unconfined compressive strength of 1.5 tsf can be readily indented by the thumb; however, they can be penetrated by the thumb only with very great effort. Type C soils with an unconfined compressive strength of 0.5 tsf can be easily penetrated several inches by the thumb, and can be molded by light finger pressure. This test should be conducted on an undisturbed soil sample, such as a large clump of spoil, as soon as practicable after excavation to keep to a miminum the effects of exposure to drying influences. If the excavation is later exposed to wetting influences (rain, flooding), the classification of the soil must be changed accordingly.

(iv) *Other strength tests.* Estimates of unconfined compressive strength of soils can also be obtained by use of a pocket penetrometer or by using a hand-operated shearvane.

(v) *Drying test.* The basic purpose of the drying test is to differentiate between cohesive material with fissures, unfissured cohesive material, and granular material. The procedure for the drying test involves drying a sample of soil that is approximately one inch thick (2.54 cm) and six inches (15.24 cm) in diameter until it is thoroughly dry:

[A] If the sample develops cracks as it dries, significant fissures are indicated.

[B] Samples that dry without cracking are to be broken by hand. If considerable force is necessary to break a sample, the soil has significant cohesive material content. The soil can be classified as a unfissured cohesive material and the unconfined compressive strength should be determined.

[C] If a sample breaks easily by hand, it is either a fissured cohesive material or a granular material. To distinguish between the two, pulverize the dried clumps of the sample by hand or by stepping on them. If the clumps do not pulverize easily, the material is cohesive with fissures. If they pulverize easily into very small fragments, the material is granular.

Appendix B to Subpart P of Part 1926 — Sloping and Benching

(a) Scope and application. This appendix contains specifications for sloping and benching when used as methods of protecting employees working in excavations from cave-ins. The requirements of this appendix apply when the design of sloping and benching protective systems is to be performed in accordance with the requirements set forth in §1926.652(b)(2).

(b) Definitions.

Actual slope means the slope to which an excavation face is excavated.

Distress means that the soil is in a condition where a cave-in is imminent or is likely to occur. Distress is evidenced by such phenomena as the development of fissures in the face of or adjacent to an open excavation; the subsidence of the edge of an excavation; the slumping of material from the face or the bulging or heaving of material from the bottom of an excavation; the spalling of material from the face of an excavation; and ravelling, i.e., small amounts of material such as pebbles or little clumps of material suddenly separating from the face of an excavation and trickling or rolling down into the excavation.

Maximum allowable slope means the steepest incline of an excavation face that is acceptable for the most favorable site conditions as protection against cave-ins, and is expressed as the ratio of horizontal distance to vertical rise (H:V).

Short term exposure means a period of time less than or equal to 24 hours that an excavation is open.

(c) Requirements.

(1) *Soil classification.* Soil and rock deposits shall be classified in accordance with appendix A to subpart P of part 1926.

(2) *Maximum allowable slope.* The maximum allowable slope for a soil or rock deposit shall be determined from Table B-1 of this appendix.

(3) *Actual slope.*

(i) *The actual slope shall not be steeper* than the maximum allowable slope.

(ii) *The actual slope shall be less* steep than the maximum allowable slope, when there are signs of distress. If that situation occurs, the slope shall be cut back to an actual slope which is at least 1/2 horizontal to one vertical (1/2 H:1V) less steep than the maximum allowable slope.

(iii) *When surcharge loads from stored* material or equipment, operating equipment, or traffic are present, a competent person shall determine the degree to which the actual slope must be reduced below the maximum allowable slope, and shall assure that such reduction is achieved. Surcharge loads from adjacent structures shall be evaluated in accordance with §1926.651(i).

(4) *Configurations.* Configurations of sloping and benching systems shall be in accordance with Figure B-1.

Soil or Rock Type	Maximum Allowable Slopes (H:V)[1] For Excavations Less Than 20 Feet Deep[3]
Stable Rock	Vertical (90°)
Type A[2]	3/4:1 (53°)
Type B	1:1 (45°)
Type C	1 1/2:1 (34°)

[1]Numbers shown in parentheses next to maximum allowable slopes are angles expressed in degrees from the horizontal. Angles have been rounded off.

[2]A short-term maximum allowable slope of 1/2 H:1V (63°) is allowed in excavations in Type A soil that are 12 feet (3.67 m) or less in depth. Short-term maximum allowable slopes for excavations greater than 12 feet (3.67 m) in depth shall be 3/4H:1V (53°).

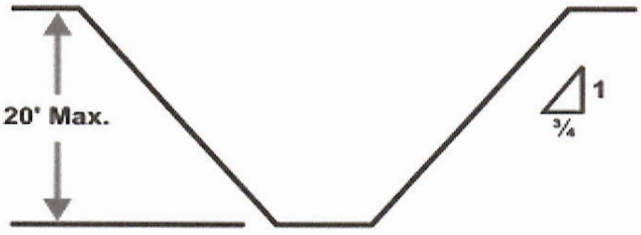
[3]Sloping or benching for excavations greater than 20 feet deep shall be designed by a registered professional engineer.

FIGURE B-1 SLOPE CONFIGURATIONS

(All slopes stated below are in the horizontal to vertical ratio)

B-1.1 Excavations made in Type A soil.

1. *All simple slope excavation 20 feet* or less in depth shall have a maximum allowable slope of 3/4 :1.

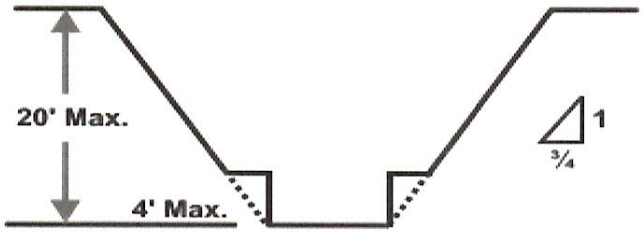


Simple Slope — General

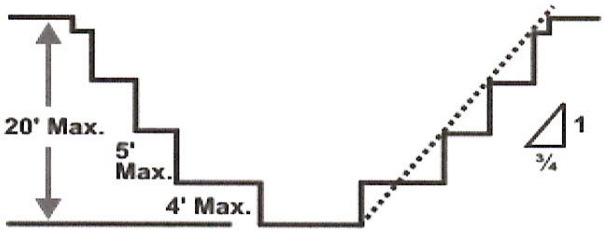
Exception: Simple slope excavations which are open 24 hours or less (short term) and which are 12 feet or less in depth shall have a maximum allowable slope of 1/2 :1.

Simple Slope — Short Term

2. *All benched excavations 20 feet or less* in depth shall have a maximum allowable slope of ¾ to 1 and maximum bench dimensions as follows:

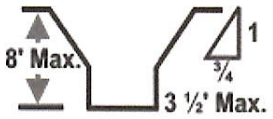


Simple Bench



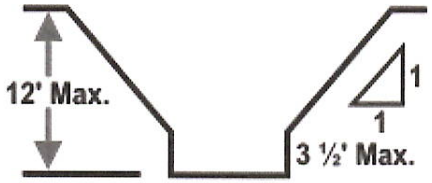
Multiple Bench

3. *All excavations 8 feet or less* in depth which have unsupported vertically sided lower portions shall have a maximum vertical side of 3½ feet.



Unsupported Vertically Sided Lower Portion — Maximum 8 Feet in Depth

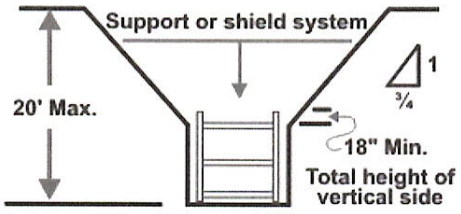
All excavations more than 8 feet but not more than 12 feet in depth which unsupported vertically sided lower portions shall have a maximum allowable slope of 1:1 and a maximum vertical side of 3½ feet.



