

TR: Trench

Lesson One

Protective Systems

DOMAIN: COGNITIVE / PSYCHOMOTOR

LEVEL OF LEARNING: COMPREHENSION /
APPLICATION

MATERIALS

IFSTA 7th Edition Fire Service Search and Rescue; Trench Rescue Training Levels: Awareness, Operations, Technician 2nd Edition, by C.V. Martinette Jr.; Trench Rescue 2nd Edition, by James Gragan; NFPA 1006, Standard for Technical Rescuer Professional Qualifications; NFPA 1670, Standard on Operations and Training for Technical Rescue Incidents; OSHA 29 CFR 1926.650 OSHA Construction Standard Subpart P; multimedia projector and laptop computer; access to white board or flipchart; assorted marker pens; timber shoring material to include: plywood trench panels, (dimensions must conform to the OSHA trench standard) or commercial panels (Shore Form, Finn Form); back hoe; a straight wall trench, a T-trench, an L-trench and a deep wall trench (12-15 feet); timbers for shoring and waling; 4'x8' ground pad; 2"x12"x 12' ground boards; 2"x4"x12' rails; utility ropes for panels trench shield (Box); ventilation equipment; three gas model atmospheric monitoring equipment timber shoring materials; Walers; hydraulic shoring equipment (optional); pneumatic shoring equipment; screw jacks (if available); trench box; fire service ladders; timbers for dewatering device with intake and discharge hose; nails; cutting station with power cutting tool; nail pouches; hammers; tape measures; safety glasses; carpenter pencils; carpenter squares; hearing protection; chaps; portable radios; equipment tarps; shelter tarps; rehab supplies; rehab station; standby medical personnel.

NFPA 1006, 2013 Edition JPRs

- 8.1.4 Support a non-intersecting trench
- 8.1.7 Disassemble support systems
- 8.2.1 Support an intersecting trench

- 8.2.2 Install supplemental sheeting and shoring
- 8.2.5 Coordinate the use of heavy equipment

Junior Member Statement:

Junior Member training activities should be supervised by qualified instructors to assure that the cognitive and psychomotor skills are completed in a safe and non-evasive manner. While it is critical that instructors be constantly aware of the capabilities of all students both mentally and physically to complete certain tasks safely and successfully, the instructor should take every opportunity to discuss with departmental leaders and students the maturity and job awareness each participant has for the hazards associated with fire and rescue training.

TERMINAL OBJECTIVE

The Technical Rescuer shall correctly identify, describe, and demonstrate the setup operation and function of various trench protective systems used during trench rescue incidents.

ENABLING OBJECTIVES

1. The Technical Rescuer given the proper equipment and as a member of a team shall correctly demonstrate supporting a non-intersecting trench to minimize soil movement.
2. The Technical Rescuer given the proper equipment and as a member of a team shall correctly demonstrate supporting an intersecting trench to minimize soil movement.
3. The Technical Rescuer given the proper equipment and as a member of a team shall correctly demonstrate installing supplemental sheeting and shoring below an existing shoring system to minimize soil movement.
4. The Technical Rescuer shall identify the rules for cutting a trench wall to the appropriate angle of repose in order to minimize soil movement and reduce the risk of entrapment.

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Protective Systems

MOTIVATION

Rescuers will be faced with many challenges when working at a trench rescue site. They will be exposed to many various configurations that at best are difficult for the contractor to shore in a pre-collapse environment let alone a post collapse environment that rescuers will face. Pre-planning and periodic live drills are the key for rescuers to safely tackle the myriad of problems with which they will be faced. Using various pieces of equipment and practicing various techniques will pay off in great benefits for the rescuers and the victims.

PRESENTATION

ENABLING OBJECTIVE #1

The Technical Rescuer given the proper equipment and as a member of a team shall correctly demonstrate supporting a non-intersecting trench to minimize soil movement.

