Structural Collapse Specialist Instructor-Led Training (ILT)

Participant Guide

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U.S. Department Of Homeland Security
Federal Emergency Management Agency
National Urban Search and Rescue Response System

The Federal Emergency Management Agency (FEMA) was established in 1979. FEMA's mission is to focus federal efforts on preparedness for, mitigation of, response to, and recovery from emergencies encompassing the full range of natural and human-caused disasters. The U.S. Department of Homeland Security (DHS) became operational in 2003, with FEMA becoming an integral part of this new department.

Under the National Response Framework (NRF), FEMA is responsible for providing federal urban search and rescue assistance to state and local governments during federally declared emergencies or disasters. The National Urban Search and Rescue (US&R) Response System's (The System) mission is to assist local governments to locate, stabilize, and safely extricate the survivors of structural collapse incidents.

Under the auspices of FEMA, the System has developed a series of courses for those members of a US&R team that will be deployed to a variety of natural and human-made disasters. As a part of the education system of US&R resources, this course was designed to provide responders with the most up-to-date information, techniques, and procedures. This course has been formatted into a blended online/face-to-face model with a portion of the material being presented online via a web-based learning management system and the remaining hands-on modules of the course being delivered in a face-to-face format.

Structural Collapse Specialist Instructor-Led Training (ILT)

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U.S. Department of Homeland Security

Federal Emergency Management Agency

National Urban Search and Rescue System

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Structural Collapse Specialist Instructor-Led Training (ILT)

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Module 0

Introduction

About the Instructor-Led Training (ILT) Component

Goal

Slides 1–2

The goal of the *Structural Collapse Specialist Instructor-Led Training (ILT)* course is to provide the rescue responder with the core knowledge, skills, and abilities to work in a structural collapse environment during search and rescue operations in one of the U.S. Department of Homeland Security (DHS) Federal Emergency Management Agency's (FEMA) Urban Search and Rescue (US&R) Task Forces (TF).

Overview

Topics include:

- Module 0: Introduction
- Module 1: Review of the Computer-Based Training (CBT) Component
- Module 2: Tool Lab
- Module 3: Shoring
- Module 4: Breaking and Breaching
- Module 5: Lifting and Moving
- Module 6: Cumulative Exercise

Target Audience

This course is designed for FEMA US&R Structural Collapse Specialists.

Delivery Method

The delivery methodology consists of group discussions, demonstrations, lectures, and field exercises.

Prerequisites

Prior to attending this course, participants must:

- Complete the general training requirements identified in the National US&R Response System's *Training Program Administration Manual* (TPAM) (current edition)
- Complete the FEMA US&R *Structural Collapse Specialist Computer-Based Training (CBT)* component (9P2630)
- Meet requirements of NFPA 1006 *Standard for Technical Rescuer Professional Qualifications* (levels I and II) (excluding Chapter 1, "Administration," section 1.3.3) (2013 edition):
  - Chapter 5, "Job Performance Requirements"
  - Chapter 6, "Rope Rescue" (levels I and II)
  - Chapter 7, "Confined Space Rescue" (levels I and II)
  - Chapter 8, "Trench Rescue" (levels I and II)
  - Chapter 10, "Vehicle Rescue" (levels I and II)
- Complete current Occupational Safety and Health Administration (OSHA)-equivalent first aid certification (29 Code of Federal Regulations [CFR] 1918)

Length

The ILT component of the course is 80 hours.

Instructor-to-Participant Ratio

1 instructor to 8 participants:

- Minimum: 16 participants
- Maximum: 72 participants (more participants acceptable if hosting site can accommodate)

Equipment/Materials

The *Structural Collapse Specialist Instructor-Led Training (ILT) Participant Guide* is provided on a USB flash drive for participants.

Participants are required to bring the following materials:

- TF uniforms including Battle Dress Uniform (BDU) long-sleeve blouses and long pants
- Safety-toe boots
- Helmets
- Leather gloves
- Long-sleeve t-shirts
- Sweatshirt(s) or BDU coat for cooler weather
- Eye protection
- Hearing protection
- Half-face cartridge respirator with P-100 cartridges
- Full-face Air-Purifying Respirator (APR) with P-100 cartridge and organic vapor cartridge
- Field notebook and writing utensil
- Rain gear

Registration and Attendance

In order to receive credit for the ILT component of this course, participants' attendance is crucial. They must sign the attendance roster at the beginning of each day and may need to complete a registration form at the beginning (depending on hosting agency or facility) in order to receive a certificate of completion. Participants will also have the opportunity to complete an end-of-course evaluation.

Class Schedule

Slides 3–4

Note: The schedule is based on eight, 10-hour days.

Day	Module
Day 1	• Module 0: Introduction • Module 1: Review of the Computer-Based Training (CBT) Component • Module 2: Tool Lab
Day 2	Module 3: Shoring
Day 3	Module 3: Shoring (continued)
Day 4	Module 4: Breaking and Breaching
Day 5	Module 4: Breaking and Breaching (continued)
Day 6	Module 5: Lifting and Moving
Day 7	Module 5: Lifting and Moving (continued)
Day 8	• Final exam • Module 6: Cumulative Exercise

Participant Evaluation Strategy

Instructors will assess participants through observation of proper techniques, questioning, and discussion.

There is a cumulative test at the end of the ILT component. Participants must make at least a 70 percent to pass the ILT course component and obtain their certificate. Participants will also be required to demonstrate proficiency of each skill at each station as an individual or as part of a squad.

Instructor-Led Training (ILT) Evaluation Strategy

At the end of the ILT component, participants will complete an anonymous evaluation. This evaluation provides an opportunity to offer feedback on the quality of the ILT component of the course. This feedback is very important to our quality improvement process.

Administrative Information

Slides 5–6

At this time, participants should be prepared to introduce themselves. Their introduction should include their name, Task Force (TF), disaster experience, and US&R responsibilities.

Code of Conduct

- Keep constantly in mind the value of life and the welfare of survivors.
- Remain cognizant of considerations regarding race, religion, gender, and nationality.
- Demonstrate proper respect for other assigned personnel.
- Do not possess or use alcohol and/or drugs illegal under federal law.
- Do not possess or use firearms.
- Understand, respect, and adhere to the established chain of command and follow its direction at all times.
- Procure equipment using established policies and guidelines, and do not utilize or remove property without official authorization.
- Demonstrate respect for public and private property.
- Maintain a state of readiness, even when unassigned.
- Adhere to the established dress code and requirements for Personal Protective Equipment (PPE).
- Abide by federal policies and regulations regarding the handling of sensitive information.
- Abide by Federal Emergency Management Agency (FEMA) directives on appropriate social media use.
- Do not take or threaten to take actions in retaliation for whistleblowing actions as established by applicable laws and regulations.
- Adhere to ethics guidelines and do not abuse authority and/or position.
- Project and embody professionalism at all times.

Note: Participants should remember that their actions reflect on their organization and FEMA.

Safety Briefing

Participants must adhere to all safety requirements during training sessions. They should see their instructor immediately if they have any questions or concerns about safety.

Requirements and Issues

Dress Code

- TF BDU (TF blouse and/or long-sleeve t-shirt)
- BDU pants (no shorts)

- Ball caps or boonie hats
- Steel-toe boots (required during hands-on practical exercises; no tennis shoes permitted at any time)

Personal Protective Equipment (PPE)

- TF uniforms including BDU long-sleeve blouses and long pants
- Steel-toe boots
- Helmets
- Leather gloves
- Long-sleeve t-shirts
- Sweatshirt(s) or BDU coat for cooler weather
- Eye protection
- Hearing protection

Transportation

Instructors will inform participants of any transportation plans.

Emergency Notification

In case of emergency, participants should notify the lead instructor, hosting agency point of contact, and their TF program manager.

Health and Medical Assistance

If participants currently have a health issue or injury, they must let the instructors know. If participants are injured or have a health issue during training, they should notify the instructors immediately.

Module 1

Review of the Computer-Based Training (CBT) Component

Review of the Computer-Based Training (CBT) Component—Introduction

Slides 1–2

In the CBT component of this course, you gained the knowledge that you will need to be a successful Structural Collapse Specialist. This module serves as a review of what you learned. Much of the knowledge gained online will be used in the field exercises throughout the remainder of this course.

In addition, you will be introduced to the disciplines you will be learning about and practicing in this component of the course.

Review of the Computer-Based Training (CBT) Component—Administration

Duration

1 hour:

- Classroom: 1 hour
- Field exercises: none

Terminal Learning Objective (TLO)

Slide 3

Upon the successful completion of this module, participants will be able to review material learned in the Computer-Based Training (CBT) component of the course.

Enabling Learning Objectives (ELO)

1. Describe the considerations for conducting safe rescue operations in a collapse environment.
2. Identify medical considerations involved in victim extrication.
3. Explain the process and considerations for completing a building size up of a collapsed structure.
4. Discuss the application and safety issues associated with many of the tools found in the rescue cache used for rescue operations.
5. Describe methods used to stabilize collapsed or partially collapsed structures.
6. Identify techniques used to breach through various structural components to gain access to trapped victims.
7. Describe the concepts and methods for lifting and moving a load off and away from a trapped victim.
8. Identify the components of an Incident Action Plan (IAP) and how it applies to rescue operations.

Resources

- *Structural Collapse Specialist Computer-Based Training (CBT) Component*
- LCD projector with remote
- PowerPoint presentation for module 1

Instructor-to-Participant Ratio

1 instructor to 8 participants:

- Minimum: 16 participants
- Maximum: 72 participants (more participants acceptable if hosting site can accommodate)

Reference List

None

Practical Exercise Statement

None

Assessment Strategy

Instructors will assess participants through observation of proper techniques, questioning, and discussion.

Activity 1.1: Computer-Based Training (CBT) Component Review Discussion

Purpose

Slides 4–20

The purpose of this activity is to review the material in the CBT component of this course and to gauge participant understanding of concepts before performing the field exercises.

Participant Directions

1. Answer questions. During discussion, be prepared to defend your answers.
2. If you believe another participant's answer is incorrect, feel free to state your alternate answer and the reason why you think your alternate answer is correct.

Summary

Slide 21

Now that you have recalled much of the information learned in the CBT component, the remainder of the course will involve taking this knowledge and applying it to hands-on skills.

Module 2

Tool Lab

Tool Lab—Introduction

Slides 1–2

The key to any successful Urban Search and Rescue (US&R) operation is a thorough knowledge of the tools in the Task Force (TF) cache. The Structural Collapse Specialist must not only be able to select the appropriate tool to accomplish the task quickly and safely, but be able to troubleshoot minor tool problems and make the necessary on-site repairs.

This module will introduce you to the various types of tools and equipment you will use during US&R operations. For each tool, you will learn when to use the tool along with its setup, breakdown, and maintenance tasks. In addition, you will learn how to troubleshoot the common issues associated with each tool.

Tool Lab—Administration

Duration

8 hours:

- Classroom: none
- Field exercises: 8 hours:
  - Activity 2.1: Pneumatic Tools (2 hours)
  - Activity 2.2: Torches (1 hour and 30 minutes)
  - Activity 2.3: Electric Tools/Manual Tools (1 hour and 30 minutes)
  - Activity 2.4: Gas-Powered Tools (1 hour and 30 minutes)
  - Activity 2.5: Patient Packaging (1 hour and 30 minutes)

Terminal Learning Objective (TLO)

Upon the successful completion of this module, participants will be able to use the various tools that may be encountered during Urban Search and Rescue (US&R) rescue operations.

Enabling Learning Objectives (ELO)

1. Review the safe use of tools and equipment.
2. Practice using a variety of tools for shoring, breaking and breaching, and lifting and moving.
3. Practice patient packaging.

Resources

- LCD projector with remote
- PowerPoint presentation for module 2

Note: The following list of resources is based on the 2023 cache list. Comparable substitutions are acceptable if the item is not available with the hosting jurisdiction cache. The following lists the materials and quantities needed for the entire module. Refer to individual activities for materials and quantities needed for each station.

- Compressors:
  - 1, 5.5-kilowatt (kW) compressor
  - 1 trailer-mounted 185 cubic feet/minute industrial air compressor with 30-pound, 45-pound, and 90-pound breaker/chipper with bits and hoses (non-cache item)
  - Tool oilers
- 1, 5-kW or larger generator
- Fuels and oils:
  - Fuel for compressor (1, 5 gallon container)
  - Fuel for generator (1, 5 gallon container)
  - Fuel for power units (1, 5 gallon container)
  - Mixed fuel (fuel and oil) for saws (1, 5 gallon container)
  - Torch fuel and oxygen for each cutting system
  - Bar oil for chain saws (1 quart container)
  - Hydraulic fluid for Stanley power unit (1, 1 gallon container)
- Torches and equipment:
  - 1 oxygen/acetylene torch setup with tips
  - 2 Petrogen torch setups with tips
  - Tip chart (1 per participant)
  - 2 strikers
  - All standard torch-cutting safety equipment:
    - 2 sets leathers, Nomex, or fire-resistant cotton outerwear welding/cutting gloves
    - 2 pairs shade 3 or 5 goggles or glasses
    - Air-Purifying Respirators (APR) with P-100 cartridge and organic vapor cartridge (provided by participants)
    - 2 fire extinguishers
  - 1 atmospheric monitor

  - Miscellaneous tools for torch setup and minor repair:
    - Adjustable wrenches
    - Cleaners
    - Brushes
    - Spare tips
  - Ventilation fan
- Patient packaging items:
  - 1 Stokes litter
  - 40 feet of 1 inch webbing
  - 1 Yates Spec Pak
  - 1 sked
  - 1 long backboard
- Tools:
  - 2 airbags (any size) with regulator, controller, airbag relief/shutoff valve, and hoses
  - 1 nail gun with regulator and hose
  - 1 palm nailer with regulator and hose
  - 1 Paratech strut with 2 base plates
  - 1 Paratech HydraFusion with pump and hose
  - 1 come-along
  - 1 chain fall
  - 1 griphoist
  - 1 breaker with various bits:
    - 1, ½ inch drill bit
    - 1 chisel bit
    - 1 bull (moil) point
  - 1 rotary hammer with various bits
  - 1 reinforcing bars (rebar) cutter
  - 1 grinder with blade
  - 1 reciprocating saw with blade
  - 1, 7¼ inch circular saw with blade
  - 1 chain saw with chain, chain oil, and tool

  - 1 electric coring tool with 2 inch bit
  - 1 gas-powered chain saw
  - 1 gas-powered rotary saw
  - 1 gas-powered ring saw
  - 1 gas-powered core drill with 2 inch bit
  - 1 Stanley hydraulic power unit with tools, hoses, and bits
  - 1 vehicle extrication power unit with tools and hoses
  - 3 tool maintenance kits:
    - Multi-wrench
    - Belts
    - Chains
    - Bars
- Equipment:
  - 2 Self-Contained Breathing Apparatus (SCBA) cylinders
  - 2 extension cords
  - 1 handheld metal detector
  - Cutting table (if available)

Instructor-to-Participant Ratio

1 instructor to 8 participants:

- Minimum: 16 participants
- Maximum: 72 participants (more participants acceptable if hosting site can accommodate)

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Practical Exercise Statement

Participants will rotate between four stations where they will learn the setup, application, and use of tools for shoring, breaking and breaching, lifting and moving, and practice patient packaging.

Assessment Strategy

Instructors will assess participants through observation of proper techniques, questioning, and discussion.

Safety Review

Slide 3

Instructors will discuss any safety concerns related to the course, the site, and/or the weather.

In the case that a participant is injured during field exercises, it must be reported immediately to an instructor. The instructor cadre or designated Rapid Intervention Team (RIT) will perform any needed extrication or medical intervention.

Tool Lab

Slides 4–6

The key to any successful US&R operation is a thorough knowledge of the tools in the TF cache. The Structural Collapse Specialist must not only be able to select the appropriate tool to accomplish the task quickly and safely, but be able to troubleshoot minor tool problems and make the necessary on-site repairs.

Unfortunately, the US&R TF is not overly abundant with tools, small tool mechanics, or personnel to shuttle tools back and forth from the work site to the Base Camp. This requires the Structural Collapse Specialist to pick up the slack and make the minor tool repairs.

For each tool, this module provides information on the following:

- When to use
- Setup
- Breakdown
- Maintenance
- Troubleshooting
- Tool-specific safety issues

Structural Collapse Specialists are strongly encouraged to read the user manuals for the tools in their cache. The information provided in this manual includes only partial instructions for operating each tool.

Note: Additional guidance and information on the tool systems and how they work are located in Appendix B.

Pneumatic Tools

Pneumatic tools have many excellent applications, weigh less, and are very portable. With the exception of airbags, air tools are often measured not only in operating pressure but also Cubic Feet per Minute (CFM). This is the amount of air the tool uses to work. The speed of the air is expressed as Feet Per Second (FPS). These factors can be affected by the friction losses in the hoses.

When static, the air in these containers represents potential energy and needs to be relieved safely. Cracking valves or couplings may blow O-rings and launch projectiles. It is important to drain the pneumatic system appropriately.

Air Compressor

Application

The air compressor is used to power pneumatic tools. Gasoline- or diesel-powered air compressors provide air at a high pressure and/or flow in order to power a variety of rescue tools. These tools include, but are not limited to:

- Nail guns
- Breakers
- Die grinders (whizzer saws)
- Palm nailers

Setup

1. Ensure the engine switch is in the off position.
2. Ensure that the air tank is drained, the drain valve is closed, and that the safety valve is functioning properly.
3. Check the oil level in the pump. Do not operate without oil or with inadequate oil.
4. Check the engine's oil and fuel level.
5. Ensure all covers and labels are in place. Do not use the compressor until all items have been verified.

Breakdown

1. Stop the engine (see the compressor's instruction manual for the correct procedure).
2. Turn the regulator knob counterclockwise until it is fully closed. Make sure that the regulated pressure gauge reads 0 pounds per square inch (psi) (0 kilopascals [kPa]).
3. Remove the hose and accessory.
4. Drain the air tank.

Maintenance

All compressed air systems contain maintenance parts that are periodically replaced (e.g., oil, filters, and separators). These used parts may contain substances that are regulated and must be disposed of in accordance with local, state, and federal laws and regulations.

Note: Take note of the positions and locations of parts during disassembly to make reassembly easier.

Troubleshooting

Refer to Table 2.1 for troubleshooting information.

Table 2.1: Troubleshooting

Possible Cause	Possible Solution
Unloader valve does not release pressure when air tank reaches blow-off pressure	Service is required to replace valve.
Defective air tank	The air tank must be replaced. Do not repair the leak. The air tank can rupture or explode.
Leaking seals	Service is required to replace seals.
Defective safety valve	Pull on the ring to operate the safety valve manually. If the valve still leaks, it must be replaced.
Restricted air intake filter	Clean or replace air intake filter.
Loose engine mounting nuts	Tighten the mounting nuts. Torque the engine mounting nuts to 12–15 foot-pounds. (16.3–20.3 Newton meters). **Warning:** There is a risk of bursting. Excessive vibration could weaken the air tank and cause it to rupture or explode. The mounting screws must be kept tightened.
Regulator not adjusted correctly for accessory being used	It is normal for some pressure drop to occur when an accessory is used, adjust the regulator if pressure drop is excessive. **Note:** Adjust the regulated pressure under flow conditions while the accessory is being used.
Water in pump oil	Drain the oil and refill the pump with synthetic compressor oil.
Pump stiffener bracket bolt is loose	Check the bolt and tighten if required. Torque the pump stiffener bracket bolt to 35–50 inch-pounds. (3.9–5.6 Newton meters). **Warning:** There is a risk of bursting. Excessive vibration could weaken the air tank and cause it to rupture or explode. The stiffener bracket bolt must be kept tightened. Never operate the unit unless it is equipped with the stiffener bracket.

Safety Issues

- If operating a trailer-mounted air compressor, ensure the wheels are chocked.
- Larger air hoses on trailer-mounted compressors have couplings that can be locked together with a pin and whip checks. Any time these hoses are under pressure, use pins and whip checks.

Airbags

The following detailed information on setup, breakdown, and maintenance is adapted with permission from the Paratech *Operation, Preventive Maintenance and Parts Support Manual for Maxiforce® G2 Air Lifting Bag System*.

Application

Lifting bag systems are multi-application, portable inflation systems used for lift and displacement of heavy rigid objects, up to 178,400 pounds (80,920 kilograms), while requiring less than 1 inch (2.5 centimeters) of bag insertion clearance. Total capable lift (utilizing two stacked lift bags) is 40 inches (100 centimeters). Inflation may be obtained from any air source (self-contained compressed air cylinder, air compressor, truck air brake system, building compressed air system, foot pump, etc.) capable of supplying 150 psi (10.3 Bar) pressure.

Air Lifting Bag (ALB) systems are designed for use in emergency situations such as building collapse, structural containment, vehicular extrication, industrial entrapment, and excavation collapse and containment. The specific situation requiring the use of an ALB system will generally determine the size and quantity of lift bag(s) to be utilized in combination with each other.

Setup

1. Remove all dust, dirt, oil, or grease from the ALB system components. Do not use any system components without first cleaning off any contaminants.
2. Inspect all inlet and delivery fittings for any damage that will permit air leakage. Do not use any component if an air leakage condition is suspected or exists.
3. