Engineering Design File

EDF-5595

PROJECT NO. 22901

TSF-09/18 V-Tanks Remediation Tank Lifting Design

INEEL

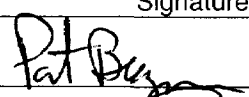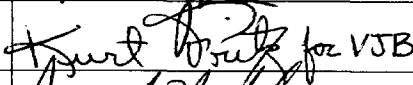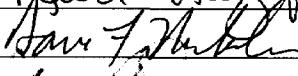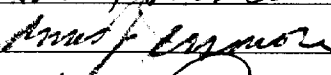**Idaho National Engineering
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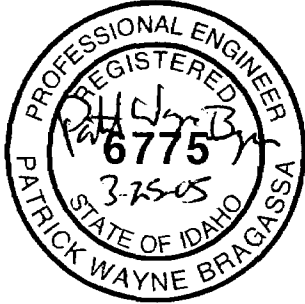EDF-5595
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EDF No.: 5595   EDF Rev. No.:   0   Project File No.: 22901

1.	Title: TSF-09/18 V-Tanks Remediation Tank Lift Lug Design

2. Index Codes:

Building/Type   N/A   SSC ID   TAN-616   Site Area   TAN

3. NPH Performance Category: _____ or ☒ N/A

4. EDF Safety Category: C.G.   or ☐ N/A   SCC Safety Category: C.G.   or ☐ N/A

5.   Summary: This Engineering Design File (EDF) will document the design for the new lift lugs to be installed to lift tanks V-1, V-2, V-3 for removal and to verify the tanks capability to be lifted in this manner and used as final disposal containers for the solidified waste material. Originally tanks V-1, V-2, V-3 were to be removed by basket-slings placed under the tanks (EDF-4672). Due to the possibility of excessive personnel exposure at the bottom of the tanks, the project has decided to remove the tanks by welding fabricated lift lugs to the top of the tanks and attaching slings at these points.

Conclusions:

Lift Lugs: The lift lugs were designed to lift the tanks with the solidified waste using a total lifted load of 71,000 lbs with a resulting Demand-Capacity Ratio of 0.649. Each lift lug will be welded to a 12"x24" baseplate to distribute the load to the tank shell.

Tank Analysis: The governing load condition for the tank analysis was determined to be during the lifting with the tank full of solidified waste. This load case required lift lugs with the base plates to distribute the loading and the associated stresses to the tank shell. The stresses were reduced to a maximum of 17,400 psi for a Demand –Capacity Ratio of 0.58. The analysis of the tanks as final disposal containers required a 30-ft surcharge of soil, which resulted in a maximum stress of 19,400 psi and a Demand Capacity ratio of 0.64.

Cribbing Design: The cribbing design utilizes 8"x12" wood timbers and is based on the tanks full of solidified waste on a supporting surface with a bearing capacity of 3000 psf. This will allow placing the loaded tanks on a transport trailer or a staging area on soil.

Crane Verification: The Grove GMK 6220 mobile crane was verified to be used for lifting the tanks from the excavation using the existing crane pad. The tanks were assumed to be empty with the exception of 6000 lbs of solidification agent added. The GMK 6220 crane is capable of making the lifts for tanks V-1, V-2, V-3, and V-9 using 70% of it's maximum capacity at the specified reach radius. A larger capacity crane will be required to lift the tanks with the solidified waste inside.

6. Review (R) and Approval (A) and Acceptance (Ac) Signatures:
   (See instructions for definitions of terms and significance of signatures.)

	R/A	Typed Name/Organization	Signature	Date
Performer/ Author	N/A	P. W. Bragassa, P.E./3K16		3-25-05
Technical Checker	R	V. J. Balls/4663	for VJB	3/25/05
Approver	A	D. Nickleson/3K16		3/25/05
Requestor	R	J. Jessmore/3C00		
System Engineer	A	G.G. Anderson/3CH0		3/30/05
Doc. Control				4/18/05

7.	Distribution: (Name and Mail Stop)	

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1. Title: TSF-09/18 V-Tanks Remediation Tank Lift Lug Design	

2. Index Codes:

Building/Type **N/A** SSC ID **TAN-616** Site Area **TAN**

8. Does document contain sensitive unclassified information? ☐ Yes ☒ No

If Yes, what category:

9. Can document be externally distributed? ☒ Yes ☐ No

10. Uniform File Code: 8201 Disposition Authority: A17-31-a-1

Record Retention Period: Until dismantlement or disposal of facility, equipment, system or process: or when superseded or obsolete, whichever is earlier.

11. For QA Records Classification Only: ☐ Lifetime ☐ Nonpermanent ☐ Permanent

Item and activity to which the QA Record apply:

12. NRC related? ☐ Yes ☒ No

13. Registered Professional Engineer's Stamp (if required)

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TSF-09/18 V-Tanks Remediation Tank Lift Lug Design

1. PURPOSE

The V-Tanks remediation project will remove and treat liquid waste from four underground steel tanks and store the treated waste temporary in consolidation tanks. The four underground tanks will be removed and the surrounding contaminated soils remediated. The waste will be pumped back into three of the 10,000 gallon V-tanks (V-1, V-2, V-3) and mixed with a solidification agent to stabilize liquid. Once solidified, the tanks with contents will be transported to the INEEL CERCLA Disposal facility (ICDF) for final disposal. This Engineering Design File will document the analysis of the tanks to verify their capability to be lifted with the solidified waste. Included in this task is the design of lifting lug brackets to be installed on the tanks and support cribbing.

2. SCOPE

Specific Design Requirements:

Lifting Lug Design:

Design of lifting lugs to be welded on to Tanks V-1, V-2, V-3. Lugs shall be capable of lifting the weight of the tank considering the verified wall thickness of ½-in, 304L stainless steel. In addition to the tanks self-weight, the lift design shall assume the tanks will be used for solidifying the treated V-tank contents and to be used as a final disposal container for the solidified waste. The solidification process will add 37,000 lbs to each of the three tanks and will fill approximately 1/2 of the volume of each the 10,000 gallon tanks, when solidified. The project engineer has requested that the lift design consider that the entire amount of solidified waste (111,000 lbs) may be located in only two of the tanks (filling approximately 2/3 of the tank), thus totaling 55,500 lbs of waste per tank.

Therefore, in summary, the tank lift lugs shall be designed for the tank dead load plus an additional 55,500 lbs of solidified waste. The design shall include engineering design calculations for the lift plan development. Lift lugs for tank V-9 are not required.

Tank Analysis:

Tanks (V-1, V-2, V-3) shall be analyzed to verify their capability to be used as containers to lift the specified amount of waste. This analysis will control the lift lug design.

The tanks shall also be analyzed to verify their ability to be used as containers for the solidified waste. This analysis shall consider a tank with 55,500 lbs of material. Tank shall be set on cribbing for support. Assume solidification of liquid waste has no structural properties. The analysis shall verify the tanks can support the weight of the solidified material.

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Tanks shall be analyzed to verify their structural integrity in the final disposal configuration. Tanks shall be assumed to be bearing on a concrete/grout bed with 30-ft of soil above the top surface of the tank.

Cribbing:

Design cribbing to support tanks V-1, 2, 3 on the transport trailer, or in a staging area. The cribbing shall coordinate with the tank analysis as required. Cribbing shall be designed to be used on a surface with a bearing capacity of 3000 psf.. Tanks shall be assumed to be fully loaded with the solidified material (55,500 lb payload).

Crane/Lift Verification:

Determine the crane requirements for lifting the four V-tanks from the excavation and setting in the staging area, or transport trailer. The previously constructed crane bearing pad shall be used as the crane location and shall be verified for the crane selected. The staging area will be changed from the previous area as shown on the released drawing 628457 (C-14). The new area will be located north and west of the crane pad to allow transporting of the treated liquid waste back into the tanks. Location will be based on available crane reach assuming the use of a Grove GMK-6220 crane. The staging area size will be changed to provide for the transport trailer.

The lift shall consider the empty weight of each tank plus 6000 lbs of solidification agent which may be added into V-1, V-2, V-3. V-9 will be assumed empty. The engineering analysis in support of the development of the lift plans for the removal of the tanks are included in this task. Lift plans shall be developed in coordination with the TAN Hoisting and Rigging SME..

Crane and Lifting Requirements at ICDF: Crane sizing and lift design for setting the tanks into the final disposal configuration at ICDF is not included in this work scope.

Transport Design: The transport plan, trailer selection, tie-downs and packaging will be provided by BBWI P&T. A separate EDF will be prepared to support this work.

3.   CONCLUSIONS/RESULTS

Lift Lugs: The lift lugs were designed to lift the tanks with the solidified waste using a total lifted load of 71,000 lbs with a resulting Demand-Capacity Ratio of 0.649. Each lift lug will be welded to a 12"x24" baseplate to distribute the load to the tank shell.

Tank Analysis: The governing load condition for the tank analysis was determined to be during the lifting with the tank full of solidified waste. This load case required utilizing lift lugs with base plates to distribute the loading and the stresses in the tank shell was reduced to a maximum of 17,400 psi for a Demand –Capacity Ratio of 0.58. The analysis of the tanks as final disposal containers required a 30-ft surcharge of soil resulted in a maximum stress of 19,400 psi and a Demand Capacity ratio of 0.64.

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Cribbing Design: The cribbing design utilizes 8"x12" wood timbers and is based on supporting the tanks full of solidified waste on a surface with a bearing capacity of 3000 psf. This will allow placing the loaded tanks on a transport trailer or a staging area on soil.

Crane Verification: The Grove GMK 6220 mobile crane was verified to be used for lifting the tanks from the excavation using the existing crane pad. The tanks were assumed to be empty with the exception of 6000 lbs of solidification agent added. The GMK 6220 crane is capable of making the lifts for tanks V-1, V-2, V-3, and V-9 using 70% of it's maximum capacity at the specified reach radius.

4. SAFETY CATEGORY

The demolition work contained in this EDF is considered " Consumer Grade", as specified in the Technical and Functional requirements document (TFR-278). All design and construction will comply with the quality requirements specified for this level of safety category.

5. NATURAL PHENOMENA HAZARDS PERFORMANCE CATEGORY

The system is classified as safety category consumer grade (CG) in accordance with the requirements of management control procedure MCP-540 titled *Documenting the Safety Category of Structures, Systems, and Components*. The safety basis for performing V-tank remedial activities is documented in the *Safety Analysis Report for Test Area North Operations* SAR-208. There are no special requirements regarding industrial or natural phenomena hazards. Normal industrial and environmental hazards will be routinely addressed per the work control process (the system performance category designation is PC 0).

6. STRUCTURE SYSTEM OR COMPONENT DESCRIPTION

The system is the temporary installation required for safely removing and treating the contents of Tanks V-1, V-2, V-3 and V-9 and preparing both the treated contents and empty tanks for disposal at the ICDF. The TAN remediation sites are known as TSF-09 (V-1, V-2, and V-3) and TSF –18 (V-9) at OU 1-10; these four tanks are commonly referred to as the V-tanks. The remediation is being conducted in accordance with the *Final Record of Decision for Test Area North, Operable Unit 1-10* (DOE-ID 1999) referred to as the ROD, and any appropriate amendments. Tanks V-1, V-2, and V-3 are identical stainless steel 10,000 gallon tanks 10 ft in diameter with a nominal 20 ft length, and located approximately 11 ft below grade.

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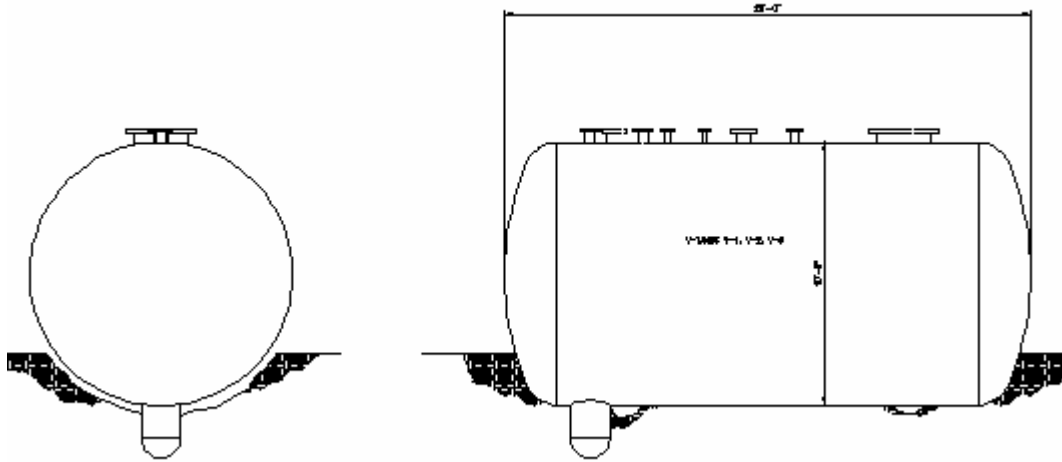
V-Tank Elevation

7. DESIGN LOADS

The tank weight is based on a measured thickness of 1/2 " 304L stainless steel. This thickness results in an empty tank weight of 15,000 lbs, which includes an assumption of the sump volume filled with sludge that cannot be retrieved.

The tank lift from the excavation shall include the dead weight of the tanks plus 6000 lbs of dry solidification agent, assumed uniformly distributed. The total weight of the tanks with the solidified waste shall assume 15,000 lbs for the tank dead load plus 55,500 lbs for the waste.

8. ASSUMPTIONS

General Assumptions: The proposed sequence of lifting and removing Tanks V-1, V-2, and V-3 will be as follows:

1) The solidification agent will be added to each of the three 10,000 gallon V tanks prior to removal from the excavation. The weight of the total amount of solidification agent is given as 6,000 lbs per tank.
(K.Wendt memo, 2/17/065)

2) A transport trailer will be positioned in the loading area and a tank will be removed from the excavation and set on cribbing positioned on the trailer. The tank will be secured to the trailer and the transporter moved out to a temporary storage area. A second trailer is brought in to the loading area and the process is repeated. A third trailer is then used to repeat the process once again. Each transport trailer will need to be capable of carrying a 10-ft diameter tank, 20-ft in length, with cribbing and weighing a total of 72,000 lbs maximum (plus weight of cribbing). The temporary storage area will be provided by the program.