1. Point out and discuss some of the different causes of a trench collapse.
 - a) Previously disturbed soil.
 - b) Excessive vibration.
 - c) Heavily saturated soil.
2. Point out that if a trench wall has collapsed it may become necessary to create an artificial foundation using other materials.
3. Identify safety procedures that should be addressed prior to actual shoring any type of the trench.
 - a) Establish the IMS system and the accountability system.
 - b) The area around the trench should be cleared of all debris and unstable structures should be secured. Moving spoil piles away should be done

with a shovel in a careful manner. Level the ground between the edge of the trench and the spoil pile.

- c) A safety observer should be placed at the end of the trench throughout this operation.
- d) The hot, warm and cold zones should be established.
- e) First stabilize the working area of the lip of the trench using 4' x 8' x 15/8 inch sheets of plywood (planking) on the non-spoil pile side and 2" x 12" x 12' boards for the spoil pile side. Anywhere the trench end is less than 4' wide it can be made safe by using the 2" x 12" x 12' boards. If greater than 4' it should be treated as a face or wall. This is used to spread out the weight of the rescuers working around the trench.

NOTE: 2" x 12" x 12' boards are recommended. However, the use of other material is permitted as long as it is no less than 2" x 8" material.

- f) Next the atmospheric conditions within the trench must be checked and documented on a continual basis.
 - g) Ventilation should be established.
 - h) Stabilize all unstable structures adjacent to the trench work area.
 - i) Establish the vibration zone around the work area (300 feet) and shut down or detour all equipment or machinery that would create harmful vibrations.
 - j) Establish the collapse zone within the trench. It is the horizontal distance equal to 1½ times the vertical depth of the trench. Look for signs of a potential secondary collapse such as cracks adjacent to the trench.
4. Identify and discuss the trench stabilization technique used most often by rescue personnel.
- a) Sheet piling is the preferred method because most commercial systems are designed for pre-collapse conditions requiring near vertical walls for the system to be effective.
 - b) As a general rule, sheet piling and shoring consist of panels with strong backs attached to them that can be lowered into the trench at any degree that allows for shores (cross braces) to be secured

- from on side of the trench to the other, without the risk of kick-out.
- c) The setting of the panels can be accomplished by various methods depending on the condition of the trench and victim location.
 - d) As a rule the strong backs will face each other in the trench and act as a bearing plate for the shores.
 - e) An exception for attaching strongbacks to the panels is when hydraulic shores are used. These devices have metal strongbacks (uprights) already attached to the hydraulic shore.
 - f) For a non-intersecting trench a minimum of 6 panels will be needed (3 on each side) to provide a minimum safe horizontal work area for rescuers of 12 feet.
 - g) As a means of entry and egress a stairway, ladder, ramp or other means of safe egress must be installed in trenches with a depth of 4 feet or greater, (OSHA CFR 1926.651 (c)(2).
 - h) Horizontal spacing shall be no more than 25 feet of lateral travel, (OSHA CFR 1926.651 (c) (2).
 - i) For rescue operations a minimum of 2 ladders are recommended to be installed in close proximity to the interior rescue personnel.
 - j) If a person is within the collapse zone of an exposed end wall, the end wall must be shored.
5. Discuss why skip-shoring or spot-shoring is not acceptable for trench rescue operations.
6. Discuss procedures for installing various types of shoring devices.
- a) For all timber and screw jack shoring operations refer to OSHA CFR 1926 Subpart P Appendix C Table C 2-3 for Type C soil, pages 18 through 21 to determine types of timber, dimension of timber and vertical and horizontal spacing requirements.
 - b) Screw jacks are good for spanning horizontal distances of 5-7 feet depending on the specific manufacturer. Cheater bars are acceptable to use when tightening.
 - c) The minimum acceptable dimension for a timber shore in Type C soil will vary from a 6"x8" to an 8"x10" for depths up to 10 feet with a maximum allowable vertical spacing of 5 feet.

