VERTICAL ALUMINUM HYDRAULIC SHORING

TABULATED DATA
Effective December 12, 2015

PSH

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Contents

General Information for Use of Vertical Aluminum Hydraulic Shores

1. The hydraulic aluminum shoring system tabulated here is based on requirements of Federal OSHA 29CFR, Part 1926, Subpart P-Excavations, and Trenches

   1926.652(c)(2)-Option (2) - Designs Using Manufacturer's Tabulated Data.

   1926.652(c)(2)(i) -Design of support systems, shield systems, or other protective systems that are drawn from manufacturer's tabulated data shall be in accordance with all specifications, recommendations, and limitations issued or made by the manufacturer.

   All provisions of Subpart P apply when utilizing this tabulated data. The contractor's competent person shall use this data to select allowable trench depth, vertical and horizontal shore spacing, and plywood use requirements for Pacific Shoring Vertical Hydraulic Shores. The competent person utilizing this tabulated data shall be experienced and knowledgeable of all requirements of Subpart P, and trained in the use and safety procedures for vertical aluminum hydraulic shores.

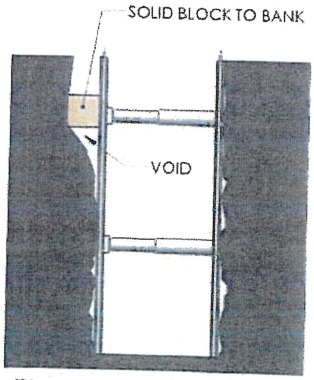


Figure 1: Voids in Excavation, See Note 5

2. Use of this tabulated data is dependent on first classifying the soil in accordance with OSHA Appendix A, Soil Classification. Classification shall be just prior to installing vertical hydraulic shores. Soil conditions may change at a later date and require vertical shores to be reset at a different spacing.
3. Vertical Hydraulic Shores are tabulated based on the effect of a 20,000 lb surcharge load set back 2 ft from the edge of the trench and the equivalent weight effect of the OSHA soil type, see classification of soil types, 2.
4. The depth and spacing given in **Table 1** governs the use of Pacific Shoring vertical shores and not tabulations given in OSHA Appendix C. This tabulated data applies exclusively to hydraulic shores manufactured by Pacific Shoring, LLC. Any alterations to the shores or variance from this tabulated data shall be indicated in a site specific plan prepared and approved by a registered engineer.
5. Faces of excavations shall be vertical and there shall be contact with the soil at each cylinder, see **Figure 1.**
6. Shores shall be set near vertical; however, they may be set as much as 30 degrees from vertical provided that vertical and horizontal spacing is maintained.
7. Vertical hydraulic shores may be stacked or longitudinally lapped, see **Figure 2,** provided shore spacing is maintained.
8. Trenches 2 times the allowable horizontal shore spacing or less shall have a

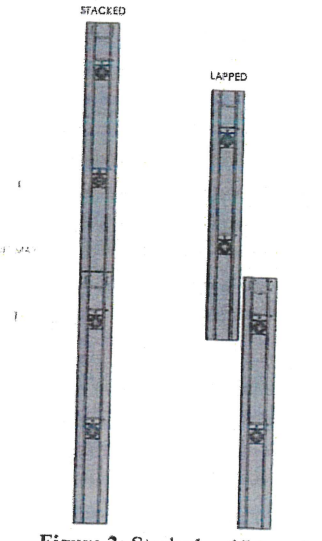


Figure 2: Stacked and Lapped Configurations, see Note 7.

minimum of 2 shores set in accordance with spacing requirements. Trenches greater than 2 times the allowable trench spacing shall have a minimum of 3 shores set at required spacing. See **Figure 3.**

9. Shores shall be installed and removed from outside the trench, see installation and removal procedure.
10. Single cylinder shores may be used in place of multiple cylinder shores provided that horizontal and vertical spacing is maintained.
11. The competent person shall continually monitor the shored excavation for changed conditions such as water seepage, soil movement cracks at the surface, sloughing or raveling, proper surcharge load weight less than 20,000 lbs and setback a minimum of 2 ft, and damaged shores.
12. Workers shall always enter, exit, and work inside the shored area of the trench.
13. Trenches less than 6ft only require one hydraulic shore per vertical plane, provided that it is placed no more than 4ft from the bottom of the excavation, and no more than 2ft below the top of the excavation. Horizontal spacing remains unchanged from the tables.

