot Flange – Mueller Model 511-606HN (Home Depot SKU# 182141) or equivalent 1.25" Floor Flange – 2.75" diameter galvanized iron with pipe threads screwed onto tank pipe leg and secured with one concrete bolt/foot.

Concrete Bolt – CR Steel Concrete Bolt (permanent expansion type) minimum 3/8" diameter x 3.5" long rated for at least ½ the buoyant force (Table 2) and installed in drilled hole min. 2.5" deep.

Fig. 5. Design A1 foot flange with bolt

Design A2 (Fig. 6)– Foot Flange and Concrete Screw Photo detail of large diameter flange and 2-screw combo for new or existing slabs before and after assembly:

Fig 6. Concrete screws installed after hole has been cleaned and adhesive added

Foot Flange – Mueller Model 301-F114 (Home Depot SKU# 564311) or equivalent 1.25" Floor Flange – 3.50" diameter black iron w pipe threads and four holes screwed onto tank pipe leg and secured with two concrete screws/foot into opposite holes

Concrete Screw – CR Steel Concrete Screw (removable or permanent expansion type) min. 1/4" diameter x 2.5" long rated for at least ¼ the buoyant force (Table 2) and installed in drilled hole min. 2.0" deep.

Cleaning the hole and adding concrete adhesive is strongly recommended!

Design B1 or B2 –Detail of eye or U anchor options for casting in new concrete slabs and connection to hold-down and connection options. Four required-each positioned +/- 4" off leg/support centrally.

Fig. 7. Eye-Anchor

Fig. 8 U-Anchor

Eye-Anchor (Fig. 7) – CR Steel Eye-Bolt min. 3/8" diameter x 6.0" long w mating large diameter washer & nut fixed under Remesh and cast into concrete min. 4.0" deep rated for at least ½ the buoyant force.

U-Anchor (Fig. 8) – CR Steel U-Bolt min. 1/4" diameter x 5.0" long w mating plate and nuts fixed under Remesh and cast into concrete min. 3.5"

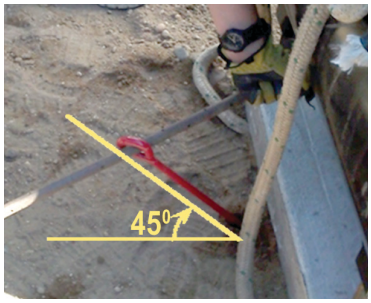

Fig 9. Thirty inch anchor at 45⁰ angle

deep rated for at least ½ the buoyant force.

Design C1 or C2 (Fig. 9 & 10) – Earth Auger Photos detail of earth auger options for casting in new concrete slabs and connection to hold-down and connection options. 4 required-each positioned +/- 4" off leg/support centrally.

Earth Auger – CR steel min. 1/2" diameter shaft and with auger screw and eye end with approx. 4-6" eye end bent vertical after installation to connect with hold down brackets.

Grainger 4LVK4 or equiv 30" long with 3" diameter auger screwed in earth under slab at a 45 degree angle, from horizontal, minimum 24" deep.

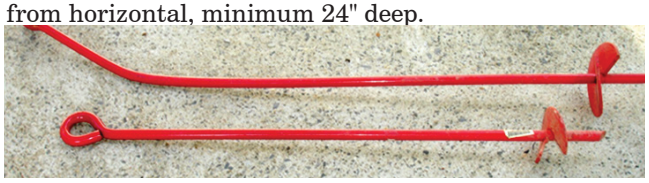

Fig. 10. 40" length and 30" length earth augers

OR

Grainger 4LVK5, 40" long with a 4" diameter auger screwed in earth under slab at a 60 degree angle, from horizontal, minimum 34" deep.

Design D1 or D2 (Fig. 11, 12 & 13) – Wire Rope or Metal Band and Connection Option Photos details of rope and band options cut to size for tank height and fitted with loops at each end for connection through turn buckle and/or quick link as needed for the designs used.