- d) According OSHA CFR 1926 Appendix C, the minimum acceptable dimension for a timber shore in Type C soil will vary from a 6"x8" to an 8"x10" for depths up to 20 feet with a maximum allowable vertical spacing of 5 feet.
 - e) For all hydraulic shoring operations refer to OSHA CFR 1926 Subpart P Appendix D Table D 1-4 for Type C soil, pages 8 through 10 to determine dimension of hydraulic cylinder, and vertical and horizontal spacing requirement.
 - f) For all pneumatic shoring operations refer to the specific manufacturer's tabulated data sheet for proper horizontal and vertical spacing requirements.
 - g) Timber, screw jacks, hydraulic shoring devices and pneumatic shoring devices can be used side by side provided that the individual device is rated for the conditions.
 - h) For end wall shoring, panels can be secured in place with a flying shore. Horizontal bracing is not sufficient.
 - i) The first set of panels placed in a trench should always have three shores to hold them in place.
7. Demonstrate installing panels using a "same side set" method.
- a) This technique is used when there is sufficient room for rescuers to stand on both sides of the trench
 - b) Ropes are attached to the bottom of the panels to assist in lowering the panels into the trench.
 - c) Panels are lowered from each side with the strong backs facing each other and then positioned as vertical as possible using the ropes
 - d) Ropes can then be wrapped around the top of the strongbacks or picketed to the ground.
8. Demonstrate installing panels using an "opposite side set" method.
- a) This technique is used when there is limited space for the rescuers to stand, usually on the spoil pile side.
 - b) Two 4" x 4" runners are placed in the trench with the bottoms secured against the bottom of the opposite side the panels will be inserted from and

- the tops on the same side as the panel will be inserted from.
- c) The panel is placed on the runners with the strong back facing down.
 - d) Rescuers will then push the runners to awaiting rescuers on the opposite side and those rescuers will position the panel vertically using the attached rope.
 - e) The near side panels will be set using the “same side set” method.
9. Discuss the general guidelines for installing various types of shoring devices.
- a) The first installed shore should be no lower than 18 inches below the lip and the last installed shore should be no higher than 24 inches from the bottom of the trench.
 - b) Timber, screw jacks have to be manually set by rescuer working from the top of the trench to the bottom and taken out in the reverse manner. “First piece In Last Piece Out.”
 - c) Hydraulic shores can be lowered in on ropes from the top without rescuers usually having to enter the trench.
 - d) Because of the force generated by pneumatic shores, the acceptable procedure for these devices is to shoot the middle shore first, then the bottom shore, then the top shore before continuing down into the trench.
 - e) If a rescuer must enter the trench to assist with placing the bottom pneumatic shore, then the top shore should be set after the middle one.
10. Discuss the general guidelines for installing timber shoring.
- a) Measure the height of both vertical walls.
 - b) Measure from the bottom of the strong back on the first two panels to be installed to the top of the location where the top shore middle and bottom shores should be installed.
 - c) Nail a 2”x4” wooden scab or a metal cleat hanger at each location. The two side cleats can be added at this time making sure the spacing fits the dimension of the timber shore.
 - d) An alternative method is to attach two 2”x4” x 12’ foot rails onto the strong backs spaced apart to