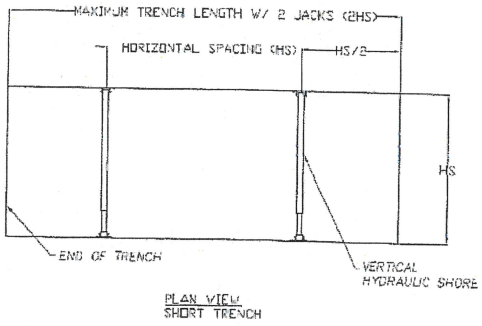


Figure 3: Short Trench, See Note 8.

Description

Vertical Aluminum Hydraulic Shores are constructed from standard duty or heavy duty vertical rails attached to 2" hydraulic cylinders. The rail lengths vary from 18" to 15 ft long. The cylinders can extend from 18" to 88". Cylinder extensions can be added to obtain lengths to 15ft. The hydraulic cylinder consists of a 2" OD piston, a 2" ID x 3/16" barrel, and a 3" OD x 3/16" oversleeve. The cylinders provide a 23,000 lb safe working load for cylinder bulging at a 1.5 factor of safety. At extensions longer than model 88-56, an additional 3" x 3" x 3/16" or 3.5" x 3.5"x 3/16" wall square oversleeve is required to prevent buckling. Based on the principal of soil arching Vertical Aluminum Hydraulic Shores can be spaced horizontally as much as 8 ft apart without sheeting on the trench walls. Plywood sheeting is used either attached or separate behind the rails to prevent the trench walls from sloughing or raveling.

Vertical Aluminum Hydraulic Shores are installed from outside the excavation. The shores are hinged so that they can be folded when lowered into the trench and then opened up and pressurized with a hydraulic hand pump. The hydraulic fluid is water soluble, environmentally safe, and biodegradable. Rails 5 ft long and less can typically be moved, set, and removed by a two man crew. Larger shores are typically handled by backhoe, loader, or boom truck.

Vertical Aluminum Hydraulic Shores are typically used in linear trench applications in OSHA Type A, Type B, and Type C-60 soils at depths to 20 ft and trench widths to 8 ft. Constraints such as the requirement that the bottom cylinder be set a maximum of 4 ft from the bottom of the excavation , bedding requirements, and pipe wall thicknesses limits the pipe diameter or duct height to approximately 36" maximum. The 8 ft maximum horizontal spacing limits pipe length to approximately 8 ft.

Classification of Soil Types

1. Soil classification shall be in accordance with OSHA Appendix A and classified just prior to installing hydraulic vertical shores. Soil conditions may change at a later date and require hydraulic vertical shores to be reset at a different spacing.
2. The equivalent weight of OSHA soil types* is assumed to be as follows:

• OSHA Type "A" Soil	25 PSF per ft of depth
• OSHA Type "B" Soil	45 PSF per ft of depth
• Type "C-60" Soil	60 PSF per ft of depth**
• OSHA Type "C" Soil	80 PSF per ft of depth

* These equivalent weights were adapted from OSHA 1926 Subpart P App C, Timber Shoring for Trenches, Tables C-1.1, C-1.2, and C-1.3

** Type C-60 soil is not identified or classified in OSHA Appendix A

3. Type C-60 soil is soil that does not qualify as OSHA Type A, or Type B, can be cut with vertical walls and will stand up long enough to safely insert and pressurize the hydraulic shore.
4. Hydraulic shores shall not be used in OSHA Type C-80 Soil

Vertical Hydraulic Shore Selection Guide

Table 1 Vertical Hydraulic Shore Selection Guide(1)