Wire Rope (Fig.11) – Dayton Model 2VJN6 Coated Steel Cable (Granger Item # 2VJN6) or equivalent 1/4" diameter galvanized steel 7 x 19 strand w UV resistant vinyl jacket rated min. 1400 lb.

Rope Ends – CR metal fittings with thimbles sized for wire rope diameter and secured by (a) steel cable

Fig. 11. CR metal wire rope with u-clamps and quick link

U-clamp or (b) metal crimp sleeve rated min. 1400 lb.

OR

Metal Band (Fig 12) – Band-It Model C206BB Steel Band Kit (Granger Item # 13E234) or equivalent 3/4" W x .030" thick stainless steel band and crimp

Fig. 12. CR metal band & Clamp with D ring and turnbuckle

clamp rated min. 1500 lb. Crimp tool and plastic spacer between band and tank are needed.

Band Ends – CR metal D-ring or bow shackle sized for metal band width and added to loop ends prior to crimping, rated min. 1500 lb.

AND

Turn Buckle – CR Steel Turnbuckle (eye/hook or 2X hook) min. 3/8" diameter w 3/8" opening/loop space rated for at least ½ the buoyant force.

OR

Quick Link – CR Steel Quick Link w threaded closure min. 1/4" diameter w 3/8" opening/loop space rated for at least ½ the buoyant force.

Fig. 13. Installer performing wire rope tie-down.

ADDITIONAL PRECAUTIONS

When installing hold down systems, additional precautions include, but are not limited to:

- **Checking with the tank manufacturer to see if anchoring recommendations are available for your specific tank type, size and installation.**
- **Checking to ensure gas or power lines are not in the area of planned earth augers, or if digging is required for the concrete slab.**

Water Ingress Prevention

In addition to preventing tank uplifting during floods, the following steps should be taken in flood zone 4 to resist water from entering the tank through the top openings and piping

- **Vent Openings** - Extended the vent pipe at least 24" above the tank top and secure a vent cap to the vent pipe top.
  Do not plug vent openings!
- **Fill Openings** – Install a leak proof fill pipe cap (such as Beckett 13100G or Philfair 93-2), or extend the fill pipe at least 24" above the tank top.
- **Gauge and Other Openings** - Ensure liquid level gauges are leak proof, and seal all unused tank top openings with threaded steel plugs.
- **Sealing Compounds** – Use water/oil resistant pipe sealing compounds, on all threaded connections.

Pre and Post Storm Recommended Actions

BEFORE FLOOD EVENTS

Recommended steps that should be taken to reduce the risk of tank damage and spills before an expected flood event include:

- Inspection of the tank, supports and flood resistance method used to ensure they are not corroded or otherwise damaged, and all connections are tight.
- Inspection of the tank piping and other tank openings to ensure they are leak-tight.
- Ensure the bottom outlet is fitted with a shut-off valve before connecting to other component
- Shut off the oil supply valve(s) at the tank and burner prior to leaving the property.

AFTER FLOOD EVENTS

Recommended steps that should be taken prior to returning the tank to service after a flood event has occurred include:

- Inspection of the tank, supports, foundation, piping, lines and other tank components for damage, and if found make appropriate repairs.
- Inspection of the tank for any entry of water, with water finding paste, and if found, contact a licensed contractor.
- If any fuel oil has spilled on your property from your tank or another tank, contact the appropriate authorities.

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Appendix - Vertical Obround Steel Tanks