Unsupported Vertically Sided Lower Portion — Maximum 12 Feet in Depth

Editor's Note: In the image for all excavations more than 8 feet but not more than 12 feet in depth in this section containing Figure B-1, 3., the CFR labeled the height to be 2'. This appears to be an error. The height is corrected to 12' in the image appearing above.

All excavations 20 feet or less in depth which have vertically sided lower portions that are supported or shielded shall have a maximum allowable slope of ¾ :1. The support or shield system must extend at least 18 inches above the top of the vertical side.

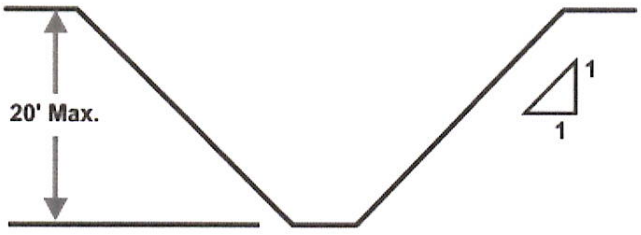


Supported or Shielded Vertically Sided Lower Portion

4. *All other simple slope, compound slope,* and vertically sided lower portion excavations shall be in accordance with the other options permitted under §1926.652(b).

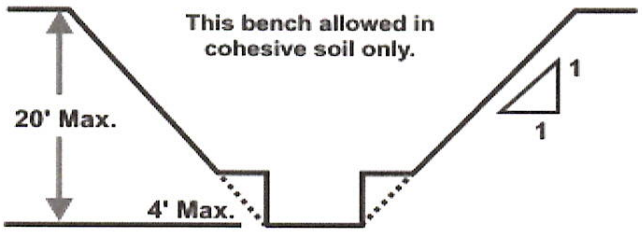
B-1.2 Excavations Made in Type B Soil

1. *All simple slope excavations 20 feet* or less in depth shall have a maximum allowable slope of 1:1.



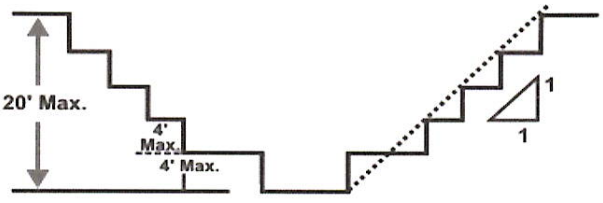
Simple Slope

2. *All benched excavations 20 feet or less* in depth shall have a maximum allowable slope of 1:1 and maximum bench dimensions as follows:



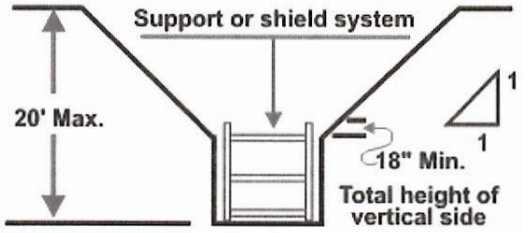
Single Bench

This bench allowed in cohesive soil only.



Multiple Bench

3. *All excavations 20 feet or less* in depth which have vertically sided lower portions shall be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations shall have a maximum allowable slope of 1:1.

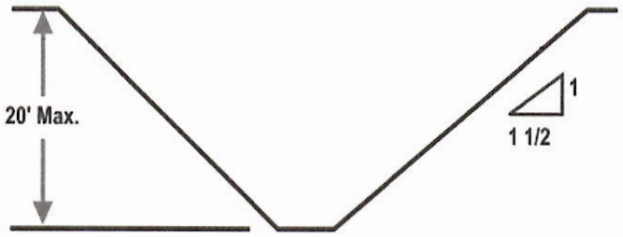


Vertically Sided Lower Portion

4. *All other sloped excavations* shall be in accordance with the other options permitted in §1926.652(b).

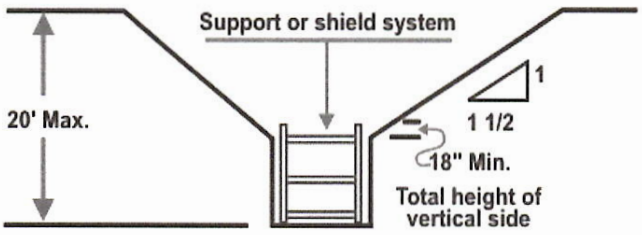
B-1.3 Excavations Made in Type C Soil

1. *All simple slope excavations 20 feet* or less in depth shall have a maximum allowable slope of 1½ :1.



Simple Slope

2. *All excavations 20 feet or less in depth* which have vertically sided lower portions shall be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations shall have a maximum allowable slope of 1½ :1.

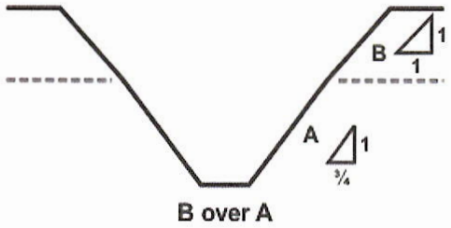


Vertical Sided Lower Portion

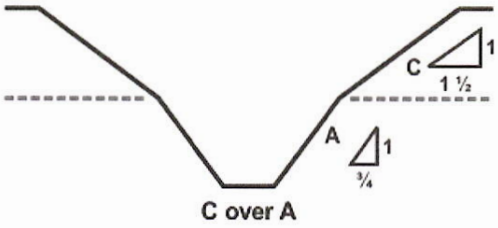
3. *All other sloped excavations* shall be in accordance with the other options permitted in §1926.652(b).

B-1.4 Excavations Made in Layered Soils

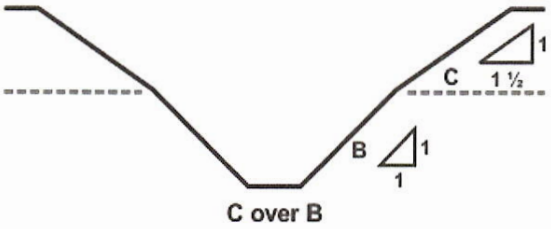
1. *All excavations 20 feet or less* in depth made in layered soils shall have a maximum allowable slope for each layer as set forth below.



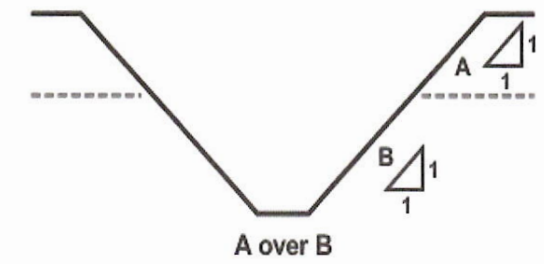
B over A



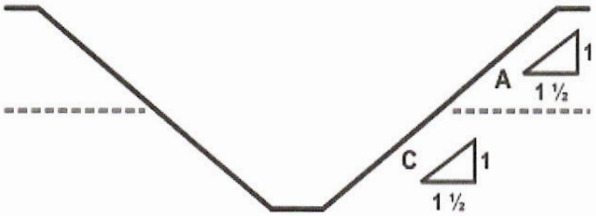
C over A



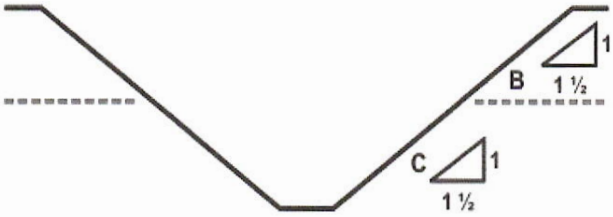
C over B



A over B



A over C



B over C

2. *All other sloped excavations* shall be in accordance with the other options permitted in §1926.652(b).