Depth of Trench (ft)	Hydraulic Cylinder Requirements(5)					Sheeting(2)
	Maximum Horizontal Spacing (ft)	Maximum Vertical Cylinder Spacing (ft)	Width of Excavation (ft)			
			to 8	8 to 12	12 to 15	
TYPE "A" Soil						
to 10'	8'	4'	2" ID	2" ID	2" ID(6)	(2)
10' to 15'	↓	↓	↓	2" ID	2" ID(6)	(2)
15' to 20'				2" ID(6)	2" ID(6)	(2)
20' to 25'				2" ID(6)	2" ID(6)	(2)
TYPE "B" Soil						
to 10'	8'	4'	2" ID	2" ID	2" ID(6)	(2)
10' to 15'	7'	↓	↓	2" ID	2" ID(6)	(2)
15' to 20'	6'			2" ID(6)	2" ID(6)	(2)
20' to 25'	5'			2" ID(6)	2" ID(6)	(3) (4)
TYPE "C-60" Soil						
to 10'	6'	4'	2" ID	2" ID	2" ID(6)	(2)
10' to 15'	5'	↓	↓	2" ID	2" ID(6)	(3)
15' to 20'	4'			2" ID(6)	2" ID(6)	(3)
20' to 25'	3'			2" ID(6)	NA	(3) (4)

Table 1 Notes

1. Soil shall first be classified in accordance with OSHA Appendix A Soil Classification for use with this selection guide. Type C-60 soil is OSHA Appendix A Type C soil that will stand up long enough to install the hydraulic shores.

2. Sheeting is required at any depth whenever sloughing or raveling occur. If sloughing or raveling occur between sheeting decrease spacing until it is prevented. Sheeting shall be equivalent to plywood described in **Table 2.** Steel plate and sheet piles with equivalent strength are also acceptable. Sheeting may be attached to jack or set into trench separately.

Material	Grade Stress Level	Effective Section Modulus KS	Allowable Bending F_b
1-1/8"-2.4.1 int APA Plywood	S-2	0.840 in^3/ft	1100 psi
Finland Form ¾" All-Birch	S-1	0.4826	3600 psi

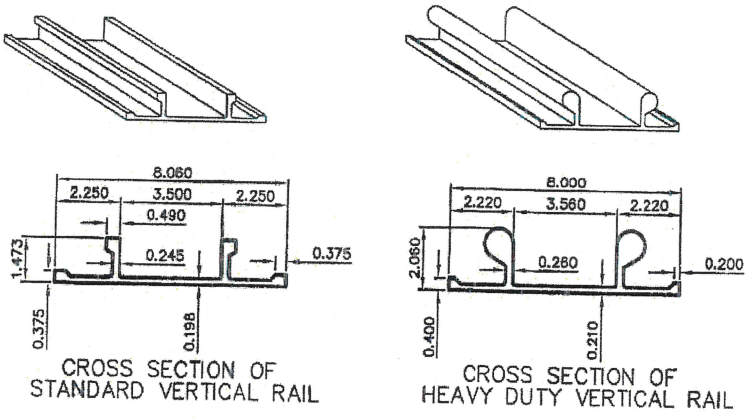
Table 2 Bending properties for OSHA Sheeting

3. Sheeting is required at this depth.
4. Sheeting must extend to the bottom of the excavation.
5. This tabulation includes lateral loading from equipment weighing 20,000 lbs or less and a maximum 2 ft high spoil pile set back a minimum of 2 ft. The competent person shall determine the effect of all other surcharge loads and reduce hydraulic shore spacing as required to resist those loads.
6. Use Pacific Shoring 2" inside diameter hydraulic cylinders with 3" aluminum oversleeves and standard extension system as required for trench width. Oversleeves larger than model 88-56 are steel 3.5"x3.5"x3/16" wall over 3" round standard aluminum pipe or steel 3"x3"x 3/16" full length.

Vertical Rail Specification Sheet

VERTICAL RAIL SPECIFICATION SHEET

SECTION PROPERTIES	STANDARD RAIL	HEAVY DUTY RAIL
MATERIAL	ALUMINUM	ALUMINUM
ALLOY	6061–T6	6061–T6
AREA	2.45 in^2	3.47 in^2
WEIGHT	2.94 plf	4.17 plf
SECTION–MODULUS – TOP (LEG SIDE)	0.44 in^3	1.25 in^3
SECTION–MODULUS – BOTTOM (BLADE SIDE)	1.29 in^3	2.38 in^3
EQUIVALENT TIMBER SIZE * (#2 DOULAS FIR)	3x10 (FLAT)	4x10 (FLAT)