Tank capacity & Size (gal) (L" x W" x H")	Flood Zone #	(Tank %V Disp) – (Oil W + Tank W) = Net Buoyant Force (lbs)	Pad Size & Weight (L" x W" x H") (lbs)
120 30 x 23 x 46	0	(0%V) – (345 + 154) = -499	48 x 35 x 6.00 NA*
	1	(20%V = 206) – (499) = -293	x 6.00 NA*
	2	(50%V = 515) – (499) = +17	x 6.00 NA*
	3	(80%V = 825) – (499) = +326	x 6.00 NA*
	4	(100%V = 1031) – (499) = +532	x 8.89 612
138 30 x 27 x 44	0	(0%V) – (396 + 158) = -554	48 x 39 x 6.00 NA*
	1	(20%V = 237) – (554) = -317	x 6.00 NA*
	2	(50%V = 593) – (554) = +38	x 6.00 NA*
	3	(80%V = 948) – (554) = +394	x 6.00 NA*
	4	(100%V = 1185) – (544) = +631	x 9.46 726
220 49 x 27 x 44	0	(0%V) – (632 + 218) = -850	61 x 39 x 6.00 NA*
	1	(20%V = 378) – (850) = -472	x 6.00 NA*
	2	(50%V = 945) – (850) = +95	x 6.00 NA*
	3	(80%V = 1512) – (850) = +662	x 6.83 761
	4	(100%V = 1890) – (850) = +1041	x10.74 1197
230 60 x 22 x 44	0	(0%V) – (660 + 236) = -896	72 x 34 x 6.00 NA*
	1	(20%V = 395) – (896) = -501	x 6.00 NA*
	2	(50%V = 988) – (896) = +92	x 6.00 NA*
	3	(80%V = 1581) – (896) = +685	x 6.86 788
	4	(100%V = 1976) – (896) = +1080	x10.83 1242
240 60 x 23 x 46	0	(0%V) – (689 + 246) = –935	72 x 35 x 6.00 NA*
	1	(20%V = 412) – (935) = -523	x 6.00 NA*
	2	(50%V = 1031) – (935) = +96	x 6.00 NA*
	3	(80%V = 1650) – (935) = +715	x 6.96 822
	4	(100%V = 2062) – (935) = +1127	x10.97 1296
275 60 x 27 x 44	0	(0%V) – (790 + 252) = -1042	72 x 39 x 6.00 NA*
	1	(20% V = 472) – (1042) = -568	x 6.00 NA*
	2	(50% V = 1180) – (1042) = +138	x 6.00 NA*
	3	(80% V = 1890) – (1042) = +848	x 7.41 975
	4	(100%V = 2362) – (1042) = +1320	x11.53 1518
330 72 x 27 x 44	0	(0%V) – (948 + 288) = -1236	84 x 39 x 6.00 NA*
	1	(20%V = 567) – (1236) = -669	x 6.00 NA*
	2	(50%V = 1418) – (1236) = +182	x 6.00 NA*
	3	(80%V = 2268) – (1236) = +1032	x 7.74 1187
	4	(100% = 2835) – (1236) = +1599	x11.89 1839

(Tank %V Displacement) and its associated upward buoyant force is a function of the % volume in water, where Zones 1, 2, 3 & 4 approximate flood heights to 25%, 50%, 75% & 100% of the tank height, with corresponding “obround” volumes of 20%, 50%, 80% & 100%.

(Oil W + Tank W) combines the downward forces of the oil and tank weight, which is consistent, regardless of the flood level, which only affects the buoyant force. Oil weight is calculated @ 40% fill, and the tank weight is from manufacturer data.

(Pad Size & Weight) of the concrete pad is calculated, after determining the Net Buoyancy Force with a 15% safety factor, by using an area extending 6" beyond the tank footprint, and adjusting for the depth.

*Note 6" is a NFPA 31 minimum pad thickness.

The (+) or (-) of Net Buoyancy Force indicates an upward or downward force.

Special Notes - Calculations for vertical obround tanks are based on, or assumes:

a) 12 ga. steel and typical dimensions (most common types are similar),
b) tank weight & oil weight based on manufacturer averages & volume charts,
c) tank is 40% filled with #2 heating oil @ 0.86 spg (7.18 lb.gal),
d) flooding is in salt water (worst case vs fresh water),
e) concrete pad L&W extend 6.0" beyond the tank footprint,
f) concrete density is 145 lb/cuft (represents common types),
g) short legs provide minimal tank/pad clearance (worst case), and
h) safety factor is +15%, applied to the net buoyancy force