Appendix C to Subpart P of Part 1926 — Timber Shoring for Trenches

(a) Scope. This appendix contains information that can be used timber shoring is provided as a method of protection from cave-ins in trenches that do not exceed 20 feet (6.1 m) in depth. This appendix must be used when design of timber shoring protective systems is to be performed in accordance with §1926.652(c)(1). Other timber shoring configurations; other systems of support such as hydraulic and pneumatic systems; and other protective systems such as sloping, benching, shielding, and freezing systems must be designed in accordance with the requirements set forth in §1926.652(b) and §1926.652(c).

(b) Soil Classification. In order to use the data presented in this appendix, the soil type or types in which the excavation is made must first be determined using the soil classification method set forth in appendix A of subpart P of this part.

(c) Presentation of Information. Information is presented in several forms as follows:

(1) *Information is presented in tabular* form in Tables C-1.1, C-1.2, and C-1.3, and Tables C-2.1, C-2.2 and C-2.3 following paragraph (g) of the appendix. Each table presents the minimum sizes of timber members to use in a shoring system, and each table contains data only for the particular soil type in which the excavation or portion of the excavation is made. The data are arranged to allow the user the flexibility to select from among several acceptable configurations of members based on varying the horizontal spacing of the crossbraces. Stable rock is exempt from shoring requirements and therefore, no data are presented for this condition.

(2) *Information concerning the basis* of the tabular data and the limitations of the data is presented in paragraph (d) of this appendix, and on the tables themselves.

(3) *Information explaining the use* of the tabular data is presented in paragraph (e) of this appendix.

(4) *Information illustrating the use* of the tabular data is presented in paragraph (f) of this appendix.

(5) *Miscellaneous notations regarding* Tables C-1.1 through C-1.3 and Tables C-2.1 through C-2.3 are presented in paragraph (g) of this Appendix.

(d) Basis and limitations of the data

(1) *Dimensions of timber members.*

(i) *The sizes of the timber members* listed in Tables C-1.1 through C-1.3 are taken from the National Bureau of Standards (NBS) report, "Recommended Technical Provisions for Construction Practice in Shoring and Sloping of Trenches and Excavations." In addition, where NBS did not recommend specific sizes of members, member sizes are based on an analysis of the sizes required for use by existing codes and on empirical practice.

(ii) *The required dimensions of the members* listed in Tables C-1.1 through C-1.3 refer to actual dimensions and not nominal dimensions of the timber. Employers wanting to use nominal size shoring are directed to Tables C-2.1 through C-2.3, or have this choice under §1926.652(c)(3), and are referred to The Corps of Engineers, The Bureau of Reclamation or data from other acceptable sources.

(2) *Limitation of application.*

(i) *It is not intended that the timber shoring specification* apply to every situation that may be experienced in the field. These data were developed to apply to the situations that are most commonly experienced in current trenching practice. Shoring systems for use in situations that are not covered by the data in this appendix must be designed as specified in §1926.652(c).

(ii) *When any of the following conditions are present,* the members specified in the tables are not considered adequate. Either an alternate timber shoring system must be designed or another type of protective system designed in accordance with §1926.652.

[A] When loads imposed by structures or by stored material adjacent to the trench weigh in excess of the load imposed by a two-foot soil surcharge. The term "adjacent" as used here means the area within a horizontal distance from the edge of the trench equal to the depth of the trench.

[B] When vertical loads imposed on cross braces exceed a 240-pound gravity load distributed on a one-foot section of the center of the crossbrace.

[C] When surcharge loads are present from equipment weighing in excess of 20,000 pounds.

[D] When only the lower portion of a trench is shored and the remaining portion of the trench is sloped or benched unless: The sloped portion is sloped at an angle less steep than three horizontal to one vertical; or the members are selected from the tables for use at a depth which is determined from the top of the overall trench, and not from the toe of the sloped portion.

(e) Use of Tables. The members of the shoring system that are to be selected using this information are the cross braces, the uprights, and the wales, where wales are required. Minimum sizes of members are specified for use in different types of soil. There are six tables of information, two for each soil type. The soil type must first be determined in accordance with the soil classification system described in appendix A to subpart P of part 1926. Using the appropriate table, the selection of the size and spacing of the members is then made. The selection is based on the depth and width of the trench where the members are to be installed and, in most instances, the selection is also based on the horizontal spacing of the crossbraces. Instances where a choice of horizontal spacing of crossbracing is available, the horizontal spacing of the crossbraces must be chosen by the user before the size of any member can be determined. When the soil type, the width and depth of the trench, and the horizontal spacing of the crossbraces are known, the size and vertical spacing of the crossbraces, the size and vertical spacing of the wales, and the size and horizontal spacing of the uprights can be read from the appropriate table.

(f) Examples to Illustrate the Use of Tables C-1.1 through C-1.3.

(1) *Example 1.*

A trench dug in Type A soil is 13 feet deep and five feet wide. From Table C-1.1, for acceptable arrangements of timber can be used.

Arrangement #B1

Space 4 × 4 crossbraces at six feet horizontally and four feet vertically.
Wales are not required.
Space 3 × 8 uprights at six feet horizontally. This arrangement is commonly called "skip shoring."

Arrangement #B2

Space 4 × 6 crossbraces at eight feet horizontally and four feet vertically.
Space 8 × 8 wales at four feet vertically.
Space 2 × 6 uprights at four feet horizontally.

Arrangement #B3

Space 6 × 6 crossbraces at 10 feet horizontally and four feet vertically.
Space 8 × 10 wales at four feet vertically.
Space 2 × 6 uprights at five feet horizontally.

Arrangement #B4

Space 6 × 6 crossbraces at 12 feet horizontally and four feet vertically.
Space 10 × 10 wales at four feet vertically.
Spaces 3 × 8 uprights at six feet horizontally.

(2) *Example 2.*
A trench dug in Type B soil in 13 feet deep and five feet wide. From Table C-1.2 three acceptable arrangements of members are listed.

Arrangement #B1

Space 6 × 6 crossbraces at six feet horizontally and five feet vertically.
Space 8 × 8 wales at five feet vertically.
Space 2 × 6 uprights at two feet horizontally.

Arrangement #B2

Space 6 × 8 crossbraces at eight feet horizontally and five feet vertically.
Space 10 × 10 wales at five feet vertically.
Space 2 × 6 uprights at two feet horizontally.

Arrangement #B3

Space 8 × 8 crossbraces at 10 feet horizontally and five feet vertically.
Space 10 × 12 wales at five feet vertically.
Space 2 × 6 uprights at two feet vertically.

(3) *Example 3.*
A trench dug in Type C soil is 13 feet deep and five feet wide. From Table C-1.3 two acceptable arrangements of members can be used.

Arrangement #B1

Space 8 × 8 crossbraces at six feet horizontally and five feet vertically.
Space 10 × 12 wales at five feet vertically.
Position 2 × 6 uprights as closely together as possible.
If water must be retained use special tongue and groove uprights to form tight sheeting.

Arrangement #B2

Space 8 × 10 crossbraces at eight feet horizontally and five feet vertically.
Space 12 × 12 wales at five feet vertically.
Position 2 × 6 uprights in a close sheeting configuration unless water pressure must be resisted. Tight sheeting must be used where water must be retained.

(4) *Example 4.*
A trench dug in Type C soil is 20 feet deep and 11 feet wide. The size and spacing of members for the section of trench that is over 15 feet in depth is determined using Table C-1.3. Only one arrangement of members is provided.
Space 8 × 10 crossbraces at six feet horizontally and five feet vertically.
Space 12 × 12 wales at five feet vertically.
Use 3 × 6 tight sheeting.
Use of Tables C-2.1 through C-2.3 would follow the same procedures.

(g) Notes for all Tables.

1. *Member sizes at spacings* other than indicated are to be determined as specified in §1926.652(c), "Design of Protective Systems."
2. *When conditions are saturated or submerged* use Tight Sheeting. Tight Sheeting refers to the use of specially-edged timber planks (e.g., tongue and groove) at least three inches thick, steel sheet piling, or similar construction that when driven or placed in position provide a tight wall to resist the lateral pressure of water and to prevent the loss of backfill material. Close Sheeting refers to the placement of planks side-by-side allowing as little space as possible between them.
3. *All spacing indicated is measured* center to center.
4. *Wales to be installed with greater* dimension horizontal.
5. *If the vertical distance* from the center of the lowest crossbrace to the bottom of the trench exceeds two and one-half feet, uprights shall be firmly embedded or a mudsill shall be used. Where uprights are embedded, the vertical distance from the center of the lowest crossbrace to the bottom of the trench shall not exceed 36 inches. When mudsills are used, the vertical distance shall not exceed 42 inches. Mudsills are wales that are installed at the toe of the trench side.
6. *Trench jacks may be used* in lieu of or in combination with timber crossbraces.
7. *Placement of crossbraces.* When the vertical spacing of crossbraces is four feet, place the top crossbrace no more than two feet below the top of the trench. When the vertical spacing of crossbraces is five feet, place the top crossbrace no more than 2.5 feet below the top of the trench.

Table C-1.1 Timber Trench Shoring - Minimum Timber Requirements*

Soil Type A $P_a = 25 \times H + 72$ psf (2 ft. Surcharge)

Depth of trench (feet)	Size (actual) and spacing of members**													
	Cross braces						Wales		Uprights					
	Horiz. spacing (feet)	Width of trench (feet)					Vertical spacing (feet)	Size (in.)	Vertical spacing (feet)	Maximum allowable horizontal spacing (feet)				
		Up to 4	Up to 6	Up to 9	Up to 12	Up to 15				Close	4	5	6	8
5 to 10	Up to 6	4 × 4	4 × 4	4 × 6	6 × 6	6 × 6	4	Not req'd	—				2 × 6	
	Up to 8	4 × 4	4 × 4	4 × 6	6 × 6	6 × 6	4	Not req'd	—					2 × 8
	Up to 10	4 × 6	4 × 6	4 × 6	6 × 6	6 × 6	4	8 × 8	4			2 × 6		
	Up to 12	4 × 6	4 × 6	6 × 6	6 × 6	6 × 6	4	8 × 8	4				2 × 6	
10 to 15	Up to 6	4 × 4	4 × 4	4 × 6	6 × 6	6 × 6	4	Not req'd	—				3 × 8	
	Up to 8	4 × 6	4 × 6	6 × 6	6 × 6	6 × 6	4	8 × 8	4		2 × 6			
	Up to 10	6 × 6	6 × 5	6 × 6	6 × 8	6 × 8	4	8 × 10	4			2 × 6		
	Up to 12	6 × 6	6 × 6	6 × 6	6 × 8	6 × 8	4	10 × 10	4				3 × 8	
15 to 20	Up to 6	6 × 6	6 × 6	6 × 6	6 × 8	6 × 8	4	6 × 8	4	3 × 6				
	Up to 8	6 × 6	6 × 6	6 × 6	6 × 8	6 × 8	4	8 × 8	4	3 × 6				
	Up to 10	8 × 8	8 × 8	8 × 8	8 × 8	8 × 10	4	8 × 10	4	3 × 6				
	Up to 12	8 × 8	8 × 8	8 × 8	8 × 8	8 × 10	4	10 × 10	4	3 × 6				
Over 20	See Note 1													

*Mixed oak or equivalent with a bending strength not less than 850 psi.
**Manufactured members of equivalent strength may be substituted for wood

Table C-1.2 Timber Trench Shoring - Minimum Timber Requirements*

Soil Type B $P_a = 45 \times H + 72$ psf (2 ft. Surcharge)

Depth of trench (feet)	Size (actual) and spacing of members**													
	Cross braces						Wales		Uprights					
	Horiz. spacing (feet)	Width of trench (feet)					Vertical spacing (feet)	Size (in.)	Vertical spacing (feet)	Maximum allowable horizontal spacing (feet)				
		Up to 4	Up to 6	Up to 9	Up to 12	Up to 15				Close	2	3		
5 to 10	Up to 6	4 × 6	4 × 6	6 × 6	6 × 6	6 × 6	5	6 × 8	5			2 × 6		
	Up to 8	6 × 6	6 × 6	6 × 6	6 × 8	6 × 8	5	8 × 10	5			2 × 6		
	Up to 10	6 × 6	6 × 6	6 × 6	6 × 8	6 × 8	5	10 × 10	5			2 × 6		
	See Note 1													
10 to 15	Up to 6	6 × 6	6 × 6	6 × 6	6 × 8	6 × 8	5	8 × 8	5		2 × 6			
	Up to 8	6 × 8	6 × 8	6 × 8	8 × 8	8 × 8	5	10 × 10	5		2 × 6			
	Up to 10	8 × 8	8 × 8	8 × 8	8 × 8	8 × 10	5	10 × 12	5		2 × 6			
	See Note 1													
15 to 20	Up to 6	6 × 8	6 × 8	6 × 8	8 × 8	8 × 8	5	8 × 10	5	3 × 6				
	Up to 8	8 × 8	8 × 8	8 × 8	8 × 8	8 × 10	5	10 × 12	5	3 × 6				
	Up to 10	8 × 10	8 × 10	8 × 10	8 × 10	10 × 10	5	12 × 12	5	3 × 6				
	See Note 1													
Over 20	See Note 1													

*Mixed oak or equivalent with a bending strength not less than 850 psi.
**Manufactured members of equivalent strength may be substituted for wood.

Table C-1.3 Timber Trench Shoring - Minimum Timber Requirements*

Soil Type C $P_a = 80 \times H + 72$ psf (2 ft. Surcharge)

Depth of trench (feet)	Size (actual) and spacing of members**													
	Cross braces						Wales		Uprights					
	Horiz. spacing (feet)	Width of trench (feet)					Vertical spacing (feet)	Size (in.)	Vertical spacing (feet)	Maximum allowable horizontal spacing (feet) (See Note 2)				
		Up to 4	Up to 6	Up to 9	Up to 12	Up to 15				Close				
5 to 10	Up to 6	6 × 8	6 × 8	6 × 8	8 × 8	8 × 8	5	8 × 10	5	2 × 6				
	Up to 8	8 × 8	8 × 8	8 × 8	8 × 8	8 × 10	5	10 × 12	5	2 × 6				
	Up to 10	8 × 10	8 × 10	8 × 10	8 × 10	10 × 10	5	12 × 12	5	2 × 6				
	See Note 1													
10 to 15	Up to 6	8 × 8	8 × 8	8 × 8	8 × 8	8 × 10	5	10 × 12	5	2 × 6				
	Up to 8	8 × 10	8 × 10	8 × 10	8 × 10	10 × 10	5	12 × 12	5	2 × 6				
	See Note 1													
	See Note 1													
15 to 20	Up to 6	8 × 10	8 × 10	8 × 10	8 × 10	10 × 10	5	12 × 12	5	3 × 6				
	See Note 1													
	See Note 1													
	See Note 1													
Over 20	See Note 1													

*Mixed oak or equivalent with a bending strength not less than 850 psi.