CROSS SECTION OF STANDARD VERTICAL RAIL

CROSS SECTION OF HEAVY DUTY VERTICAL RAIL

Figure 4. Vertical Rail Specifications

Vertical Hydraulic Rail Dimensions

Table 3: Vertical Hydraulic Rail Dimensions

Rail Height (ft)	Cylinder Locations (in)				
1.5'	10.5				
2'	12.5				
3.5'	10.5	36			
4'	11	37			
5'	12	38			
6'	18	44			
7'	18.5	66.5			
8'	24	72			
9'	16	52	88		
10'	22	58	94		
12'	24	72	95	120	
16'	24	72	120	145	168
20'	24	72	120	168	216

Table 3 Notes:

1. Dimensions listed are measured from top of rail to approximate centerline of each cylinder.
2. Spacing between cylinders never exceeds 4ft.
3. Custom rail and cylinder spacing available upon request, however when using them with this tabulated data all spacing requirements of the data shall be met.

Aluminum Hydraulic Shore Installation and Removal Procedure

Required for installation

- Vertical Hydraulic Jack
- Pump with fluid and operating pressure gauge
- Release tool

Installation Procedure

Step 1 Attach hydraulic hose to hydraulic fitting on shore. Open the valve on the pump can so that the shore cannot be pressurized. Set plywood if required and not attached to the shore into trench.

Step 2 Lower shore into trench with folded up blade toward opposite trench wall and hydraulic fitting toward adjacent wall. After the shore is set to elevation hold adjacent blade in place with release tool and let go of opposite blade allowing it to completely unfold and lock into position. In order for the shore to lock into position the cylinder must be 90 degrees from the blade. Heavy or wide shores that cannot be safely lifted by one person should be set in with lifting equipment such as backhoe, boom truck, or crane.

Step 3 Close the valve on the pump can and pressurize the hydraulic shore to between 750 and 1500 psi. Pressure gauge should hold at pressure and not indicate any loss of pressure.

Step 4 Remove the hydraulic hose by prying off with release tool. Clip hose to top of pump to prevent contamination by dragging it in the dirt. Move to next shore location and repeat process.

While trench shores are in place

- Check at least at start of shift for loose shores. This can be done by tapping the top of the shore with a metal rod; it will sound loose, sort of like kicking a tire to see if it is flat. Remove and replace loose shores.
- Check for sloughing or raveling. If it is occurring sheeting must be used.
- Confirm that soil classification has not changed.

Required for Removal

- Vertical Hydraulic Shore
- Release tool
- Removal tool or lifting equipment

Removal Procedure

Step 1 Place release tool over hydraulic fitting and removal hook in handle on opposite blade.

Step 2 Push release tool away to release fluid and pressure. Pull up on the removal hook to fold the shore up and then lift it out of trench.

Note - Depending on the length of the shore and width of the trench different installation procedures may be used. It is the responsibility of the contractor and his competent person to establish a safe installation and removal procedure for each application. All trench shore installers shall be instructed in the procedure prior to installing the shores.

Safe Handling and Use of Trench Shores

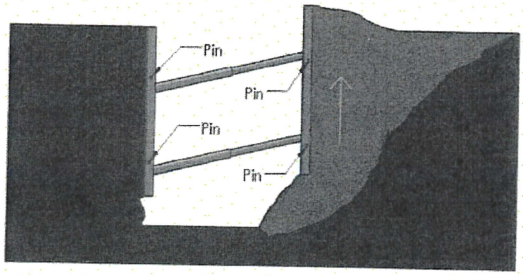
By removing the shoring installer from the unshored trench and making shoring equipment more available and easy to install, trench jacks have no doubt had a huge impact on excavation safety. Utilizing trench jacks for shoring still has safety hazards that users should understand and protect workers from. These things happen rarely however it is still important that workers be informed of the risks they are taking before placing them at risk. The following are hazards and safety procedures associated with the use of trench jacks

- Injury to back and muscles from lifting heavy objects - An 8 ft long 52-88 extension trench jack weighs approximately 120 lbs. A two man crew can safely lift, set, and remove it from the trench. Anything longer or heavier should be lifted and set with equipment such as a backhoe or boom truck.
- Overhead lifting hazard - When jacks are being hoisted by sling from a tractor bucket or boom truck the swinging jack presents a hazard to workers guiding it. Loose plywood and rocks can also fall off onto workers. Workers should stand clear and guide with a lead rope.
- Finger and hand protection - Trench jacks have moving parts at the connection between the cylinder and the rail. When the jack swings open fingers can be crushed under the cylinder block and when it is swung closed fingers can easily be sheared off if they are between the block and the rail leg. When the hydraulic hose is being connected to the block fitting and when the jack is being lifted by hand, shearing and crushing is most likely to happen. Awareness through safety instruction and hand placement a safe distance, 12", from the blocks is safe practice. Trench jacks may have optional finger guards however it is still possible to get fingers under the block and wrists are cut and banged when the jack folds or unfolds.
- Bank collapse with worker standing on it - When the jack is being set it is still possible for the trench wall to collapse from the additional weight and activity going on around it. Trench jack installation should closely follow the excavation activity.

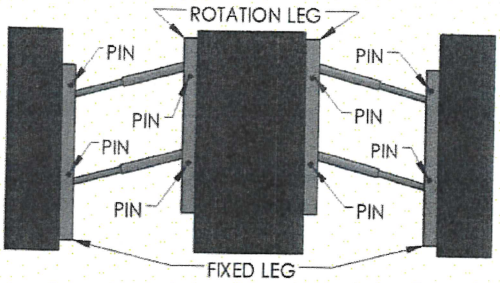
  During jack removal the arch column is being literally removed with the load still on it. Pipe bedding and initial backfill cut the trench depth adding some stability prior to removing the jack. If backfill operations are closely following jack removal the length of unshored collapsible trench wall becomes short. Soil arching back to the backfilled area is likely and trench wall failure becomes less likely. Remote backfill operation such as excavator wheel or vibraplate, or remote operated compactors must always be used for compaction outside the shored area. When trench jacks are being removed to allow pipe installation and then reset there is a greater likelihood of trench wall collapse. Equipment and personnel in close proximity are at risk of losing the ground under their feet. Keep equipment and personnel except those needed to remove the jack a safe distance away. This type of operation is not uncommon and most often works safely, however if there is any evidence of trench wall collapse the operation should be discontinued and a different method of getting production materials into the trench or a different shoring system should be used. Several bad accidents have occurred in conjunction with this type of operation.
- Get the surcharge loads right - Equipment over 20,000 lbs and large spoil piles over 2 ft high quickly add additional surcharges, especially in the top 10 ft, that can easily overload the trench jack. If one cylinder fails, a progressive failure to the bottom of the trench and then down the length of the trench is possible. A boom truck or backhoe outrigger placed next to a trench jack can trigger this. The way to adjust for additional surcharge load is to move the load away from the trench, spread the load with timber pad or steel plate, or decrease the trench jack spacing. Centering the load on the jack places most of the load on that jack. The alternative, centering the load between the jacks distributes the load evenly between the jacks, however it increases the possibility of the arch void to fall out or arch shear failure at the jack. One alternative may not be any better than the other.

- Trench Jack fold up failure - If all of the jacks were unfolded into the trench from one side of the trench it is possible to get a bank failure that can lift the rotating jack leg. This type of failure is not common; however the author has spoken with more than one worker that has fortunately from outside the trench witnessed this type of failure. No workers were inside the trench. The story goes that 40 ft of trench folded up the jacks and collapsed. The solution is to rotate the jack so that the rotation leg is on the other side of the trench. The problem is that the installers have to move to the other side of the trench to set and pressurize the jack. Two soil conditions that this would be most likely to happen are in medium dense to loose non-cohesive soils and soft clays with high surcharge loads.

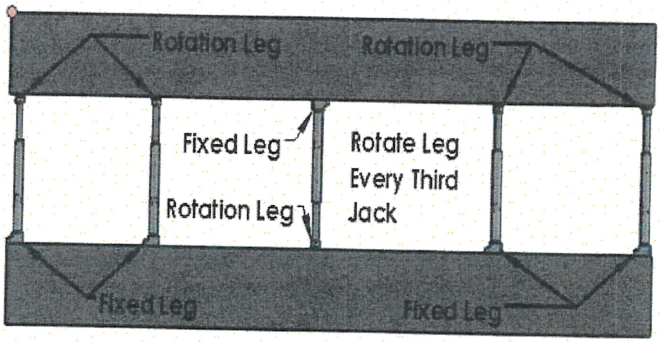
Figure 5:



a) Trench Jack Fold Up Failure



b) Leg Rotation



c) Jack Rotation to Prevent Failure

- Loose trench jacks in the trench - Jacks that are not pressurized in the trench are not setting up arching and preventing trench collapse. In this condition the jacks can also fall down on workers below them. Jacks should not leak at all. Pressure can change slightly up or down due to temperature changes or increase due to loading however it should never loosen up in the ditch. If jacks are left overnight they should be checked before entering the trench in the morning. Simply tap them with a hammer or bar of metal, they will sound loose if they are. Remove and replace jacks that bleed off. If the trench wall has voids where the cylinder hits the wall, use wood blocking to extend the connection to the soil, see **Figure 6** (a)
- Non-vertical trench walls - Trench walls that are not vertical, an inverted A shape, the trench jack is not stable see **Figure 6** (b). Assuming a coefficient of friction of 0.1 between the soil and the aluminum rail and applying a factor of safety of 1.5 calculations indicate that the slope of the trench wall should not exceed 3 degrees or the jack will lift up and fail to provide an arching point.
- In trenches that are sloped above, extending the jack 18" above the hinge point does not provide roll off protection for workers below due to the fact that the jack is spaced. Place fabric or boards behind the jack rail to stop objects at the surface and bank ravel from falling on workers, see **Figure 6** (c)

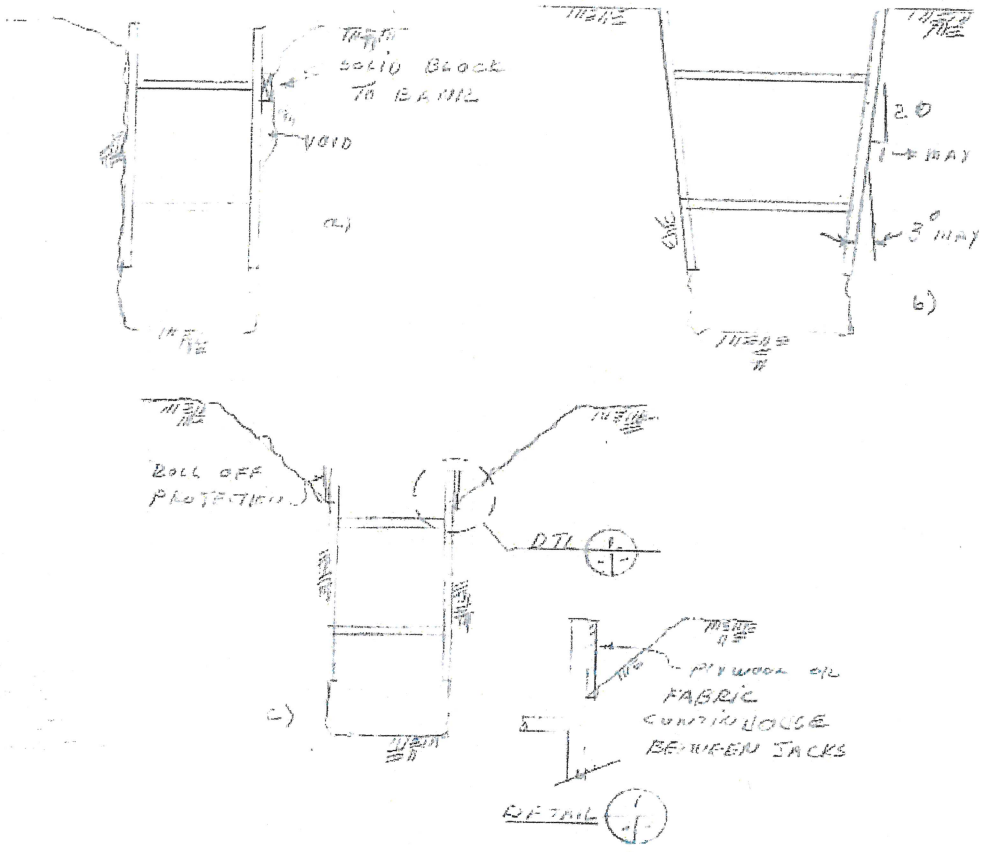


Figure 6: Trench safety issues