- receive a scab block and timber shore; the interior rescuer would only have to attach the top cap.
- e) Install the first set of panels and have a rescuer measure the distance between the strong backs at the top installation location and relay the measurements to the cutting team.
 - f) Have the cutting team cut the top timber shore according to the measurement taken.
 - g) Have rescuer enter the trench to waist level and begin installing the timbers. Shore from top to bottom and cap the tops with a 2"x4" wooden scab as they go making sure to stay within the safe zone (waist level of the previously installed shore) as they install the next shore.
 - h) If the timber shore is cut a little short, a shim can be inserted and nailed to fill the void space before the top cap is secured.
11. Discuss the general guidelines for shoring a non-intersecting trench using shoring devices.
- a) Timbers – Set top shore, middle shore and bottom shore. Remove in reverse order.
 - b) Pneumatic – Set the middle strut, bottom strut, and top strut, as a rule all necessary shores can be installed from ground level.
 - c) Hydraulic – Set and expand struts between the uprights, as a rule all necessary shores can be installed from ground level.
 - d) Screw jacks – Follow timber guidelines.
 - e) Backfill all voids behind the panels once they are set and shored.
 - f) Using basic carpentry skills toe-nail all screw jacks and pneumatic shores to the strong backs.
12. Demonstrate setting internal and external walers for a non-intersecting trench.
- a) Wales (Waler) are horizontal members that span multiple trench panels to create a safe work area.
 - b) Timber wales are of larger dimension than shoring devices.
 - c) Wales are lowered into the trench at appropriate heights and secured with shoring devices.
 - d) Typically lower wales and middle wales, if needed, are lowered into the trench first, but not placed until the top wale is secured.

- e) Shoring devices can be set further apart horizontally when attached to wales allowing for a more open workspace.
- f) See OSHA CFR 1926 Appendix C Table C 2-3 for waler installation specifications.
- g) Walers can also be used externally behind the panels to assist in filling large voids caused by lip failures and slough-ins.
- h) Outside walers are placed against the trench wall before insertion of the panels.
- i) After the installation of the wales and panels, but before the shores are installed, backfilling will be necessary to allow the forces of the shores to be distributed effectively when the shores are installed. Backfilling is defined as filling in the trench behind the panels.

Reference: IFSTA 7th Edition Fire Service Search and Rescue, pages 249 through 256.

Reference: Trench Rescue Training Levels: Awareness, Operation, Technician, 2nd Edition, pages 178 through 188 and 202 through 211.

Reference: 29 CFR OSHA Construction Standard 1926, Subpart P, Appendix B and C and D; and 29 CFR OSHA Construction Standard 1926.652(a).

13. Demonstrate procedures for shoring a deep wall trench.
- a) Measure the depth and width of the trench.
 - b) Prepare panels and wales.
 - c) Prepare the shores.
 - d) Set the bottom wales on the trench floor.
 - e) Lower the bottom set of panels (2) in an upright position and secure.
 - f) Place a top panel horizontally across the two deep panels.
 - g) Shore the top panels using appropriate shoring devices.
 - h) The lower upright panels can be waled or each panel can be shored depending on availability of equipment

Reference: Trench Rescue Training Levels: Awareness, Operation, Technician, 2nd Edition, pages 220 through 223.

PRESENTATION

ENABLING OBJECTIVE #2

The Technical Rescuer given the proper equipment and as a member of a team shall correctly demonstrate supporting an intersecting trench to minimize soil movement.

1. Demonstrate procedures for shoring a T-Trench.
 - a) Seven panels and two walers will be needed in addition to the same materials used for a non-intersecting trench.
 - b) This type of trench is very unstable because there are two unsupported interior corners that are exposed.
 - c) Two walers will be needed to capture the three panels that will be needed to support the upper portion of the T.
 - d) Limit the activity on the corners of the trench.
 - e) Implement all pre-entry guidelines.
 - f) Set pickets for tiebacks for panels and wales, if needed.
 - g) Set two panels on the wall of the T-leg and secure the shores in the appropriate order according to the type used. This should be done 4 feet away from the intersecting leg.
 - h) Lower the appropriate number of wales to the bottom of the upper wall of the T.
 - i) Set two panels on the opposite T-leg corners and three panels on the upper wall of the T.
 - j) Secure the shores to the walers in the appropriate order according to the type used.
 - k) Tighten the T-leg shores if needed.

Reference: Trench Rescue training Level: Awareness, Operations, Technician 2nd Edition, pages 211 through 215.

2. Demonstrate procedures for shoring an L-Trench.
 - a) A minimum of six panels and 4 – 12 foot long 6" x 6" walers will be needed in addition to the same materials used for a non-intersecting trench.
 - b) This type of trench is very unstable because of the unsupported interior corner that is exposed.
 - c) Limit the activity on the corners of the trench
 - d) Implement all pre-entry guidelines for a non-intersecting trench.

- e) Set pickets for tie backs for panels and wales (if needed).
- f) Set the opposing L-wall panels.
- g) Lower the appropriate number of wales to the bottom of the trench for both sides.
- h) Secure the appropriate number of thrust blocks on the inside L-panels, this can be done prior to placing the panels in the trench.
- i) Secure all walers into position in the appropriate order according to devices used.
- j) Secure all outside wall corner blocks and attach appropriate shoring device(s) between the outside wall corner and inside wall corner at the appropriate levels within the trench.
- k) When using pneumatic shores, use one 23 degree angle swivel or two 15 degree angle swivels.

NOTE: See dimensions for thrust blocks on page 219 of the Trench Rescue Training Levels: Awareness, Operations Technician Manual.

Reference: Trench Rescue Training Level: Awareness, Operations, Technician 2nd Edition, pages 216 through 219.

PRESENTATION

ENABLING OBJECTIVE #3

The Technical Rescuer given the proper equipment and as a member of a team, shall correctly demonstrate installing supplemental sheeting and shoring below an existing shoring system to minimize soil movement.

1. Discuss the installation guidelines for supplemental shoring.
 - a) Supplemental shoring is required when a void is created extending 2 feet below the bottom of the protective system.
 - b) When constructing a standard panel to panel shoring operation supplemental shoring consists of 2 to 4 - 2" x 12" x 12 foot long strongbacks placed horizontally behind the bottom of the vertical strong back of each panel and to the same configuration on the opposite wall.

- c) This system would continue until the victim is reached and retrieved.
- d) When constructing a waler type protective system, sheets of plywood (1-1/8"), Shoreform (minimum 1") or additional 2" x 12" strongbacks can be lowered between the strongbacks attached to the panel, as needed and shimmed in placed until they need to be lowered again.

Reference: Trench Rescue Training Levels: Awareness, Operations and Technician 2nd Edition, page 188 and 189.

PRESENTATION

ENABLING OBJECTIVE #4

The Technical Rescuer shall identify the rules for cutting a trench wall to the appropriate angle of repose in order to minimize soil movement and reduce the risk of entrapment.

1. Point out that sloping or benching is a method to decrease the angle of a wall to the point that it cannot collapse.
 - a) This method reduces the gravitational forces and total amount of unconfined compressive forces that may be present.
 - b) This method may be useful for a "body recovery" operation when a large safe opening is needed.
 - c) The technique requires a tabulated data sheet.
 - d) It is time consuming.
 - e) It requires a lot of space.
 - f) See OSHA CFR 1926. Appendix B page 2 for allowable slope data chart.
2. The maximum slope designated for Type C soil is 1-1/2 foot of run (horizontal) for every 1 foot of rise (vertical).

Reference Trench Rescue Training Levels: Awareness, Operations and Technician 2nd Edition, pages 190 – 192.

APPLICATION

1. Divide the candidates into an appropriate number of task groups. Have each task group demonstrate constructing a safe protective system for each of the following trench configurations:

Straight wall 6 – 8 feet deep.
T-trench 6 – 8 feet deep.
L-trench 6 – 8 feet deep.
Deep wall trench 12 – 15 feet deep.

2. While working in the straight wall trench, have each task group demonstrate constructing a safe supplemental shoring system.

SUMMARY

It is not enough to just talk about the various trench designs and how to address them. This lesson plan puts the rescuer where the rubber meets the road in the trenches. It challenges the rescuer to identify the various types of trench designs and come up with a safe plan for creating a functional protective system that protects victims and rescuers based on available equipment.