**Manufactured members of equivalent strength may be substituted for wood.

Table C-2.1 Timber Trench Shoring - Minimum Timber Requirements*

Soil Type A $P_a = 25 \times H + 72$ psf (2 ft. Surcharge)

Depth of trench (feet)	Size (S4S) and spacing of members**													
	Cross braces						Wales		Uprights					
	Horiz. spacing (feet)	Width of trench (feet)					Vert. spacing (feet)	Size (in.)	Vert. spacing (feet)	Maximum allowable horizontal spacing (feet)				
		Up to 4	Up to 6	Up to 9	Up to 12	Up to 15				Close	4	5	6	8
5 to 10	Up to 6	4 × 4	4 × 4	4 × 4	4 × 4	4 × 6	4	Not req'd	Not req'd				4 × 6	
	Up to 8	4 × 4	4 × 4	4 × 4	4 × 6	4 × 6	4	Not req'd	Not req'd					4 × 8
	Up to 10	4 × 6	4 × 6	4 × 6	6 × 6	6 × 6	4	8 × 8	4			4 × 6		
	Up to 12	4 × 6	4 × 6	4 × 6	6 × 6	6 × 6	4	8 × 8	4				4 × 6	
10 to 15	Up to 6	4 × 4	4 × 4	4 × 4	6 × 6	6 × 6	4	Not req'd	Not req'd				4 × 10	
	Up to 8	4 × 6	4 × 6	4 × 6	6 × 6	6 × 6	4	6 × 8	4		4 × 6			
	Up to 10	6 × 6	6 × 6	6 × 6	6 × 6	6 × 6	4	8 × 8	4			4 × 8		
	Up to 12	6 × 6	6 × 6	6 × 6	6 × 6	6 × 6	4	8 × 10	4		4 × 6		4 × 10	
15 to 20	Up to 6	6 × 6	6 × 6	6 × 6	6 × 6	6 × 6	4	6 × 8	4	3 × 6				
	Up to 8	6 × 6	6 × 6	6 × 6	6 × 6	6 × 6	4	8 × 8	4	3 × 6	4 × 12			
	Up to 10	6 × 6	6 × 6	6 × 6	6 × 6	6 × 8	4	8 × 10	4	3 × 6				
	Up to 12	6 × 6	6 × 6	6 × 6	6 × 8	6 × 8	4	8 × 12	4	3 × 6	4 × 12			
Over 20	See Note 1													

*Douglas fir or equivalent with a bending strength not less than 1500 psi.

**Manufactured members of equivalent strength may be substituted for wood.

Table C-2.2 Timber Trench Shoring - Minimum Timber Requirements*
Soil Type B $P_a = 45 \times H + 72$ psf (2 ft. Surcharge)

Depth of trench (feet)	Size (S4S) and spacing of members**												
	Cross braces						Wales		Uprights				
	Horiz. spacing (feet)	Width of trench (feet)					Vertical spacing (feet)	Size (in.)	Vertical spacing (feet)	Maximum allowable horizontal spacing (feet)				
		Up to 4	Up to 6	Up to 9	Up to 12	Up to 15				Close	2	3	4	6
5 to 10	Up to 6	4 × 6	4 × 6	4 × 6	6 × 6	6 × 6	5	6 × 8	5			3 × 12 4 × 8		4 × 12
	Up to 8	4 × 6	4 × 6	6 × 6	6 × 6	6 × 6	5	8 × 8	5		3 × 8		4 × 8	
	Up to 10	4 × 6	4 × 6	6 × 6	6 × 6	6 × 8	5	8 × 10	5			4 × 8		
	See Note 1													
10 to 15	Up to 6	6 × 6	6 × 6	6 × 6	6 × 8	6 × 8	5	8 × 8	5	3 × 6	4 × 10			
	Up to 8	6 × 8	6 × 8	6 × 8	8 × 8	8 × 8	5	10 × 10	5	3 × 6	4 × 10			
	Up to 10	6 × 8	6 × 8	8 × 8	8 × 8	8 × 8	5	10 × 12	5	3 × 6	4 × 10			
	See Note 1													
15 to 20	Up to 6	6 × 8	6 × 8	6 × 8	6 × 8	8 × 8	5	8 × 10	5	4 × 6				
	Up to 8	6 × 8	6 × 8	6 × 8	8 × 8	8 × 8	5	10 × 12	5	4 × 6				
	Up to 10	8 × 8	8 × 8	8 × 8	8 × 8	8 × 8	5	12 × 12	5	4 × 6				
	See Note 1													
Over 20	See Note 1													

*Douglas fir or equivalent with a bending strength not less than 1500 psi.
**Manufactured members of equivalent strength may be substituted for wood.

Table C-2.3 Timber Trench Shoring - Minimum Timber Requirements*
Soil Type C $P_a = 80 \times H + 72$ psf (2 ft. Surcharge)

Depth of trench (feet)	Size (S4S) and spacing of members**												
	Cross braces						Wales		Uprights				
	Horiz. spacing (feet)	Width of trench (feet)					Vert. spacing (feet)	Size (in.)	Vert. spacing (feet)	Maximum allowable horizontal spacing (feet)				
		Up to 4	Up to 6	Up to 9	Up to 12	Up to 15				Close				
5 to 10	Up to 6	6 × 6	6 × 6	6 × 6	6 × 6	8 × 8	5	8 × 8	5	3 × 6				
	Up to 8	6 × 6	6 × 6	6 × 6	8 × 8	8 × 8	5	10 × 10	5	3 × 6				
	Up to 10	6 × 6	6 × 6	8 × 8	8 × 8	8 × 8	5	10 × 12	5	3 × 6				
	See Note 1													
10 to 15	Up to 6	6 × 8	6 × 8	6 × 8	8 × 8	8 × 8	5	10 × 10	5	4 × 6				
	Up to 8	8 × 8	8 × 8	8 × 8	8 × 8	8 × 8	5	12 × 12	5	4 × 6				
	See Note 1													
	See Note 1													
15 to 20	Up to 6	8 × 8	8 × 8	8 × 8	8 × 10	8 × 10	5	10 × 12	5	4 × 6				
	See Note 1													
	See Note 1													
	See Note 1													
Over 20	See Note 1													

*Douglas fir or equivalent with a bending strength not less than 1500 psi.
**Manufactured members of equivalent strength may be substituted for wood.

Appendix D to Subpart P of Part 1926 — Aluminum Hydraulic Shoring for Trenches

(a) Scope. This appendix contains information that can be used when aluminum hydraulic shoring is provided as a method of protection against cave-ins in trenches that do not exceed 20 feet (6.1m) in depth. This appendix must be used when design of the aluminum hydraulic protective system cannot be performed in accordance with §1926.652(c)(2).

(b) Soil Classification. In order to use data presented in this appendix, the soi1 type or types in which the excavation is made must first be determined using the soil classification method set forth in appendix A of subpart P of part 1926.

(c) Presentation of Information. Information is presented in several forms as follows:

(1) *Information is presented in tabular form* in Tables D-1.1, D-1.2, D-1.3 and E-1.4. Each table presents the maximum vertical and horizontal spacings that may be used with various aluminum member sizes and various hydraulic cylinder sizes. Each table contains data only for the particular soil type in which the excavation or portion of the excavation is made. Tables D-1.1 and D-1.2 are for vertical shores in Types A and B soil. Tables

D-1.3 and D1.4 are for horizontal waler systems in Types B and C soil.

(2) *Information concerning the basis* of the tabular data and the limitations of the data is presented in paragraph (d) of this appendix.

(3) *Information explaining the use* of the tabular data is presented in paragraph (e) of this appendix.

(4) *Information illustrating the use* of the tabular data is presented in paragraph (f) of this appendix.

(5) *Miscellaneous notations (footnotes)* regarding Table D-1.1 through D-1.4 are presented in paragraph (g) of this appendix.

(6) *Figures, illustrating typical installations* of hydraulic shoring, are included just prior to the Tables. The illustrations page is entitled "Aluminum Hydraulic Shoring; Typical Installations."

(d) Basis and limitations of the data.

(1) *Vertical shore rails* and horizontal wales are those that meet the Section Modulus requirements in the D-1 Tables. Aluminum material is 6061-T6 or material of equivalent strength and properties.

(2) *Hydraulic cylinders specifications.*

(i) *2-inch* cylinders shall be a minimum 2-inch inside diameter with a minimum safe working capacity of no less than 18,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufacturer.

(ii) *3-inch* cylinders shall be a minimum 3-inch inside diameter with a safe working capacity of not less than 30,000 pounds axial compressive load at extensions as recommended by product manufacturer.