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3) At a designated time, one of the transport trailers with a single tank is brought back into a solidification staging area from the temporary storage area. A transfer piping system is installed to transfer treated liquid waste from the V-Tank Consolidation Tanks back into the trailer mounted tank. The waste placed in the tank is solidified by the solidification agent already within the tank. This solidified material is specified to weight 55,500 lbs and occupy 2/3 of the volume of the tank. The transport trailer is then moved back to the temporary storage area.

4) The process is repeated once more for each of the two remaining tanks.

5) Tanks are transferred to ICDF for disposal.

6) Tanks are removed from trailer and placed in disposal location. Rigging design, crane selection, disposal provided by ICDF.

9. ACCEPTANCE CRITERIA

The lift lug design shall be in conformance with the acceptance criteria of the AISC, Manual of Steel Construction, Allowable Stress Design and the DOE Hoisting and Rigging Standard, DOE-STD-1090. The lift lugs are permanently attached lift points, therefore considered part of the lifted load.Evaluation of the tanks for lifting and for use as containers to support the solidified waste shall be based on the prevention of yielding of the vessels, since the tanks are being removed and disposed. Stresses up to the yield stress would be acceptable to prevent damage, however, the acceptable stress will be limited to 2/3 of yield to guarantee the integrity of the tanks.

10. SOFTWARE

The tank analysis was performed using STAAD.Pro 2004, Rev 0, using a Dell Optiplex GX260 personal computer running the Windows 2000 operating system, CPU property ID 374874. This software has been verified and validated by EDF-5276, Rev 0, *Validation of STAAD.Pro 2004 for Plate and Beam Elements.* The evaluation performed utilizes a finite-element analysis using plate elements. Timber design for support cribbing utilized StruCalc 6.0, by Cascade Consulting Associates.

11. REFERENCES

- AISC, American Institute of Steel Construction, Manual of Steel Construction, Allowable Stress Design.

- ANSI/AISC, American Institute of Steel Construction, Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities.

- Technical and Function Requirements (TFR-278) *T&FR for the Remediation of V-Tanks, TSF-09 and TSF-18, Operable Unit 1-10.*

- Safety Analysis Report for Test Area North Operations SAR-208.

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- Bechtel Rigging Handbook, Second Edition.

- DOE-STD-1090, Department of Energy Hoisting and Rigging Standard

- StruCalc 6.0, Version 6.00.7, Timber Design Software, Cascade Consulting Associates

- STAAD.Pro 2004 Validation Engineering Design File, EDF-5276, Tracking Number 160097

- STAAD.Pro 2004 Structural Analysis Software, Rev. 0. Research Engineers International, Yorba Linda, California.
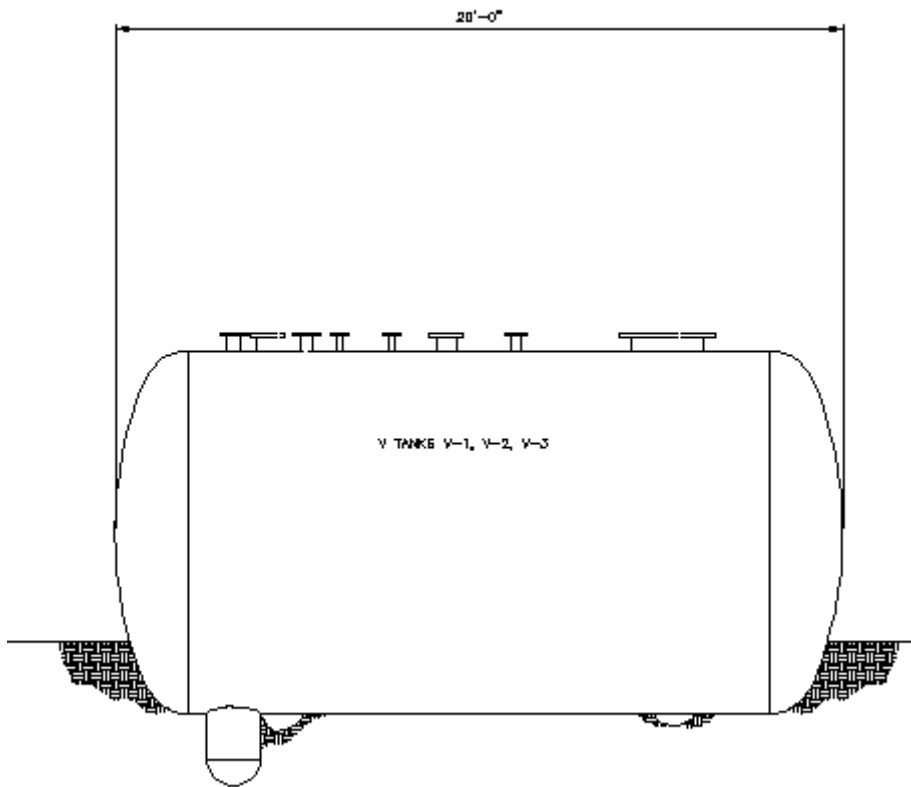
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12. CALCULATIONS

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TAN V Tanks Rigging Design Modifications

Dimensional definitions:

$$pcf \equiv \frac{lbf}{ft^3} \qquad plf \equiv \frac{lbf}{ft} \qquad psf \equiv \frac{lbf}{ft^2} \qquad kip \equiv 1000\,lbf \qquad (lbf = pound\text{-}force)$$

$$ksi \equiv \frac{kip}{in^2} \qquad pli := \frac{lbf}{in} \qquad sf := ft^2 \qquad psi := \frac{lbf}{in^2}$$

Calculate the Weight of the V-Tanks: Using a measured thickness of 1/2" Stainless steel

Total Solidified waste weight: $solid := 55500\,lbf$

Elevation View of V-Tank

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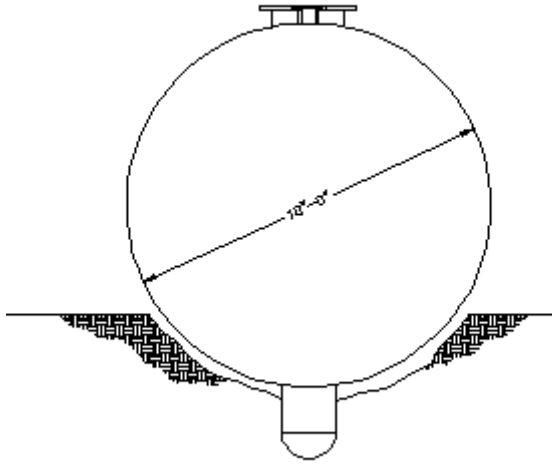
Surface area of tank:

assuming sphere halfs on ends

$$A := \left(2 \cdot \pi \cdot r^2\right) + 2 \cdot \pi \cdot r \cdot \mathbf{h}$$

where:

r = radius $r := 5ft$

h = length (straight)

$h := 16 \ ft$

$$A := \left(2 \cdot \pi \cdot r^2\right) + 2 \cdot \pi \cdot r \cdot h$$

$$A = 659.734 \ ft^2$$

for 1/2" steel the unit weight is:

$\gamma steel := 20.42 psf$ $tankweight := A \cdot \gamma steel$

$tankweight = 13471.778 \ lbf$

From STAAD.Pro model which creates a more accurate model of the tank surface area:

$weight2 := 14248 lbf$

Sump weight: sump is 18 in diameter, 12 inches deep:

$\pi \cdot 18in \cdot 12in + 2 \cdot \pi \cdot 6in^2 = 4.974 ft^2$ sump weight: $5ft^2 \cdot 20.42 psf = 102.1 \ lbf$

Miscellaneous piping, flanges, plates etc. Assume 200 lbf

Total empty weight: $tank1 := weight2 + 102 lbf + 200 lbf$

$tank1 = 14550 \ lbf$

Assume sump is full of sludge that cannot be removed: $Vol := \pi (9in)^2 \cdot 12in$

using a sludge unit weight = 115pcf (consistant with grout)

$wt := Vol \cdot 115 pcf$ $wt = 203.222 \ lbf$

Tank weight: $Tank := tank1 + 203 lbf$ $Tank = 14753 \ lbf$

Round up to 15,000 lbf

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The existing design is based on the assumption that the tanks would be substantially cleaned and contamination would not be a concern during the tank removal. Basket-slinging the tanks would be the easiest method of rigging and was chosen for this reason in the original design rflected in EDF-4672.

Due to changes in the treatment process, Radiation Engineering now is concerned that the radiation levels will be high enough that working around the bottom of the tanks could cause workers to be exposed. Therefore it has been requested that the lifting method be changed to installing lift eyes on the top tank surface and attaching rigging to the eyes for lifting. The following design is for the lifting eye brackets.
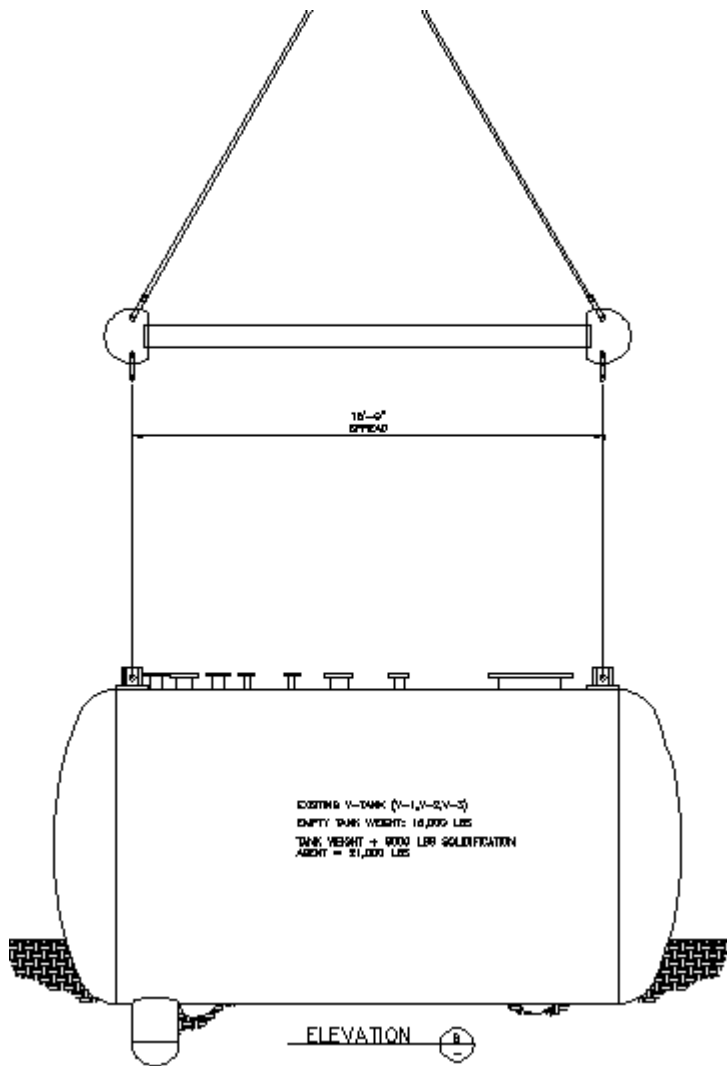
Proposed Rigging Method

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Lifting Lugs shall be treated as "Pin-connected" members: (Bechtel Rigging Handbook Section 4.2.16)

Using 1.5" A36 plate: $F_y := 36\,ksi$ $F_u := 58\,ksi$
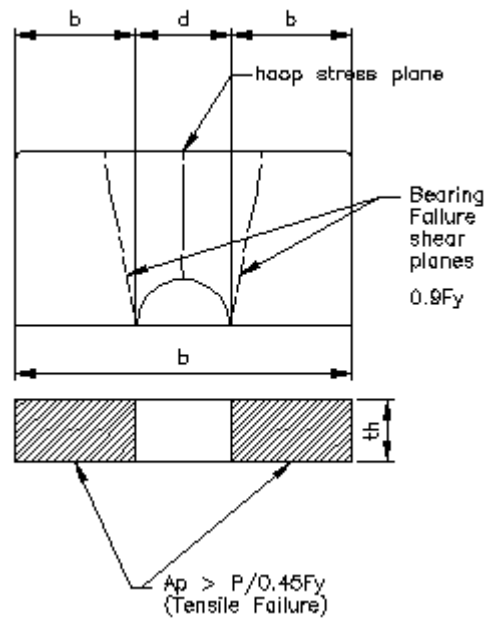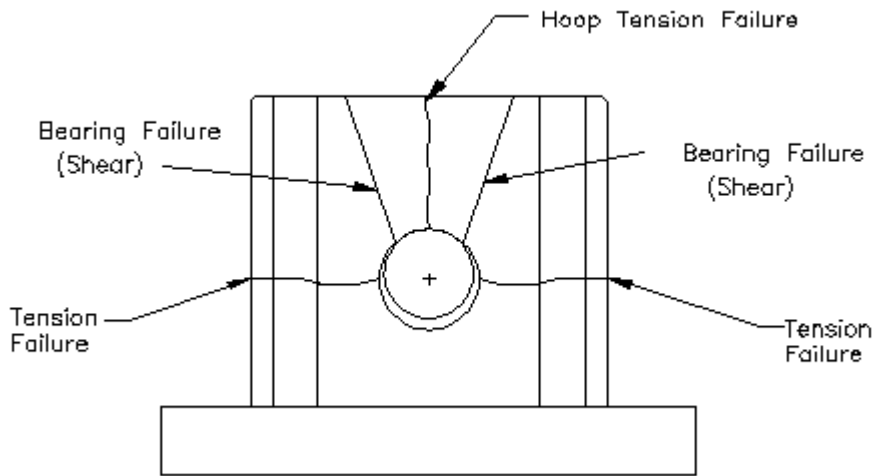
Assume shackle diameter of 2" $d := 2\,in$ $th := 1.5\,in$ $P := 15000\,lbf$

Crobsby 1-3/4 G-209 shackle has a swl of 25 tons and 2-inch diameter pin

$Load := P + solid$ $Load = 70500\,lbf$ round to 71,000 lbf $Load := 71000\,lbf$

load per bracket: $Ptotal := \dfrac{Load}{2}$ $Ptotal = 35500\,lbf$

Lug Failure Modes:

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AISC D.3.1 Pin Connected Members: The allowable stress on the net area of the pin hole for pin-connected members is 0.45Fy (tension stress across the lug through the pin hole)
(Tension Failure)

allowable stress per AISC D.3.1: $0.45 \cdot Fy = 16.2 \, ksi$

Minimum area required across the net
pin hole $\geq$ P/.45Fy
(area across the bracket through
pin hole in tension)

$B := 8in$

Ptotal $= 35500$ lbf

$\dfrac{35500 lbf}{0.45 \cdot Fy} = 2.191 \, in^2$

Net cross section area provided:

$th \cdot (B - d) = 9 \, in^2$

Allowable load: AISC: $0.45 \cdot Fy \cdot 9 in^2 = 145800 lbf$

tension failure DC: $tendc := \dfrac{35500 lbf}{145800 lbf}$ $tendc = 0.243$

The bearing stress on the projected area of the pin shall not exceed the stress allowed in Section J8.
AISC J.8.: (J8-1) On contact area of milled surfaces and ends of fitted bearing stiffeners; on projected area of pins in reamed, drilled or bored holes: Fp = 0.90Fy (J8-1)

Projected area of the pin: $2in \cdot 1.5in = 3 \, in^2$ (assumes 2" diameter shackle pin)

Allowable bearing stress per AISC J8-1: $Fp := 0.9 \cdot Fy$

Allowable load: $Fp \cdot 3in^2 = 97200 \, lbf$
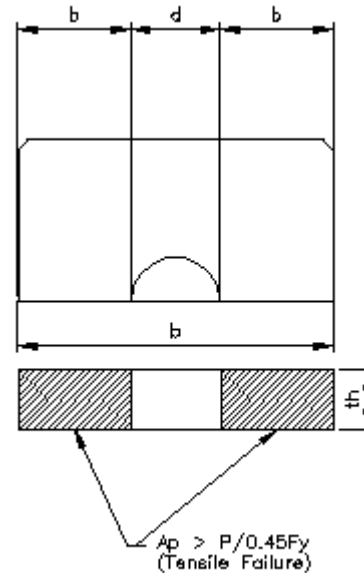
governing D/C $DC := \dfrac{Ptotal}{54675 lbf}$ $DC = 0.649$

Hoop Tension failure:

assuming the hoop tension is resisted by a direct shear through a single plane.
Conseratively assume the full load P is resisted at this point.

$area := th \cdot 3in$ $area = 4.5 \, in^2$ $\dfrac{35500 \, lbf}{area} = 7.889 \, ksi$ ok

pin diameter = 2"   drill bracket hole at 2-1/32"

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Welding:

Weld Criteria Summary:

Plate to tank:
Base Metal: ASTM A36 1.5" plate bracket, 1/2" thick tank wall

Lug to plate:
1.5 in lug to 1.5 in plate

Filler Material:
Weld Inspection: Welds shall be inspected in accordance with the procedures of AWS D1.1 for visual inspections. All welds shall receive a visual inspection. Acceptance criteria shall be as defined by AWS D1.1 Section 6.
Welding bracket to base plate: 1.5 in thick bracket to 1.5 in thick base plate:

The maximum tension on the bracket will be equal to the sling tension. P_{total} = 35500 lbf

The bracket is 8 inches in length. If the bracket is welded all round with a 1/2 in fillet weld and assume 1/2" of weld at end is tapered (2" total) and neglect the ends:

$weldlength$:= 8in + 8in − 2in   fu := 70ksi

$$Pweld1 := \frac{0.30 \cdot fu \cdot .707 in \cdot \frac{1}{2} in}{1in}$$

Pweld1 = 7423.5 pli

Weld strength:

weld := Pweld1 · 14in

weld = 103929 lbf

weld is acceptable, overdesigned for durability.

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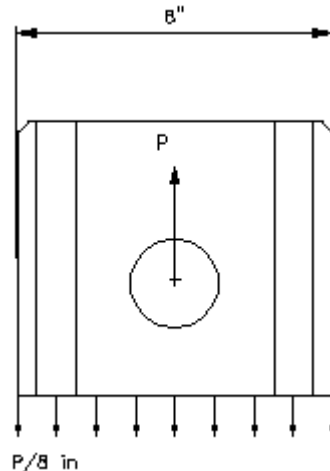
Bracket:

To assume distribution of the load to the base plate and to stiffen the bracket, gusset plates will be added to each side.
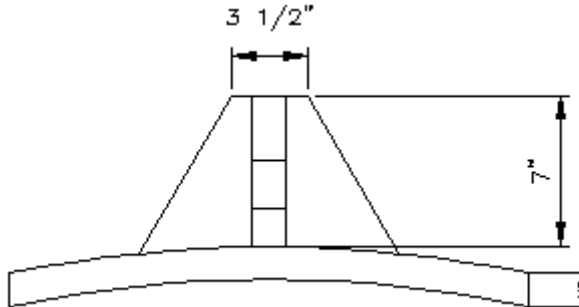
Use 1" gusset plates welded with 3/8 in fillets to baseplate.

Use 3/8" fillet to weld gussets to bracket.

$$Pweld2 := \frac{0.30 \cdot fu \cdot .707 in \cdot \frac{3}{8} in}{1 in} \qquad Pweld2 = 5567.625 \; pli$$

Welding Baseplate to tank: 1-1/2" baseplate to 1/2" tank shell:
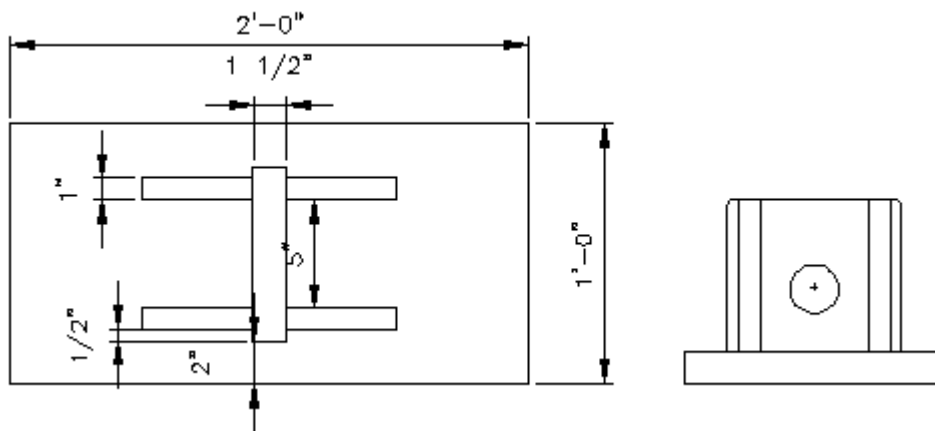
Weld: Try using a 3/8" fillet all around the lug plate to limit overwelding the tank wall (thick = 1/2")

for 3/8" fillet weld using 304L stainless steel as a base metal;

Use INEEL Weld Procedure CS 3.0, CS 3.04, CS 6.9 Electrodes: E 309 AWS D1.6 Table 3.3 Fu = 75ksi (E 309 -17 and 18 has Fu=80 ksi) but will use the lower value of 75 ksi

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Fillet weld strength from AWS table 2-10 minimum weld size: 5/16" $fu := 75\,ksi$

On throat of weld:

$$Pweld2 := \frac{0.30 \cdot fu \cdot .707 in \cdot \frac{3}{8} in}{1 in}$$

$Pweld2 = 5965.312\,pli$

If the plates are welded all round to assure distribution, reduce length by 1/2 in at each corner for weld taper. Also assume 12" of weld is bad or cannot be placed due to interferences :

$perimeter := 2ft + 2ft + 1ft + 1ft - 4in - 12in$

$perimeter = 56\,in$

weld strength: $baseweld := Pweld2 \cdot perimeter$ $baseweld = 334057.5\,lbf$

$$dcweld := \frac{Ptotal}{baseweld}$$

$dcweld = 0.106$ ok

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Rigging Design:

Proposed Spreader Bar: Spreader beam is owned by INEEL
Capacity: 50 tons

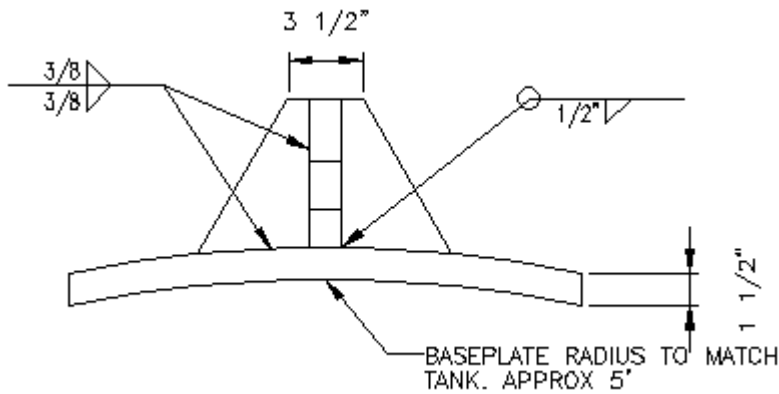This beam has the correct spread and can be used even when the tanks are loaded with waste. The rigging design for lifting the loaded tanks (weight approx 71,000 lb) will be performed by others. However the lift brackets must accomodate the final lifting weight. Therefore, some components such as the shackles will require a longer reach and thicker pin to fit properly in the brackets.

Rigging Requirements for lifting tanks from excavation:
Tanks will have waste removed,
but may have 6000 lbs of dry solidification agent deposited inside.Total weight
for lift: 15,000 lbs + 6000 lbs = 21,000 lbs

$Lift1 := 21000 \, lbf \qquad P := 21000 \, lbf$

$\dfrac{P}{2} = 10500 \, lbf$
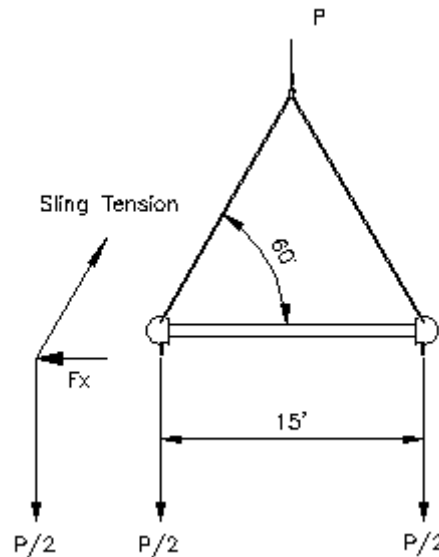
Lift from excavation will utilize spreader beam for a controlled lift. Final rigging design will be part of subcontract, however a rigging design will be provided by this analysis to provide the design criteria

Shackles: shackles need to fit into bracket holes (2-1/32" diam) without too much play to prevent twisting or slipping of the shackle while connected to the bracket. Therefore shackles shall have a 2" pin.

Specify a Crosby G-209 Screw Pin anchor Shackle, 1-3/4" nominal. This shackle has a pin diameter of 2", a through opening reach of 7" and a rated capacity of 25 tons. The spread of the pin base is 2.88" which will allow use in the 1-1/2 " plate brackets. Although much over the required load capacity, it is the fit up in the bracket which is desired.

Balanced load distribution would yield an equal vertical component of force at each lift bracket of 10,500 lbs. Allow for an over loading of each sling due to load shift of 25%.

Bottom Slings:

$Force := 10500 \, lbf \cdot 1.25 \qquad Force = 13125 \, lbf$ use 15,000 lb capacity slings as a minimum for bottom slings

Top Slings:

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Vertical component: $Y := 13125 \text{lbf}$ assume a sling angle of 60 degrees

$$\phi := 60 \text{deg}$$

Actual force: $\text{tension} := \dfrac{13125 \text{lbf}}{\sin(\phi)}$ $\text{tension} = 15155.445 \text{ lbf}$
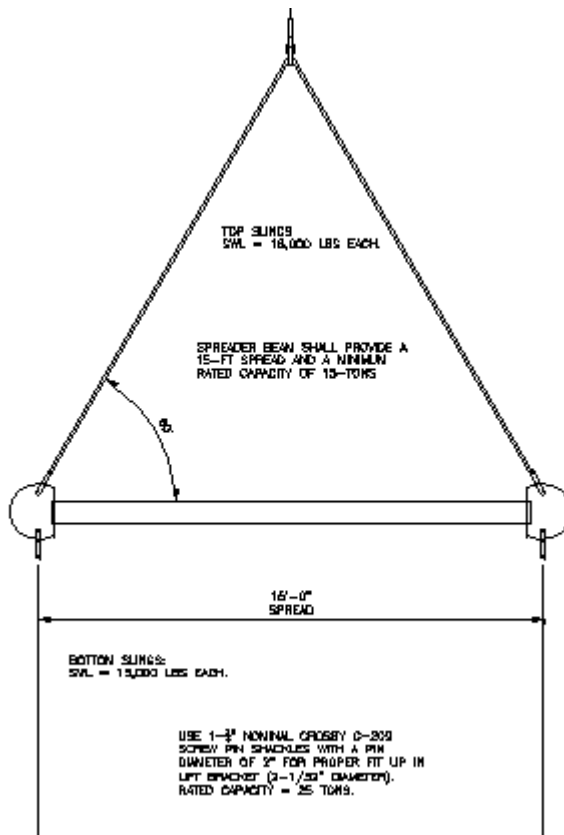
Summary:

Slings: Use 18,000 lb capacity slings

Top Slings: , minimum angle 60 degrees

Shackles: use (6) 1-3/4" Nominal Crosby G-209 Screw Pin Anchors, Min Capacity 25 ton

$$\text{BottomDC} := \dfrac{10500 \text{lbf}}{15000 \text{lbf}} \qquad \text{BottomDC} = 0.7$$

$$\text{TopDC} := \dfrac{15155 \text{lbf}}{18000 \text{lbf}} \qquad \text{TopDC} = 0.842$$

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433.34 01/09/2003 Rev. 01	INEEL LIFT PLAN	
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SEE INSTRUCTIONS				

Lift Category: ☐ Critical Lift ☐ Pre-Engineered Production Lift ☐ Personnel Lift ☒ Ordinary Lift (optional)

SSC Engineer: G.G. ANDERSON	Phone: 6-4178	Date: 3/24/05

Facility: TAN	W.O./Procedures No.:	Index No. (optional):

Task: Lift V-tanks V-1,V-2,V-3 from excavation to trailer or staging area

Rigging Configuration Sketch

LIFTING NOTES:

1. SHACKLES ATTACHING RIGGING TO TANK LIFT LUGS SHALL HAVE A 2" DIAMETER PIN FOR PROPER FIT UP IN 2-½" HOLE (NOMINAL 25 TON CAPACITY). REMAINING SHACKLES SIZED FOR SLING CAPACITY

2. INSPECT TANKS FOR CRACKS OR CORROSION TO LIMITS OF EXCAVATION.

3. ATTACH RIGGING AND LIFT TANK APPROXIMATELY 2-FT TO VERIFY RELEASE. VERIFY LIFT WEIGHT WITH DYNAMOMETER AND STOP LIFT IF WEIGHT EXCEEDS 25,000 LBS. ONCE TANK HAS BEEN LIFTED, HOLD FOR APPROXIMATELY 5 MINUTES. FROM SAFE DISTANCE, VISUALLY INSPECT UNDERSIDE OF TANK AND SUMP.

4. CONTINUE WITH LIFT AND SET TANK ON CRIBBING IN DESIGNATED LOCATION.

5. CRANE AND ALL RIGGING SHALL BE PROVIDED BY LIFTING SUBCONTRACTOR.

VERIFY CRANE CAPACITY FOR REACH AND LIFTED LOAD

USE DYNAMOMETER FOR ALL LIFTS

TOP SHACKLE MIN SWL=15-TON

TOP SLINGS SWL=18,000 LBS MIN SLING ANGLE 60 DEGREES

SPREADER BEAM MIN 15-TON CAP 15-FT SPREAD BOTTOM SLINGS SWL=18,000 LB

SHACKLES AT TANK LIFT LUGS: 25 TON CAPACITY. SEE NOTE 1.

15'-0"

VERIFY LUG INSTALLATION

TANKS V-1,2,3 WEIGHT=15,000 LBS (EMPTY) 21,000 LBS MAX

10'-0"

20'-0"

Weights: Tank Empty weight: 15,000 lbs
Tank weight loaded with solidification agent: 21,000 lbs (lifted load)

Dimensions:
Tank Length: 20-ft
Tank Diameter: 10-ft

Comments:
Subcontractor will provide mobile crane and all rigging for lift. Subcontractor is responsible for verifying crane reach and capacity, selection and installation of rigging and hardware, providing crane operator and riggers and making the associated lifts. Load may hang slightly off-balance

APPROVALS

Responsible Manager Print/Type Name	Responsible Manager Signature	Date
B.P. Shagula Safety Engineer/H&R SME Print/Type Name	Safety Engineer/H&R SME Signature	Date
G.G. Anderson H&R Engineer Print/Type Name	H&R Engineer Signature	Date

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Tank Analysis:

The tank was modeled using a finite element analysis program, STAAD.Pro 2004 to determine its capability of safely holding the volume of solidified waste within while being lifted. This analysis will also determine if the tanks can be supported by saddles or cribbing during the solidification process. STAAD.Pro 2004 has been validated and verified for use in finite element plate analysis and is documented in EDF-5276.

Tank Weight as determined previously: wt = 14,248 lbf based on wall thickness of 1/2-inch

Per K. Wendt Email on 2/10/05, the weight of the solidified waste wil lequal 37,000 lbs for all three tanks, but requested the analysis consider only two tanks for the total volume of contents.

Therefore: $\dfrac{37000\text{lbf}\cdot 3}{2} = 55500\,\text{lbf}$ per tank

The material will fill approximately 2/3 of the volume of the 10,000 gallon tanks

To determine the distribution of the mass of waste in the tank, the STAAD.Pro model was used. The top 1/3 of thetank was deleted and the empty weight of the remaining tank calculated by STAAD.Pro to be 10,748 lbf. This value was then used to determine the area of the bottom 2/3.

Tank weight = Area x thickness x γsteel and solving:

$\text{Area} := \dfrac{11309\text{lbf}}{0.5\text{in}\cdot 490\text{pcf}}$ $\text{Area} = 553.91\text{ft}^2$

If this area is used for the distribution of the 55,500 lbs of solidified waste:

$\dfrac{55500\text{lbf}}{\text{Area}} = 100.197\text{psf}$
This value will be applied to the tank elements in the bottom 2/3 of the tank. The total weight of the tank will be checked to verify the values are correctly applied.

total weight should be a minimum of: $55500\text{lbf} + 14248\text{lbf} = 69748\,\text{lbf}$

Tank model supports: to model the support conditions of the tank during lifting, the lifting bracket base plate is modeled on the tank using 1.5" thick plate. Supports are used around the perimeter (approximate) of this base plate at the approximate locations of the continuous weld around the plate connecting to the tank. This is conservative since the supports are at points, and not continuous. The supports around the perimeter of the plate are released in the x and z axis to resist only vertical loads. Restraint in the x and z axis is provided at four exterior nodes on the tank.

The tanks are stainless steel, assumed to be 304L Fy =30 ksi Fu = 80 ksi

The resulting stresses in the tank vessel shall be acceptable up to 75% of yield values. Stresses up to yield could be accepted since this is a one time lift only to dispose of the tanks.

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STAAD.Pro Model
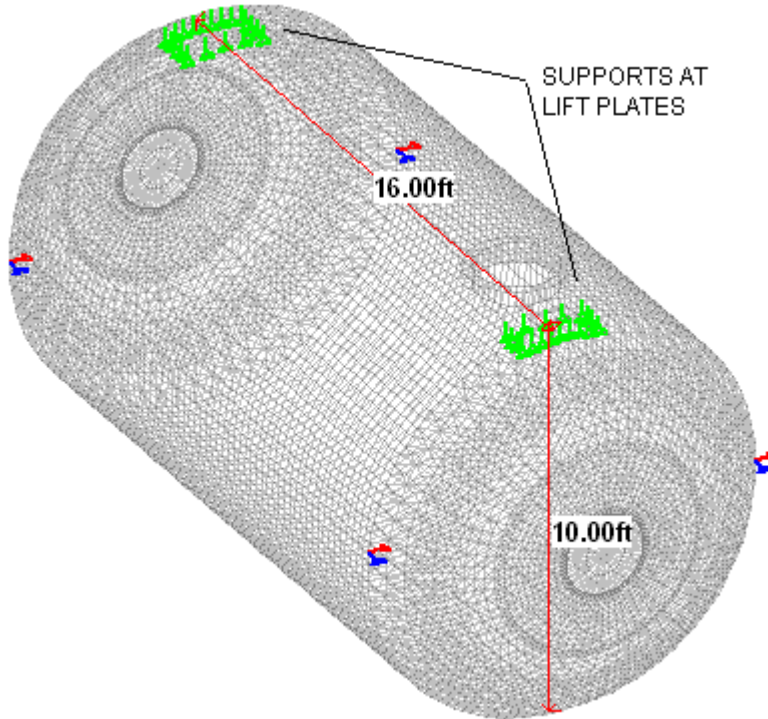
The statics check below indicates that the total weight calculated equals 70, 740 lbs, which is slightly greater than the required 69,748 lbs. OK

```
         STATIC LOAD/REACTION/EQUILIBRIUM SUMMARY FOR CASE NO.      1
         LOADTYPE DEAD   TITLE LOAD CASE 1



***TOTAL APPLIED LOAD ( POUN FEET ) SUMMARY (LOADING    1 )
     SUMMATION FORCE-X =          0.00
     SUMMATION FORCE-Y =     -70740.04
     SUMMATION FORCE-Z =          0.00
```

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Pressure loads are applied in the global Y axis. This loading was chosen after several variations and resulted in the largest resulting stresses.

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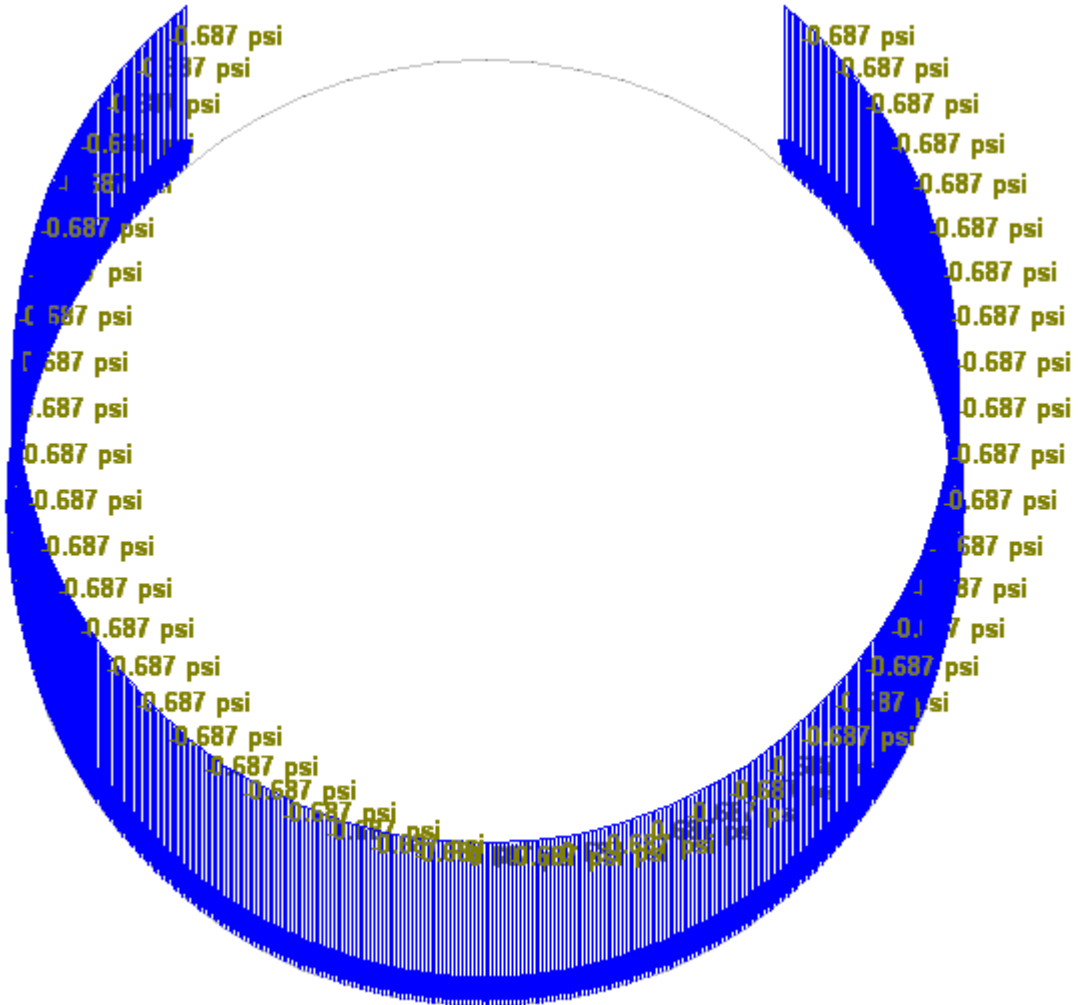
STAAD.Pro 2004 Analysis Summary: The plate stress summary below shows a maximum plate stress of 17,400 psi located at the ends of the tank, adjacent to the lift bracket plate corners. As shown in the stress contour diagrams, the maximum stress is a point stress which dissapates quickly. This maximum stress is only 58% of the yield stress of 30,000 psi, and is acceptable.

Plate Centre Principal Stress Summary

	Plate	L/C	Principal		Von Mis		Tresca	
			Top (psi)	Bottom (psi)	Top (psi)	Bottom (psi)	Top (psi)	Bottom (psi)
Max (t)	16932	1:LOAD CASE	17.4E 3	6.55E 3	15.5E 3	6.66E 3	12.4E 3	6.76E 3
Max (b)	11684	1:LOAD CASE	17.3E 3	6.68E 3	15.5E 3	6.69E 3	12.4E 3	6.7E 3
Max VM (t)	16932	1:LOAD CASE	17.4E 3	6.55E 3	15.5E 3	6.66E 3	12.4E 3	6.76E 3
Max VM (b)	16343	1:LOAD CASE	2.55E 3	6.27E 3	2.22E 3	8.35E 3	1.49E 3	9.47E 3
Tresca (t)	16932	1:LOAD CASE	17.4E 3	6.55E 3	15.5E 3	6.66E 3	12.4E 3	6.76E 3
Tresca (b)	16343	1:LOAD CASE	2.55E 3	6.27E 3	2.22E 3	8.35E 3	1.49E 3	9.47E 3

Isometric View of Stress Contours

Max Absolute
psi
<= 149
1229
2308
3388
4468
5548
6628
7707
8787
9867
10.9 E3
12 E3
13.1 E3
14.2 E3
15.3 E3
16.3 E3
>= 17.4

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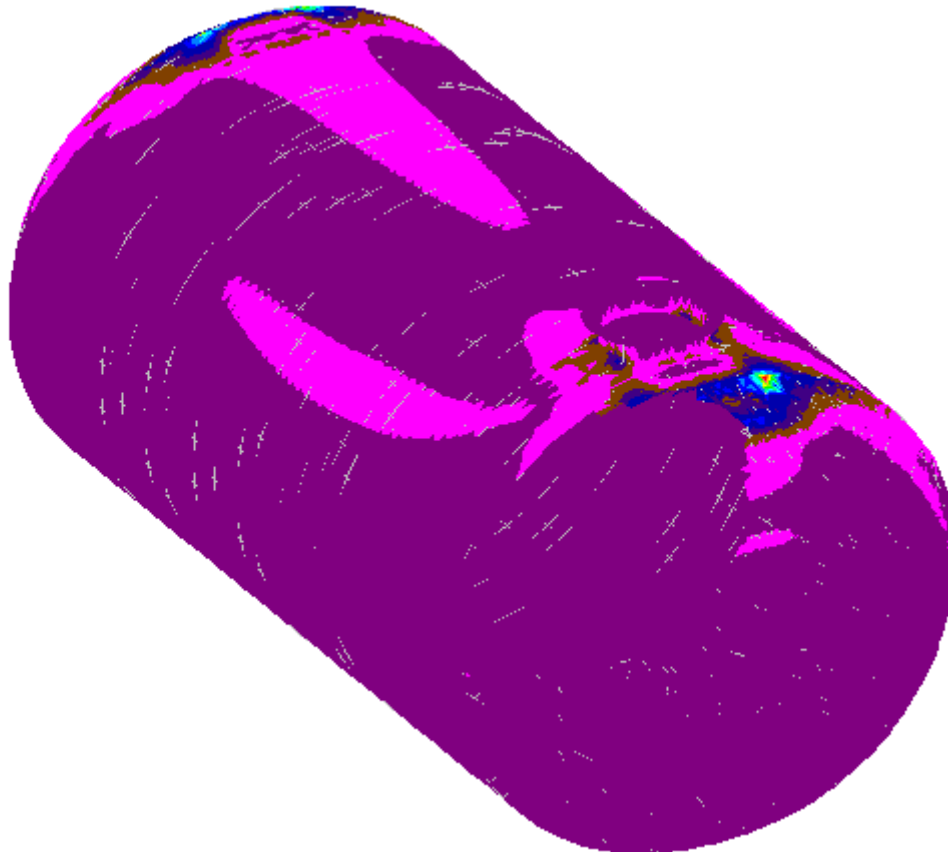
Isometric View of Von Mises Stresses

Max Von Mis
psi
<= 168
1129
2090
3052
4013
4974
5935
6896
7858
8819
9780
10.7 E3
11.7 E3
12.7 E3
13.6 E3
14.6 E3
>= 15.5 E3

Load 1

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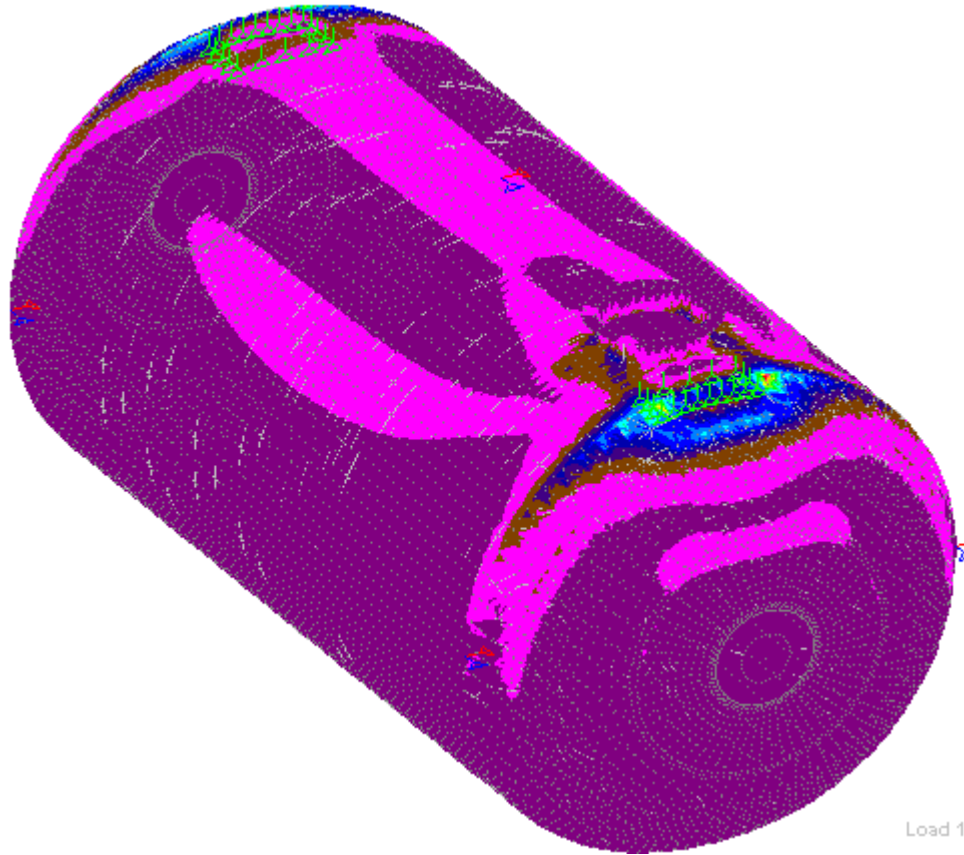
Checking the model using an impact factor of 1.5 on the loaded weight results in a maximum plate stress of 26.1 ksi at the corners of the lift bracket plate.

Max Absolute
psi

	<= 223
	1843
	3462
	5082
	6702
	8322
	9941
	11.6 E3
	13.2 E3
	14.8 E3
	16.4 E3
	18 E3
	19.7 E3
	21.3 E3
	22.9 E3
	24.5 E3
	>= 26.1 E3
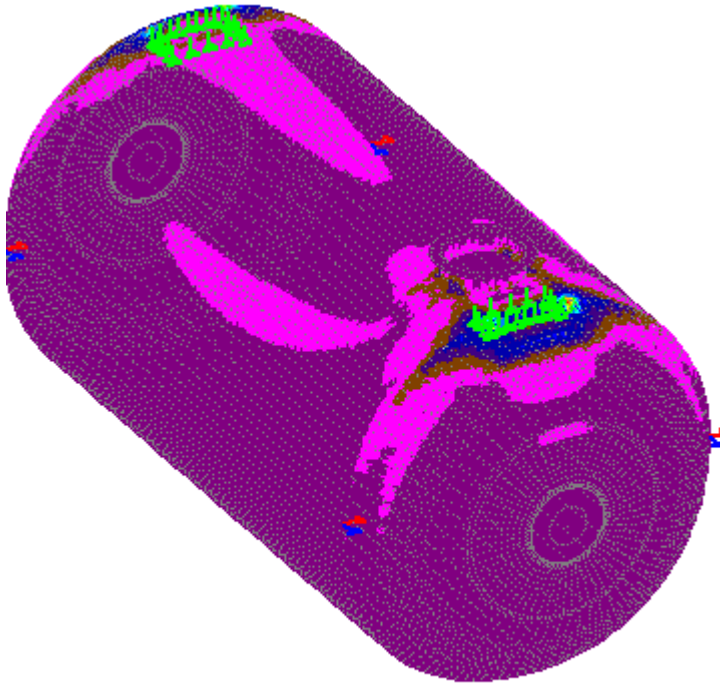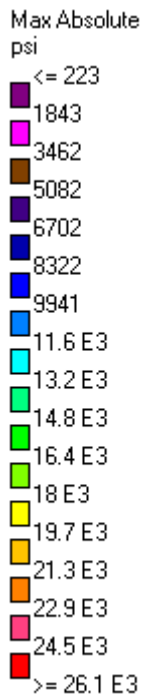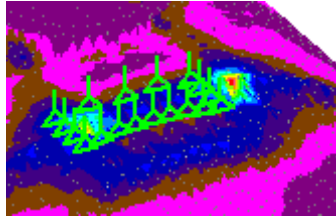
These results show that even with an impact force due to jerking or dropping of the tank, the stress is still only 87% of yield.

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Tank Support on Cribbing:

Design cribbing to support tanks V-1, 2, 3 on the transport trailer, or in a staging area. Cribbing shall be designed to be used on a surface with a bearing capacity of 3000 psf.. Tanks shall be assumed to be fully loaded with the solidified material (55,500 lb payload). Seismic and wind will be ignored, since the tanks will be tied down while on the trailer.
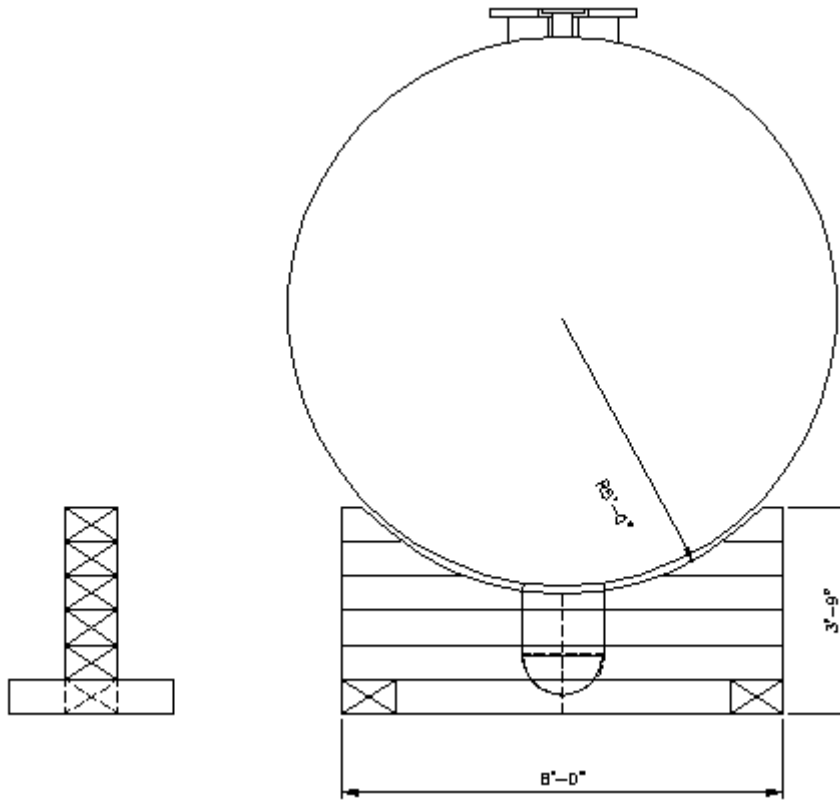
Weights: Tankweight   := 15000 lbf   (rounded up)

solidwaste   := 55500lbf

stageweight := Tankweight + solidwaste   stageweight = 70500 lbf

for miscellaneous tarps, etc, round up to 71,000 lbf

weight   := 71000 lbf

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If 8x12 nominal DF-L (N) timbers are used and the length of each saddle is limited to 8' due to the maximum trailer width.
The actual dimensions for 8x12 timber is: 7.5" x 11.5"

The bearing area for a single saddle, 8' long and neglecting outriggers is: $11.5\text{in} \cdot 8\text{ft} = 7.667 \,\text{ft}^2$

Number of saddles required for 3000 psf bearing area: $7.667\text{ft}^2 \cdot 3000\text{psf} = 23001$ lbf

$\dfrac{71000\text{lbf}}{23001\text{lbf}} = 3.087$ or three saddles required if evenly distributed.

center timber would however see 5/8 of the load: $71000\,\text{lbf} \cdot \dfrac{5}{8} = 44375$ lbf

$\dfrac{44375\text{lbf}}{7.667\text{ft}^2} = 5787.792\,\text{psf}$ which would exceed the 3000 psf bearing capacity

therefore, use four supports for overall stability and load variations.

if a 14ft dimension is assumed as an overall length and even spacing then:

$w := \dfrac{71000\text{lbf}}{14\text{ft}}$ $\dfrac{14\text{ft}}{3} = 4.667$ ft

end support load: $R1 := \dfrac{4 \cdot w \cdot 4.667\text{ft}}{10}$ $R1 = 9467.343$ lbf

interior supports: $R2 := \dfrac{11 \cdot w \cdot 4.667\text{ft}}{10}$ $R2 = 26035.193$ lbf

$\dfrac{R2}{7.667\text{ft}^2} = 3395.747\,\text{psf}$ although over the 3000 psf, the outrigger skid beams were neglected and would reduce the bearing load. ok

Timber capacities: Douglas fir Larch North has a bearing compression design values of 625 psi for compression perpendicular to the grain.

arc length supporting tanks approximately 8.166 ft from autocad model:

$fc := 625\text{psi}$ allowable load per foot $625\text{psi} \cdot 7.5\text{in} \cdot 12\text{in} = 56250\text{lbf}$

Bearing Surface Area: $7.5\text{in} \cdot 8.166\text{ft} = 5.104\,\text{ft}^2$

for 2 saddles: $71000\dfrac{\text{lbf}}{2} = 35500\text{lbf}$ $Fc := \dfrac{35500\text{lbf}}{5.104\text{ft}^2}$ $Fc = 48.301$ psi

Ok timbers will not crush. Use 4 saddles per tank.

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Cribbing Saddle connections:

8'-2" BEARING ARC

3'-9"

7 1/2"

8'-0"
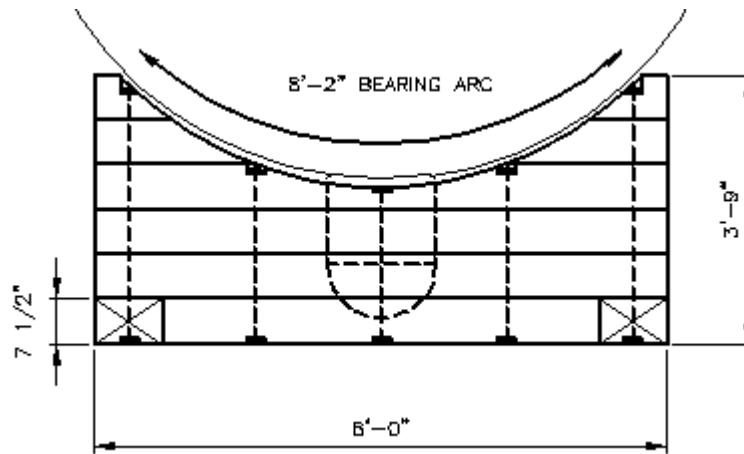
If five (5) 3/4 inch A36 threaded rods are used to tie the 8x12 timbers together, the total shearing strength of the assembly would be:

AISC Table 1-D for A307 rod, 3/4-inch $\qquad$ $Fv := 4400 \, lbf$ $\qquad$ $5 \cdot Fv = 22000 \, lbf$ $\qquad$ per saddle

The lateral force requirement for cargo securement systems of 49 CFR 393.102 is 0.5g and for forward or rearward is 0.8 g's. The tanks will be secured with tiedowns, but check shear capability of saddles only

Forward: $\qquad$ $\dfrac{R2 \cdot .8}{2} = 10414.077 \, lbf$

lateral: $\qquad$ $\dfrac{R2 \cdot .5}{2} = 6508.798 \, lbf$ $\qquad$ per saddle < 22,000 lbf ok

bolts are capable of resisting shear.

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Shear Between timbers due to radial loading

for 4 saddles: the interior saddles reactions: $R2 = 26035.193 \text{ lbf}$

the radial dimension of the bearing area determined from autocad model: $Lr := 8.166 \text{ ft}$ $\dfrac{R2}{Lr} = 3188.243 \text{ plf}$

horizontal shear component, worst angle at approx 50 degrees near top of saddle. This angle drops significantly towards the bottom of the tank.

$v := \cos(39\deg) \cdot 3188 \text{plf}$ $v = 2477.541 \text{ plf}$ vertical component: $y := \sin(39\deg) \cdot 3188 \text{plf}$
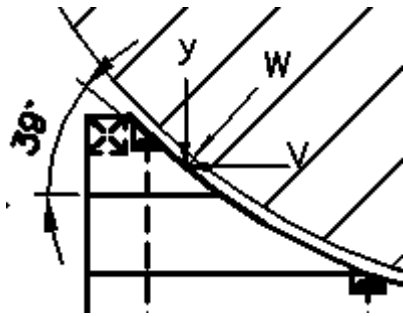
$y = 2006.273 \text{ plf}$

friction coef for wood: .35 (Modern College Physics, 6th ed H.E. White pg 118)

friction force: between timbers $0.35 \cdot y = 702.196 \text{ plf}$
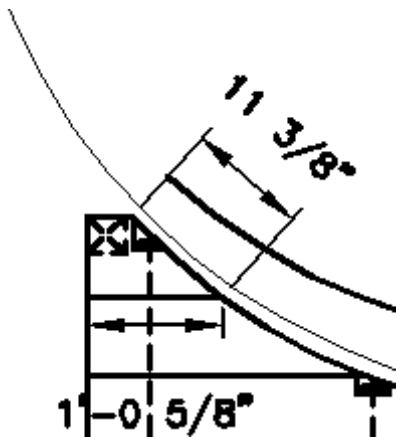
At top timber:

total lateral force: $v \cdot 11.375 \text{in} = 2348.503 \text{lbf}$

friction resistance: $855 \text{plf} \cdot 1 \text{ft} = 855 \text{ lbf}$

rod shear strength: 4.4 kips

       ok

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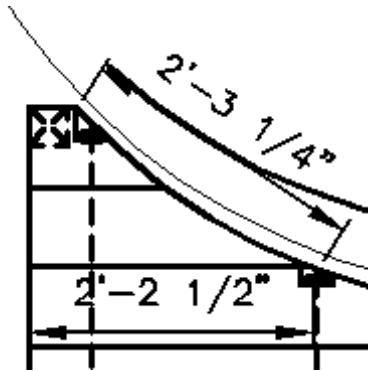
second section:

lateral force: $v \cdot 2.25 \text{ft} = 5574.468\,\text{lbf}$

friction: $855 \text{plf} \cdot 2.25 \text{ft} = 1923.75 \text{lbf}$

net $:= 4611 \text{lbf} - 1924 \text{lbf}$ net $= 2687$ lbf

rod shear strength 4.4 kips ok

conservative since horizontal angle is reduced to approximately 30 deg, but worst case load is assumed.

Lateral Bracing
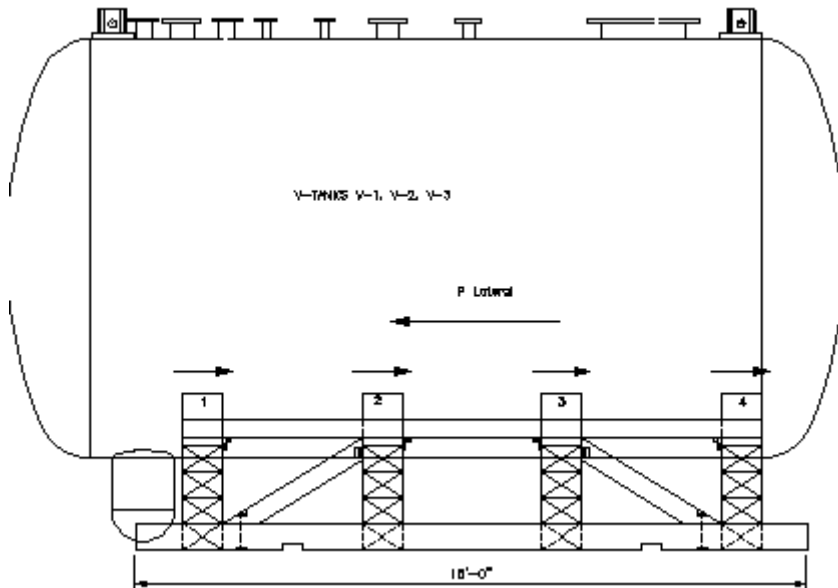
Lateral Force: if the 0.8g force due to truck accelleration/stopping is assumed then the lateral force would be:

$\text{Plat} := 71000 \text{lbf} \cdot 0.8$ $\text{Plat} = 56800$ lbf

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If only the braces in compression are use, then two braces would resist this load

$\text{Fbrace} := \text{Plat} \cdot \cos(32\text{deg})$

$\text{Fbrace} = 48169.132 \text{ lbf}$

for two braces: $\dfrac{\text{Fbrace}}{2} = 24084.566 \text{lbf}$
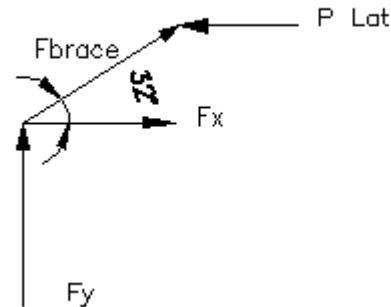
Check Brace Using StruCalc 6.0 and 24.1 kips

```
Column[ 2000 International Building Code (97 NDS) ] ver: 6.00.7
By: Pat Bragassa , Bechtel BWXT Idaho on: 03-23-2005 : 10:29:20 AM
Project: Vtank Cribbing - Location:
Summary:
    5.5 IN x 5.5 IN x 2.83 FT / #2 - Douglas Fir-Larch (North) - Dry Use
    Section Adequate By: 12.7%
Vertical Reactions:
    Live:                           Vert-LL-Rxn=   24083  LB
    Dead:                           Vert-DL-Rxn=      24  LB
    Total:                          Vert-TL-Rxn=   24107  LB
Axial Loads:
    Live Loads:                              PL=   24083  LB
    Dead Loads:                              PD=       0  LB
    Column Self weight:                     CSW=      24  LB
    Total Loads:                             PT=   24107  LB
    Eccentricity (X-X Axis):                 ex=    0.00  IN
    Eccentricity (Y-Y Axis):                 ey=    0.00  IN
    Axial Duration Factor:             Cd-Axial=    1.33
Column Data:
    Length:                                   L=    2.83  FT
    Maximum Unbraced Length (X-X Axis):      Lx=    2.83  FT
    Maximum Unbraced Length (Y-Y Axis):      Ly=    2.83  FT
    Column End Condition:                    Ke=     1.0
Calculated Properties:
    Column Section (X-X Axis):               dx=    5.50  IN
    Column Section (Y-Y Axis):               dy=    5.50  IN
    Area:                                     A=   30.25  IN2
    Section Modulus (X-X Axis):              Sx=   27.73  IN3
    Section Modulus (Y-Y Axis):              Sy=   27.73  IN3
    Slenderness Ratio:                  Lex/dx=    6.17
                                        Ley/dy=     6.2
Properties For: #2- Douglas Fir-Larch (North)
    Compressive Stress:                      Fc=     700  PSI
    Modulus of Elasticity:                    E= 1300000  PSI
    Bending Stress (X-X Axis):              Fbx=     725  PSI
    Bending Stress (Y-Y Axis):              Fby=     725  PSI
Adjusted Properties:
    Fc':                                    Fc'=     913  PSI
        Adjustment Factors: Cd=1.33 Cp=0.98
Column Calculations (Controlling Case Only):
    Controlling Load Case: Axial Total Load Only (L + D)
    Compressive Stress:                      fc=     797  PSI
    Allowable Compressive Stress:           Fc'=     913  PSI
```

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Use a 6x6 DFL timber for brace: Allowable stress = 913 psi, actual = 797 psi ok.

for 3/4 inch A307 rod, and since this is an impact force, use ultimate strength:

$Ult := 58ksi$ $Arearod := \pi \cdot \left[(.375in)^2\right]$ $Arearod = 0.442in^2$

$Vult := 0.442in^2 \cdot 58ksi$ $Vult = 25636\ lbf$

shear at base will be resisted by two 3/4-in rods, one through the brace and one through the saddle.

shear per rod: $24084\dfrac{lbf}{2} = 12042\ lbf$

stress per rod: $\dfrac{12042\,lbf}{Arearod} = 27.258\ ksi$

less than yield stress, ok
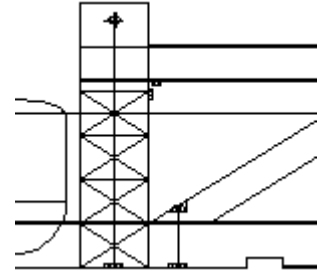
Bearing on timbers: Ref ANSI/NFPA NDS National Design Standard, Section 8.2 single shear conections and considering the 8x12 skid. The diagonal brace will transfer the shear to the saddle and skid by contact bearing even if the brace bolt fails.

Table 8A Dowel Bearing Strength: for bearing strnegth paralle to grain for DFL-n, fe=5500 psi

Equation 8.2.1 for yield mode Im (bearing dominate yield of wood fibers)

$Z := \dfrac{D \cdot tm \cdot \textcolor{red}{Fem}}{4 \cdot K}$ $D := .75in$ (bolt diam) $tm := 7.5\ in$ (thickness of 8x12)

$Fem := 5500\ psi$ (dowel bearing strength)

$K := 1$ (no angle through skid)

$Z := \dfrac{D \cdot tm \cdot Fem}{4 \cdot K}$ $Z = 7734.375\ lbf$ (allowable shear values)

If an additional 2 bolts are added, then 4 bolts will resist the shear:

$\dfrac{24084\,lbf}{4} = 6021\ lbf$ ok < Z = 7734 lbf

add 2 bolts and block to the opposite side of saddle to resist shear.

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Brace Connection:
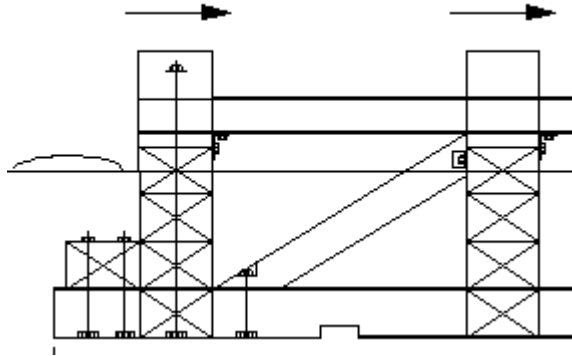
Cribbing Lifting Plan: Design cribbing to be lifted as an assembly: Top horizintal braces (4x6) will be used and rigging can be choked around for ease. Since the top brace is continuous through each saddle and tied with the rods, asembly should act togther.

Cribbing assembly weight

cribbing weight: 8x12 df-L timbers from NDS Supplement, weight approx 21 plf

$(8\text{ft} \cdot 4 + 6\text{ft}) \cdot 21\text{plf} = 798\,\text{lbf}$ per saddle

for 4 saddles: $800\,\text{lbf} \cdot 4 = 3200\,\text{lbf}$ Skids: $16\text{ft} \cdot 21\text{plf} \cdot 2 = 672\text{lbf}$

$\text{cribwt} := 672\text{lbf} + 3200\text{lbf}$ $\text{cribwt} = 3872\,\text{lbf}$

round to 4000 lbf $\text{crib} := 4000\,\text{lbf}$

each side beam will carry 1/2
the load or 2000 lbf

$w := 2000\,\dfrac{\text{lbf}}{14\text{ft}}$

$w = 142.857\,\text{plf}$

2000 lbs / 14 ft = 143 plf

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Analyzing the 4x6's using StruCalc 6.0

```
Multi-Loaded Beam[ 2000 International Building Code (97 NDS) ]
Ver: 6.00.7
By: Pat Bragassa , Bechtel BWXT Idaho on: 03-23-2005 : 12:40:41 AM
Project:  - Location:
Summary:
     3.5 IN x 5.5 IN x 14.0 FT (4 + 6 + 4) / Select Structural -
Douglas Fir-Larch (North) - Dry Use
     Section Adequate By: 3.6%   Controlling Factor: Moment of Inertia



   Left Cantilever Loading:
   Uniform Load:
       Live Load:                          wL-1=    143  PLF
       Dead Load:                          wD-1=      0  PLF
       Beam Self Weight:                    BSW=      5  PLF
       Total Load:                         wT-1=    148  PLF
   Center Span Loading:
   Uniform Load:
       Live Load:                          wL-2=      0  PLF
       Dead Load:                          wD-2=      0  PLF
       Beam Self Weight:                    BSW=      5  PLF
       Total Load:                         wT-2=      5  PLF
   Right Cantilever Loading:
   Uniform Load:
       Live Load:                          wL-3=      0  PLF
       Dead Load:                          wD-3=      0  PLF
       Beam Self Weight:                    BSW=      5  PLF
       Total Load:                         wT-3=      5  PLF
   Properties For: Select Structural- Douglas Fir-Larch (North)
       Bending Stress:                       Fb=   1350  PSI
       Shear Stress:                         Fv=     95  PSI
       Modulus of Elasticity:                 E= 1900000 PSI
       Stress Perpendicular to Grain:    Fc_perp=    625  PSI
   Adjusted Properties
       Fb' (Compression Face in Tension):    Fb'=   2174  PSI
           Adjustment Factors: Cd=1.25 Cl=0.99 Cf=1.30
       Fv':                                  Fv'=    119  PSI
           Adjustment Factors: Cd=1.25

Comparisons With Required Sections:
     Section Modulus (Moment):            Sreq=    6.52  IN3
                                             S=   17.65  IN3
     Area (Shear):                        Areq=    6.64  IN2
                                             A=   19.25  IN2
     Moment of Inertia (Deflection):      Ireq=   46.82  IN4
                                             I=   48.53  IN4
```
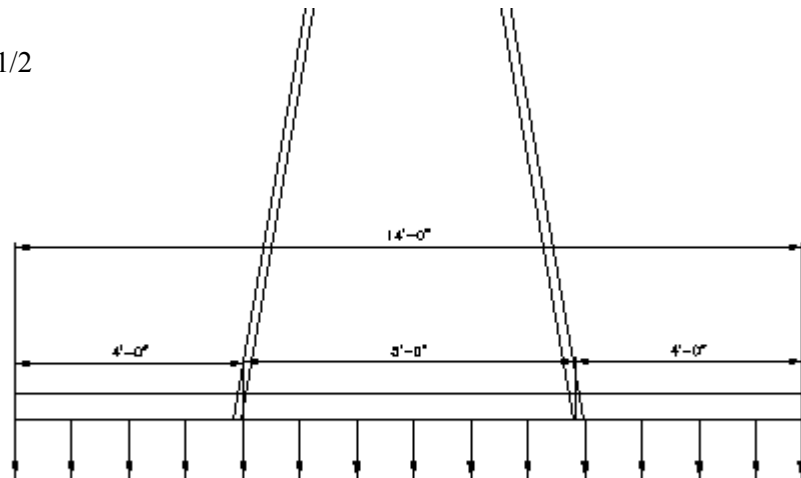
Therefore 4x6 beams are ok for lifting.

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Rigging: Use 4 endless slings and choke around 4x6s at the tow center saddles.

select each choker to support 1/2 the total load.
(2000 lbf)

for a min sling angle of 60 deg:

$$ten := \frac{2000 lbf}{\sin(60 deg)}$$

$$ten = 2309.40 \, llbf$$
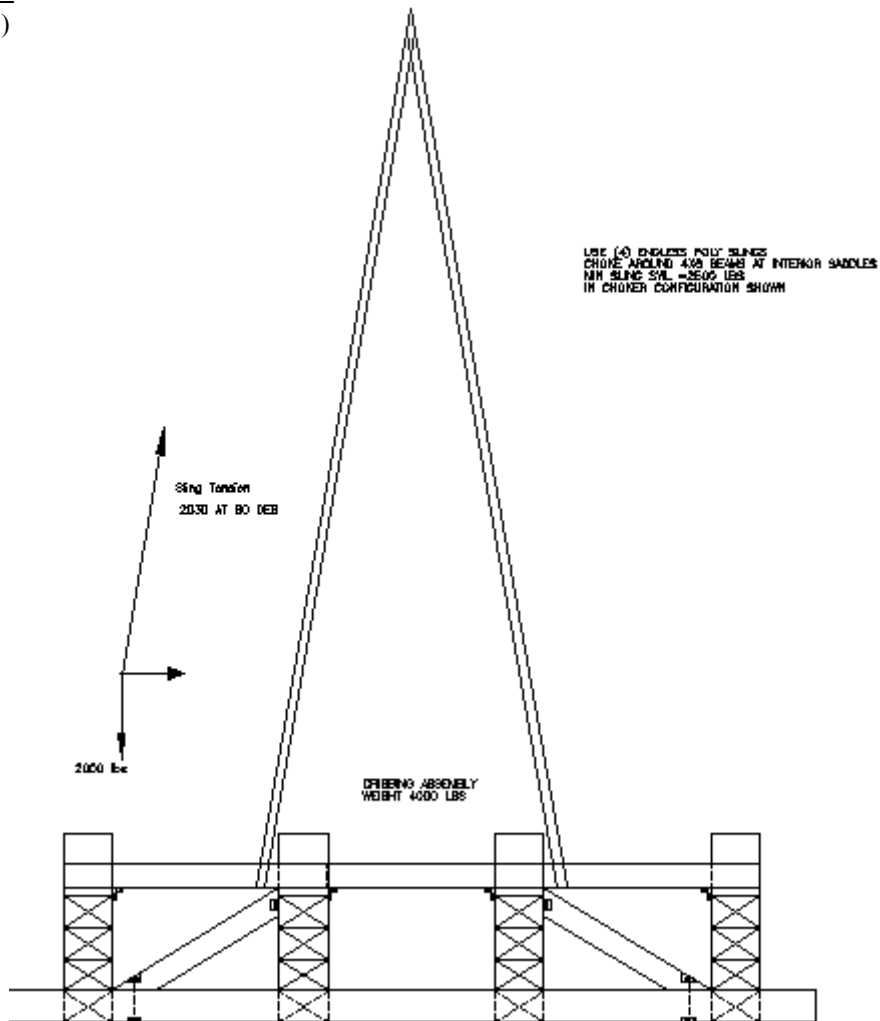
therefore use 2500 lb slings

for a sling angle of 80deg:

$$ten := \frac{2000 \, lbf}{\sin(80 deg)}$$

$$ten = 2030.853 \, lbf$$

use 2500 lb slings
and angle is not
critical.

USE (4) ENDLESS POLY SLINGS
CHOKE AROUND 4X8 BEAMS AT INTERIOR SADDLES
MIN SLING SVL ~2500 LBS
IN CHOKER CONFIGURATION SHOWN

Sling Tension
2030 AT 80 DEG

2000 lbf

DRIBBING ASSEMBLY
WEIGHT 4000 LBS

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Crane Verification:

Since the weight of the empty V-tanks has increased due to the fact that the original design assumed 1/4-in steel was used and it has been verified in the field that the actual thickness is 1/2-inch, the crane used to make the initial lifts from the excavation must be re-investigated.

Tank calculated weight with 1/2" thickness: $\quad$ weight1 := 15000lbf

Check the capacity of the INEEL Grove 9120 Mobile Crane:

using the weight of the tank at 15,000 lbf and 6000 lbf of dry solidification agent
the total payload is 21,000 lbf

Crane Load Data:

```
   CRANE  LOAD  CAPACITY  NOTES:

CRANE:  GROVE TM 9120
BOOM: 130.0' MAIN BOOM (JIB STOWED)
COUNTER WEIGHTS: 30,000 LBS
OUTRIGGERS: 100% DEPLOYED
LOAD CAPACITIES BASED ON 360° OF ROTATION
   LOADS:
      130 TON HOOK BLOCK      =   3483 LBS
      15 TON HEADACHE BALL     =    803 LBS
      WIRE ROPE               =    300 LBS
      RIGGING AND MISC.        =   1500 LBS
         TOTAL ADDED LOADS    =   6086 LBS
      RETRACTABLE JIB          =   1154 LBS
         TOTAL ADDITIONAL LOADS  =   7240 LBS
```

grossweight := 15000lbf + 7240lbf + 6000lbf $\qquad$ grossweight = 28240 lbf

ROUND TOTAL WEIGHT TO 28,400 LBS.

ESTIMATED CRANE CONFIGURATION AND CAPACITIES TABLE							
	TANK	ESTIMATED REACH RADIUS (FT)	BOOM ANGLE	BOOM LENGTH (FT)	CAPACITY (LBS)	EMPTY TANK WEIGHT (LBS)	TOTAL LIFTED LOAD (LBS)
LIFTING TANKS FROM EXCAVATION	V-3	60	63.5°	130	24,450	15,000	28,400
	V-2	70	58.5°	130	20,850	15,000	28,400
	V-1	80	52.5°	130	17,650	15,000	28,400
	V-9	90	48.5°	130	13,900	2200	9,440
SETTING TANKS ON TRANSPORTER	TOTAL LIFTED LOAD INCLUDES THE WEIGHT OF EMPTY TANK PLUS THE RIGGING AND 6000 LBS OF SOLIDIFICATION AGENT						

Total lifted load: 28,400 lbs > capacity of 24,450 lbs

The table above indicates that the Grove 9120 cannot be used to make the picks. if the solidification agent is not added in the excavation only V-3 could be lifted empty with the 9120.
Therefore a larger crane will be used.

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The crane to be used for lifting will be assumed to be the Grove GMK 6220, owned by Mullen Crane and Transport. This crane is a mobile, all-terrain crane used recently for the TAN-725 Stack Demolition.

Crane Load Data Provided by Mullen Crane: Note Spreader beam weight is for Mullen Provided beam and is a maximum weight.

CRANE LOAD CAPACITY NOTES:

CRANE: GROVE GMK 6220

BOOM: 197-ft

COUNTER WEIGHTS: 94,700 LBS

OUTRIGGERS: 100% DEPLOYED

LOAD CAPACITIES BASED ON 360° OF ROTATION

LOADS:

HOOK BLOCK	=	2140	LBS
LOAD FALL	=	1260	LBS
SPREADER BAR	=	4160	LBS
RIGGING AND MISC.	=	140	LBS
TOTAL ADDED LOADS	=	7700	LBS

$totalload := 15000lbf + 7700lbf + 6000lbf$

$totalload = 28700 \; lbf$

The load chart below indicates that at the 60-ft, 70-ft and 80-ft radii, the GMK 6220 crane has suffcient capacity.

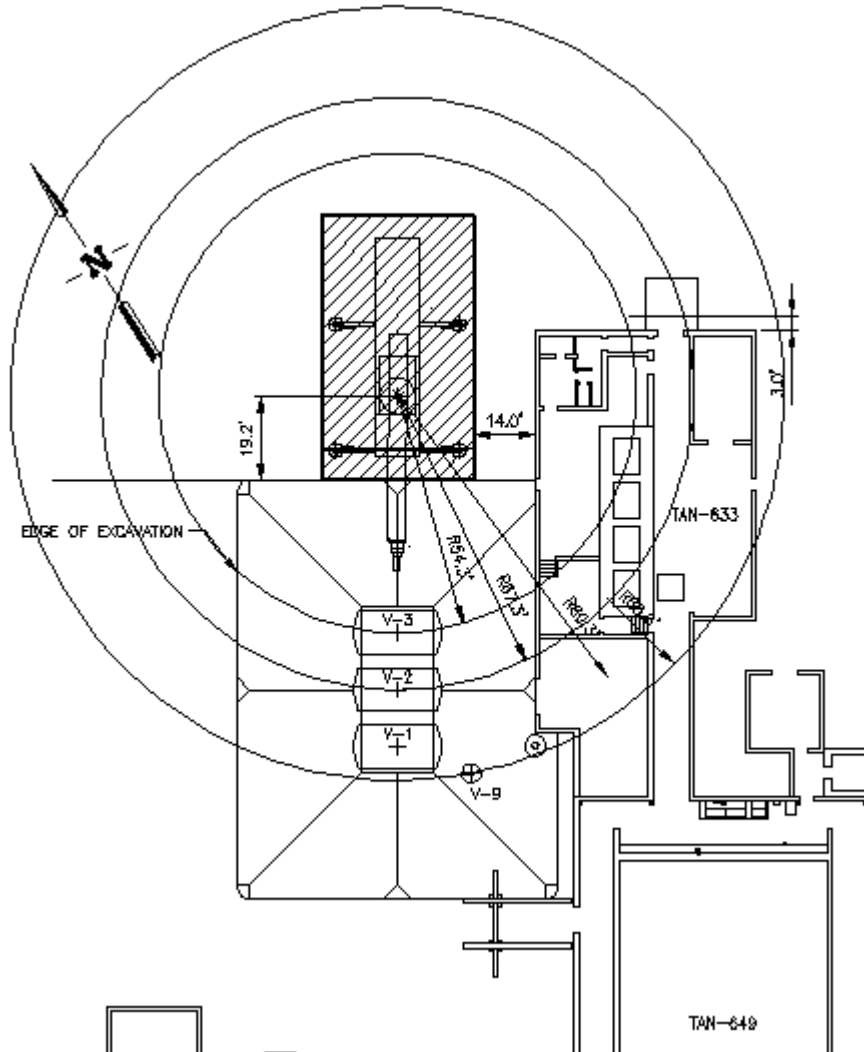From Load Charts for GMK 6220 Crane

Grove GMK 6220 Capacity Chart

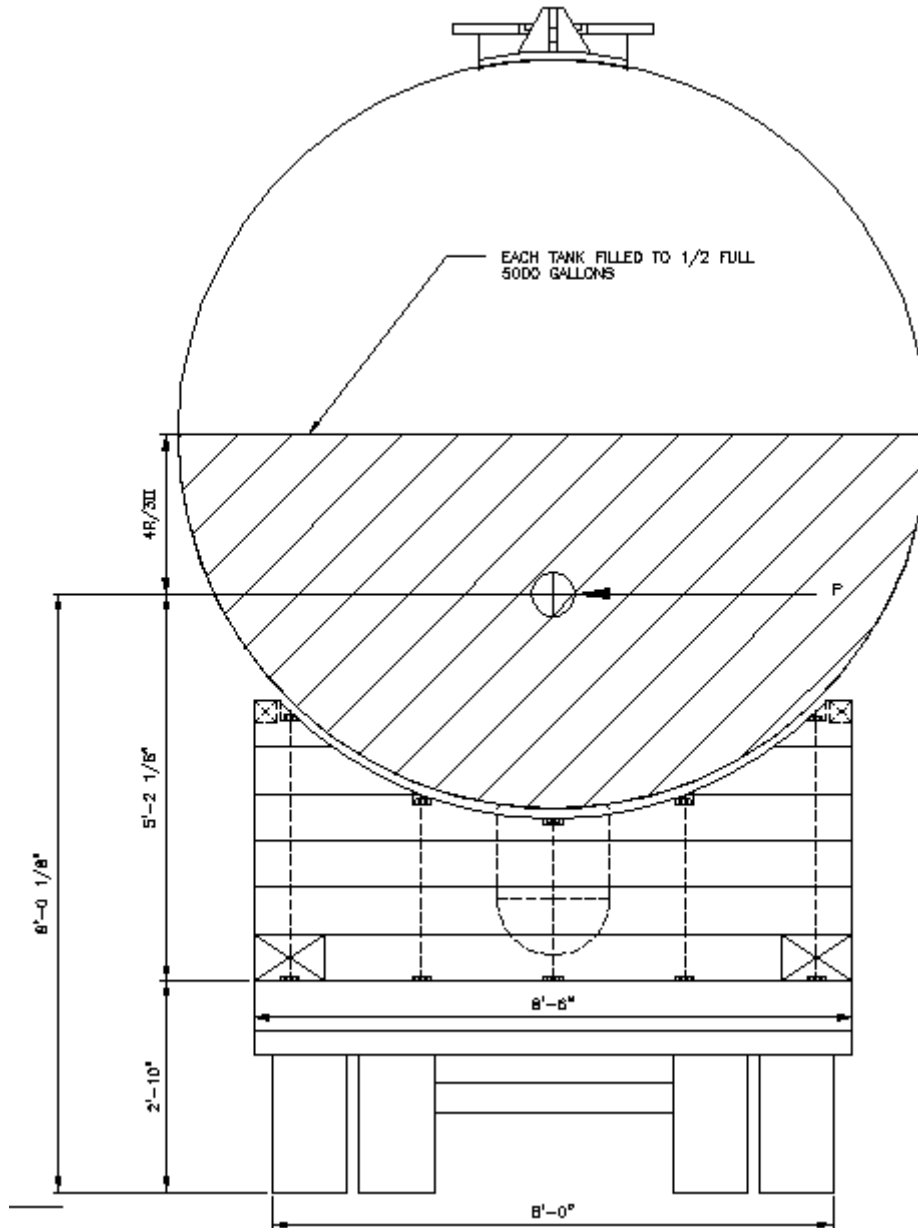| ESTIMATED CRANE CONFIGURATION AND CAPACITIES TABLE							
	TANK	ESTIMATED REACH RADIUS (FT)	BOOM LENGTH (FT) **	CAPACITY (LBS)	EMPTY TANK WEIGHT	TOTAL LIFTED LOAD (LBS)	
LIFTING TANKS FROM EXCAVATION	V-3	60	105	64,000	15000	28,700	44%
	V-2	70	105	51,000	15000	28,700	56%
	V-1	80	105	41,000	15000	28,700	70%
	V-9	90	136	30,400	2200	5,740 *	19%

*ASSUME SPREADER BAR NOT REQUIRED

TOTAL LIFTED LOAD INCLUDES TANK PLUS 6000 LBS SOLIDIFICATION AGENT AND RIGGING

The Grove GMK 6220 crane can safely lift the V-tanks from the current crane pad and with up to 6,000 lbs of added weight from solidification agent.

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GMK 6220 Crane Site Plan

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Check Stability of Transport Trailer:

EACH TANK FILLED TO 1/2 FULL
5000 GALLONS

$4R/3\pi$

$5'-2\ 1/8"$

$8'-0\ 1/8"$

$2'-10"$

$8'-6"$

$8'-0"$

Vertical Forces:

$\text{Tankdead} := 15000\,\text{lbf}$ Tank contents: $\text{contents} := 55000\,\text{lbf}$ (assume heaviest load)

cribbing weight: 8x12 df-L timbers from NDS Supplement, weight approx 21 plf

$(8\text{ft}\cdot 4 + 6\text{ft})\cdot 21\text{plf} = 798\,\text{lbf}$ per saddle

for 4 saddles: $800\,\text{lbf}\cdot 4 = 3200\,\text{lbf}$ Skids: $16\text{ft}\cdot 21\text{plf}\cdot 2 = 672\,\text{lbf}$

$\text{cribwt} := 672\,\text{lbf} + 3200\,\text{lbf}$ $\text{cribwt} = 3872\,\text{lbf}$

$\text{Trailerwt} := 15200\,\text{lbf}$ (from D. Petersen, P&T)

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Vertical Load total: $Vert := Tankdead + contents + cribwt + Trailerwt$

$Vert = 89072 lbf$

resisting moment: $Rm := Vert \cdot 4ft$ $Rm = 356.288 \ kip \cdot ft$

determine the maximum accelleration that the trailer can withstand without tipping.

$Tankdead + contents = 70000 lbf$

$P := 70000 lbf$ $P = 70000 \ lbf$

If this lateral force is applied at the centroid of the volume:

moment arm would be equal to 10-ft

Over turning Moment: $Om := P \cdot 10ft$ $Om = 700 kip \cdot ft$

$$FS := \frac{Rm}{Om}$$

the maximum lateral accelleration for a factor of safety of 1.5 to 1 is:

$$Ommax := \frac{Rm}{1.5}$$ $Ommax = 237.525 kip \cdot ft$

$Ommax = 70,000 \ lbf \ x \ g \ x \ 10ft$

$$gmax := \frac{Ommax}{70kip \cdot 10ft}$$ $gmax = 0.339$

Speed will be reduced during transport.

Friction mats will be used under cribbing capable of providing
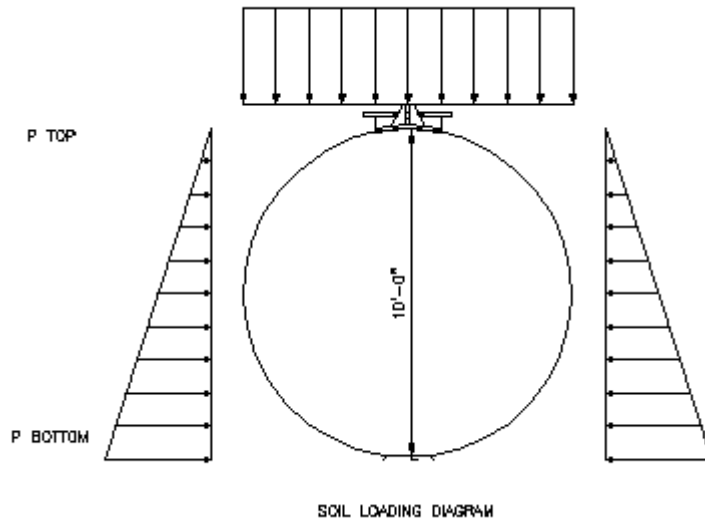frictional forces equal to 0.8 g min.

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Verify Buried Tank Structural Integrity: -Final Disposal at ICDF

Tanks shall be analyzed to verify their structural integrity in the final disposal configuration. Tanks shall be assumed to be bearing on a concrete/grout bed with 30-ft of soil above the top surface of the tank.

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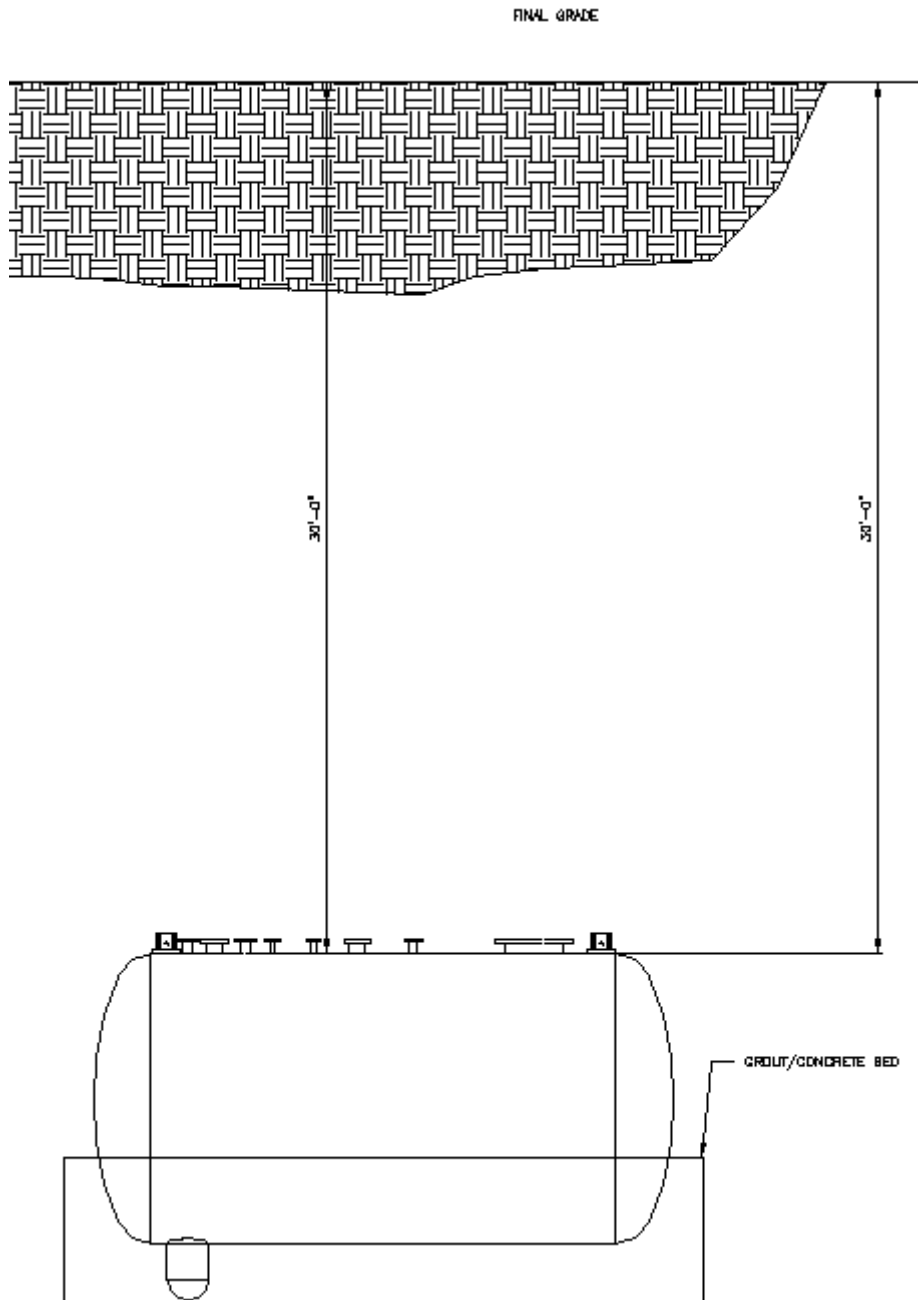
Soil Loading on Tanks:

Assuming "at-rest" soil pressure:

SOIL LOADING DIAGRAM

Using the model created in STAAD.Pro 2004, the soil loads on the tank will be applied using STAAD's hydrostatic pressure function. This function allows varying pressure loads to be applied to plates based on a maximum and minimum pressure. The program automatically calculates the pressure for a specific plate based on its location along the vertical axis.

Assumed Soil Properties: $\phi := 30\text{deg}$ $\gamma := 115\text{pcf}$

$\text{Ko} := 1 - \sin(\phi)$ $\text{Ko} = 0.5$

depth to top of tank = 30-ft
depth to bottom of tank = 40-ft, (neglecting grout bed)

$\sigma\text{bottom} := \text{Ko}\cdot\gamma\cdot40\text{ft}$ $\sigma\text{bottom} = 2300\text{psf}$

$\sigma\text{top} := \text{Ko}\cdot\gamma\cdot30\text{ft}$ $\sigma\text{top} = 1725\text{psf}$

for convenience, the soil loads were averaged for a uniform load application. The soil loads were applied to the STAAD.Pro model using several different applications and the controlling stress used. The soil pressure was applied radially in each plate's local z-axis, and the pressure was applied in the global axis (both z and x) which produced the greatest stresses.

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Soil Loading Stress Analysis Results:
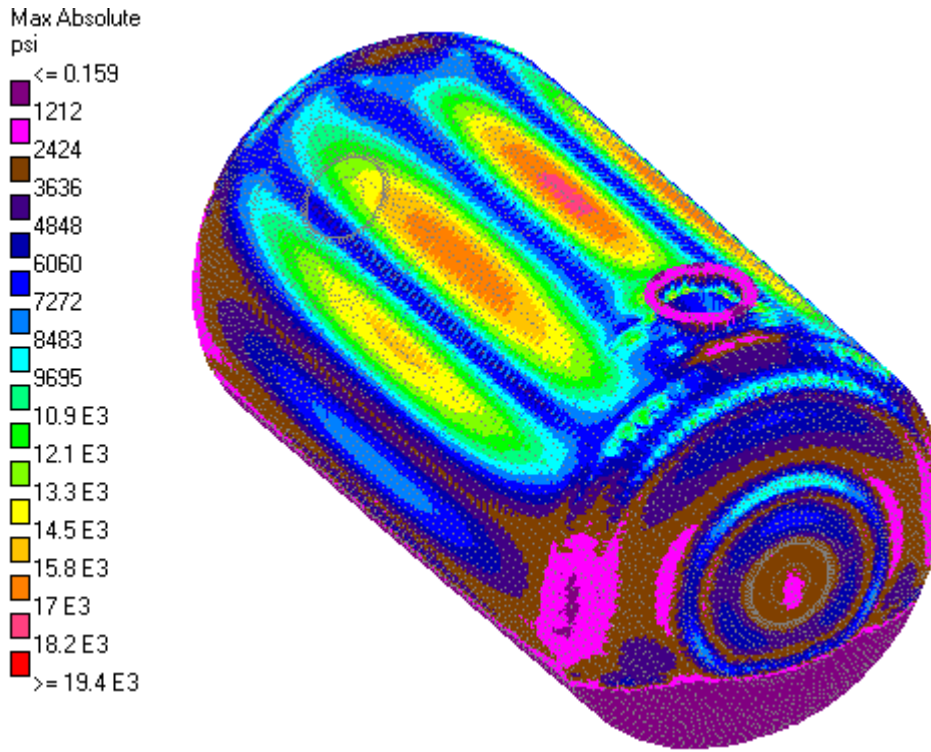
Plate Centre Principal Stress Summary

	Plate	L/C	Principal		Von Mis		Tresca	
			Top (psi)	Bottom (psi)	Top (psi)	Bottom (psi)	Top (psi)	Bottom (psi)
Max (t)	3646	1:LOAD CASE	19.4E 3	4.85E 3	17.6E 3	7.13E 3	14.8E 3	8.18E 3
Max (b)	2048	1:LOAD CASE	9.92E 3	17.2E 3	9.16E 3	15E 3	8.13E 3	10.3E 3
Max VM (t)	3646	1:LOAD CASE	19.4E 3	4.85E 3	17.6E 3	7.13E 3	14.8E 3	8.18E 3
Max VM (b)	16892	1:LOAD CASE	5.99E 3	13.4E 3	5.19E 3	16.9E 3	3.21E 3	19E 3
Tresca (t)	3646	1:LOAD CASE	19.4E 3	4.85E 3	17.6E 3	7.13E 3	14.8E 3	8.18E 3
Tresca (b)	16892	1:LOAD CASE	5.99E 3	13.4E 3	5.19E 3	16.9E 3	3.21E 3	19E 3

The maximum plate stress was found to be 19,400 psi. This analysis assumed an empty tank with no resistance from any contents. The analysis shows that the tanks are capable of being buried 30-ft below grade and the vessels will not yield with a demand capacity ratio of 0.64 based on yielding of the material.