(3) *Limitation of application.*

(i) *It is not intended* that the aluminum hydraulic specification apply to every situation that may be experienced in the field. These data were developed to apply to the situations that are most commonly experienced in current trenching practice. Shoring systems for use in situations that are not covered by the data in this appendix must be otherwise designed as specified in §1926.652(c).

(ii) *When any of the following conditions are present,* the members specified in the Tables are not considered adequate. In this case, an alternative aluminum hydraulic shoring system or other type of protective system must be designed in accordance with §1926.652.

[A] When vertical loads imposed on cross braces exceed a 100 Pound gravity load distributed on a one foot section of the center of the hydraulic cylinder.

[B] When surcharge loads are present from equipment weighing in excess of 20,000 pounds.

[C] When only the lower portion or a trench is shored and the remaining portion of the trench is sloped or benched unless: The sloped portion is sloped at an angle less steep than three horizontal to one vertical; or the members are selected from the tables for use at a depth which is determined from the top of the overall trench, and not from the toe of the sloped portion.

(e) Use of Tables D-1.1, D-1.2, D-1.3 and D-1.4. The members of the shoring system that are to be selected using this information are the hydraulic cylinders, and either the vertical shores or the horizontal wales. When a waler system is used the vertical timber sheeting to be used is also selected from these tables. The Tables D-1.1 and D-1.2 for vertical shores are used in Type A and B soils that do not require sheeting. Type B soils that may require sheeting, and Type C soils that always require sheeting are found in the horizontal wale Tables D-1.3 and D-1.4. The soil type must first be determined in accordance with the soil classification system described in appendix A to subpart P of part 1926. Using the appropriate table, the selection of the size and spacing of the members is made. The selection is based on the depth and width of the trench where the members are to be installed. In these tables the vertical spacing is held constant at four feet on center. The tables show the maximum horizontal spacing of cylinders allowed for each size of wale in the waler system tables, and in the vertical shore tables, the hydraulic cylinder horizontal spacing is the same as the vertical shore spacing.

(f) Example to Illustrate the Use of the Tables:

(1) *Example 1:* A trench dug in Type A soil is 6 feet deep and 3 feet wide. From Table D-1.1: Find vertical shores and 2 inch diameter cylinders spaced 8 feet on center (o.c.) horizontally and 4 feet on center (o.c.) vertically. (See Figures 1 & 3 for typical installations.)

(2) *Example 2:* A trench is dug in Type B soil that does not require sheeting, 13 feet deep and 5 feet wide. From Table D-1.2: Find vertical shores and 2 inch diameter cylinders spaced 6.5 feet o.c. horizontally and 4 feet o.c. vertically. (See Figures 1 & 3 for typical installations.)

(3) *A trench is dug in Type* B soil that does not require sheeting, but does experience some minor raveling of the trench face. The trench is 16 feet deep and 9 feet wide. From Table D-1.2: Find vertical shores and 2 inch diameter cylinder (with special oversleeves as designated by footnote #B2) spaced 5.5 feet o.c. horizontally and 4 feet o.c. vertically, plywood (per footnote (g)(7) to the D-1 Table) should be used behind the shores. (See Figures 2 & 3 for typical installations.)

(4) *Example 4:* A trench is dug in previously disturbed Type B soil, with characteristics of a Type C soil, and will require sheeting. The trench is 18 feet deep and 12 feet wide. 8 foot horizontal spacing between cylinders is desired for working space. From Table D-1.3: Find horizontal wale with a section modulus of 14.0 spaced at 4 feet o.c. vertically and 3 inch diameter cylinder spaced at 9 feet maximum o.c. horizontally. 3 × 12 timber sheeting is required at close spacing vertically. (See Figure 4 for typical installation.)

(5) *Example 5:* A trench is dug in Type C soil, 9 feet deep and 4 feet wide. Horizontal cylinder spacing in excess of 6 feet is desired for working space. From Table D-1.4: Find horizontal wale with a section modulus of 7.0 and 2 inch diameter cylinders spaced at 6.5 feet o.c. horizontally. Or, find horizontal wale with a 14.0 section modulus and 3 inch diameter cylinder spaced at 10 feet o.c. horizontally. Both wales are spaced 4 feet o.c. vertically. 3 × 12 timber sheeting is required at close spacing vertically. (See Figure 4 for typical installation.)

(g) Footnotes, and general notes, for Tables D-1.1, D-1.2, D-1.3, and D-1.4.

(1) *For applications other than those* listed in the tables, refer to §1926.652(c)(2) for use of manufacturer's tabulated data. For trench depths in excess of 20 feet, refer to §1926.652(c)(2) and §1926.652(c)(3).

(2) *2 inch diameter* cylinders, at this width, shall have structural steel tube (3.5 × 3.5 × 0.1875) oversleeves, or structural oversleeves of manufacturer's specification, extending the full, collapsed length.

(3) *Hydraulic cylinders capacities.*

(i) *2 inch cylinders* shall be a minimum 2-inch inside diameter with a safe working capacity of not less than 18,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufacturer.

(ii) *3-inch cylinders* shall be a minimum 3-inch inside diameter with a safe work capacity of not less than 30,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufacturer.

(4) *All spacing indicated is measured center to center.*

(5) *Vertical shoring rails* shall have a minimum section modulus of 0.40 inch.

(6) *When vertical shores are used,* there must be a minimum of three shores spaced equally, horizontally, in a group.

(7) *Plywood shall be 1.125 in.* thick softwood or 0.75 inch. thick, 14 ply, arctic white birch (Finland form). Please note that plywood is not intended as a structural member, but only for prevention of local raveling (sloughing of the trench face) between shores.

(8) *See appendix C for timber specifications.*

(9) *Wales are calculated for simple span conditions.*

(10) *See appendix D, item (d), for basis and limitations of the data.*

Aluminum Hydraulic Shoring Typical Installations

FIGURE No. 1

Vertical Aluminum Hydraulic Shoring
(Spot Bracing)

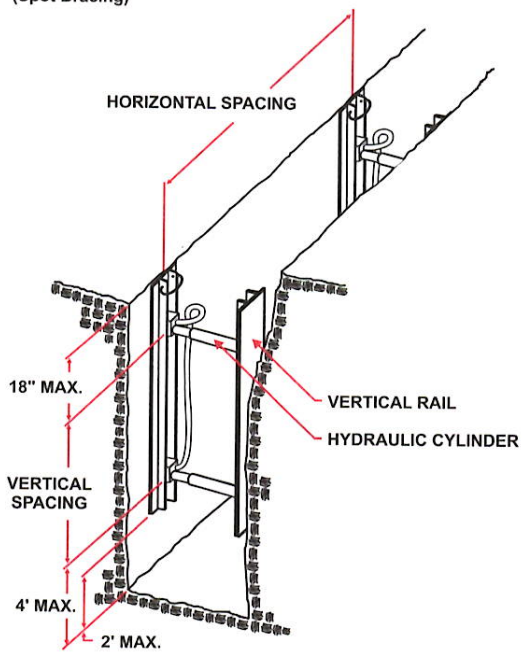


FIGURE No. 2

Vertical Aluminum Hydraulic Shoring
(With Plywood)

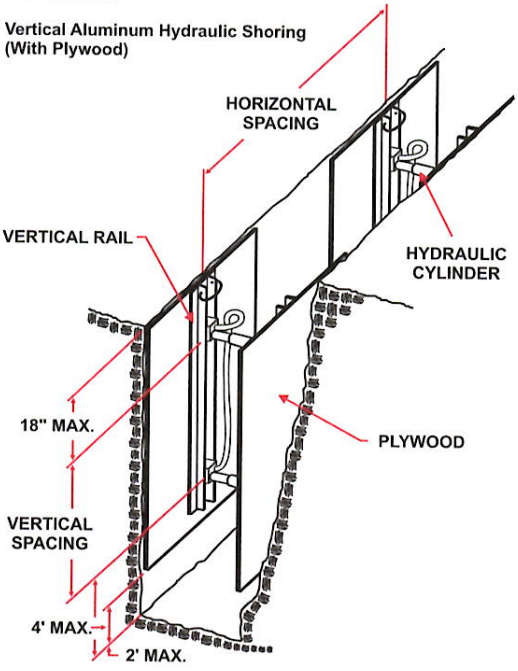


FIGURE No. 3

Vertical Aluminum Hydraulic Shoring
(Stacked)

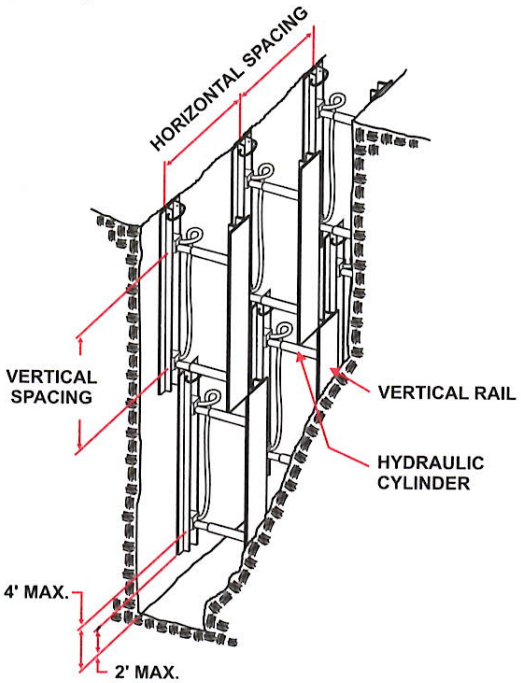


FIGURE No. 4

Aluminum Hydraulic Shoring
Waler System
(Typical)

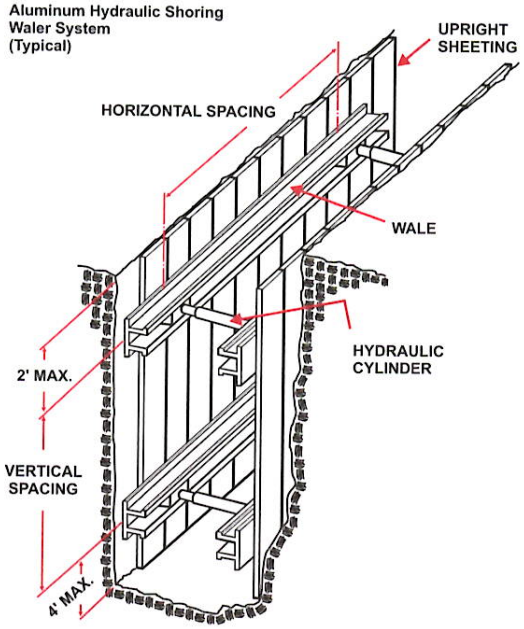


Table D-1.1 Aluminum Hydraulic Shoring
Vertical Shores for Soil Type A

Depth of trench (feet)	Hydraulic cylinders				
	Maximum horizontal spacing (feet)	Maximum vertical spacing (feet)	Width of trench (feet)		
			Up to 8	Over 8 up to 12	Over 12 up to 15
Over 5 up to 10	8	4	2 inch diameter	2 inch diameter Note (2)	3 inch diameter
Over 10 up to 15	8				
Over 15 up to 20	7				
Over 20	Note (1)				

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Note (1): See Appendix D, Item (g)(1)
Note (2): See Appendix D, Item (g)(2)

Table D-1.2 Aluminum Hydraulic Shoring
Vertical Shores for Soil Type B

Depth of trench (feet)	Hydraulic cylinders				
	Maximum horizontal spacing (feet)	Maximum vertical spacing (feet)	Width of trench (feet)		
			Up to 8	Over 8 up to 12	Over 12 up to 15
Over 5 up to 10	8	4	2 inch diameter	2 inch diameter Note (2)	3 inch diameter
Over 10 up to 15	6.5				
Over 15 up to 20	5.5				
Over 20	Note (1)				

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Note (1): See Appendix D, Item (g)(1)
Note (2): See Appendix D, Item (g)(2)

Table D-1.3 Aluminum Hydraulic Shoring
Waler Systems for Soil Type B

Depth of trench (feet)	Wales		Hydraulic cylinders						Timber uprights		
			Width of trench (feet)						Max. horiz. spacing (on center)		
	Vertical spacing (feet)	*Section modulus ($in.^3$)	Up to 8		Over 8 up to 12		Over 12 up to 15		Solid sheet	2 ft.	3 ft.
			Horiz. spacing	Cylinder diameter	Horiz. spacing	Cylinder diameter	Horiz. spacing	Cylinder diameter			
Over 5 up to 10	4	3.5	8.0	2 in.	8.0	2 in. Note (2)	8.0	3 in.			3 × 12
		7.0	9.0	2 in.	9.0	2 in. Note (2)	9.0	3 in.			
		14.0	12.0	3 in.	12.0	3 in.	12.0	3 in.			
Over 10 up to 15	4	3.5	6.0	2 in.	6.0	2 in. Note (2)	6.0	3 in.		3 × 12	
		7.0	8.0	3 in.	8.0	3 in.	8.0	3 in.			
		14.0	10.0	3 in.	10.0	3 in.	10.0	3 in.			
Over 15 up to 20	4	3.5	5.5	2 in.	5.5	2 in. Note (2)	5.5	3 in.	3 × 12		
		7.0	6.0	3 in.	6.0	3 in.	6.0	3 in.			
		14.0	9.0	3 in.	9.0	3 in.	9.0	3 in.			
Over 20	Note (1)										

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Notes (1): See Appendix D, Item (g)(1)
Notes (2): See Appendix D, Item (g)(2)
*Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.

Table D-1.4 Aluminum Hydraulic Shoring
Waler Systems for Soil Type C

Depth of trench (feet)	Wales		Hydraulic cylinders						Timber uprights		
			Width of trench (feet)						Max. horiz. spacing (on center)		
	Vertical spacing (feet)	*Section modulus ($in.^3$)	Up to 8		Over 8 up to 12		Over 12 up to 15		Solid sheet	2 ft.	3 ft.
			Horiz. spacing	Cylinder diameter	Horiz. spacing	Cylinder diameter	Horiz. spacing	Cylin-der diame-ter			
Over 5 up to 10	4	3.5	6.0	2 in.	6.0	2 in. Note (2)	6.0	3 in.	3 × 12		
		7.0	6.5	2 in.	6.5	2 in. Note (2)	6.5	3 in.			
		14.0	10.0	3 in.	10.0	3 in.	10.0	3 in.			
Over 10 up to 15	4	3.5	4.0	2 in.	4.0	2 in. Note (2)	4.0	3 in.	3 × 12		
		7.0	5.5	3 in.	5.5	3 in.	5.5	3 in.			
		14.0	8.0	3 in.	8.0	3 in.	8.0	3 in.			

Table D-1.4 Aluminum Hydraulic Shoring
Waler Systems for Soil Type C
(continued)

Depth of trench (feet)	Wales		Hydraulic cylinders						Timber uprights		
			Width of trench (feet)						Max. horiz. spacing (on center)		
			Up to 8		Over 8 up to 12		Over 12 up to 15				
	Vertical spacing (feet)	*Section modulus ($in.^3$)	Horiz. spacing	Cylinder diameter	Horiz. spacing	Cylinder diameter	Horiz. spacing	Cylinder diameter	Solid sheet	2 ft.	3 ft.
Over 15 up to 20	4	3.5	3.5	2 in.	3.5	2 in. Note (2)	3.5	3 in.	3 × 12		
		7.0	5.0	3 in.	5.0	3 in.	5.0	3 in.			
		14.0	6.0	3 in.	6.0	3 in.	6.0	3 in.			
Over 20	Note (1)										

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Notes (1): See Appendix D, Item (g)(1)
Notes (2): See Appendix D, Item (g)(2)
*Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.

Appendix E to Subpart P of Part 1926 — Alternatives to Timber Shoring

Figure E-1. Aluminum Hydraulic Shoring

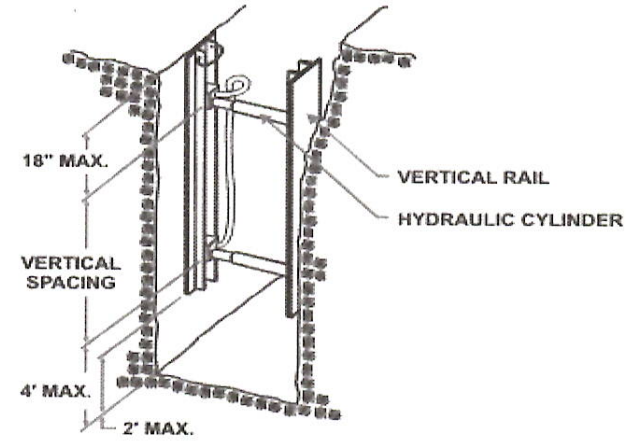


Figure E-2. Pneumatic/Hydraulic Shoring

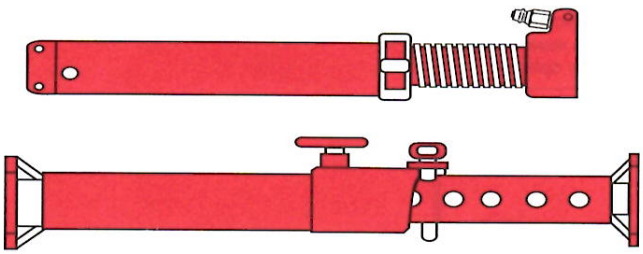


Figure E-3. Trench Jacks (Screw Jacks)

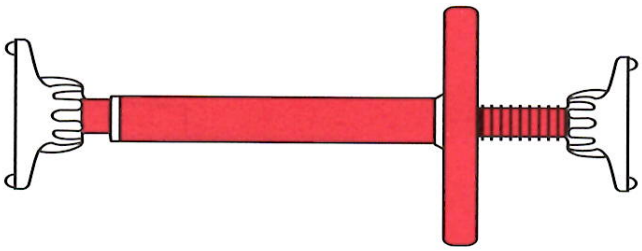
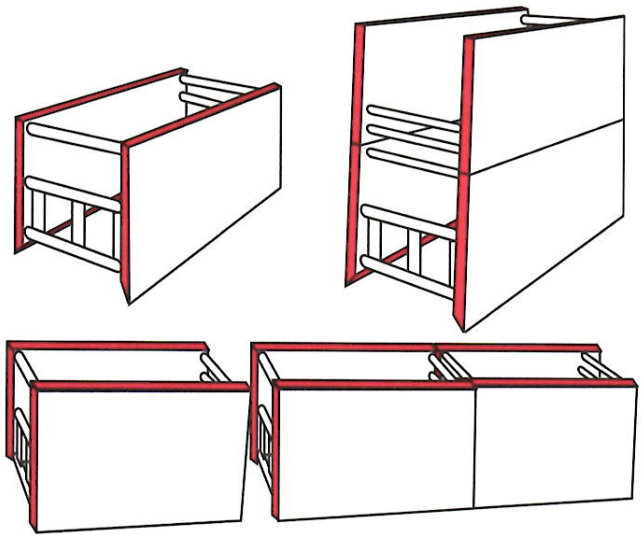


Figure E-4. Trench Shields



Appendix F to Subpart P of Part 1926 — Selection of Protective Systems

The following figures are a graphic summary of the requirements contained in subpart P for excavations 20 feet or less in depth. Protective systems for use in excavations more than 20 feet in depth must be designed by a registered professional engineer in accordance with §1926.652 (b) and (c).

Figure 1. Preliminary Decisions

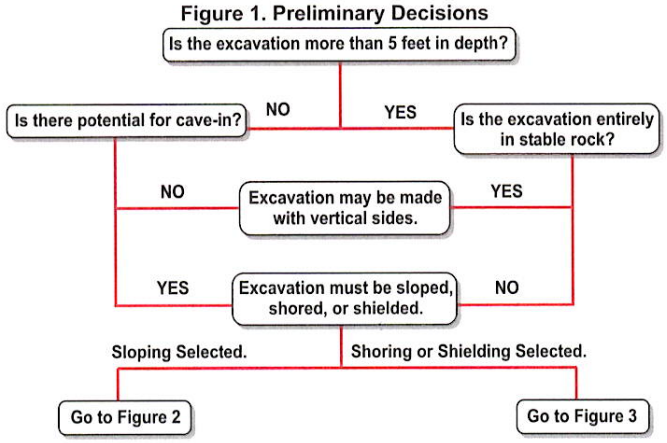


Figure 2. Sloping Options

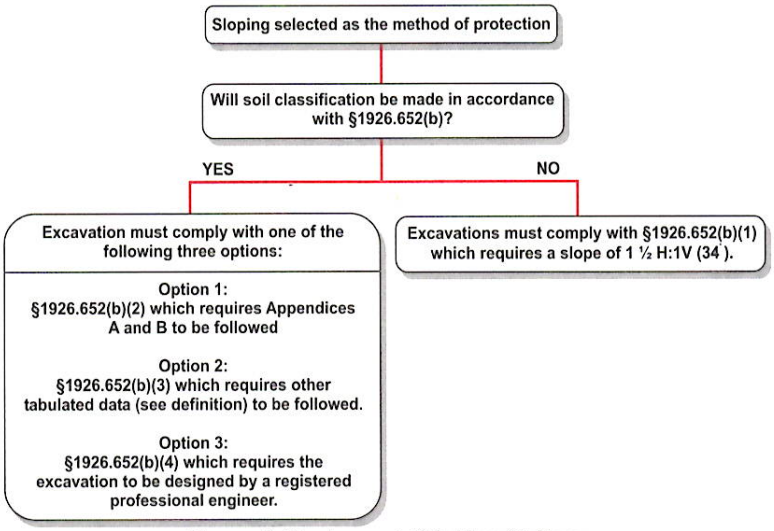
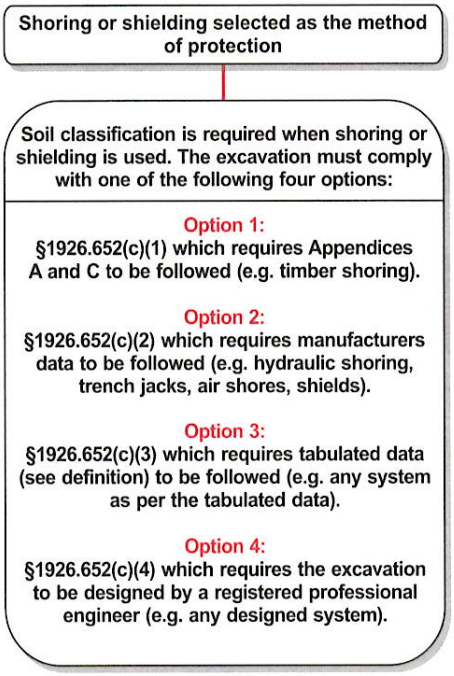


Figure 3. Shoring and Shielding Options



Authority: §107, Contract Worker Hours and Safety Standards Act (Construction Safety Act) (40 U.S.C. 333); Secs. 4, 6, 8, Occupational Safety and Hea1th Act of 1970 (29 U.S.C. 653, 655, 657); Secretary of Labor's Order No. 12-71 (36 FR 8754), 8-76 (41 FR 25059), or 9-83 (48 FR 35736), as applicab'e, and 29 CFR part 1911.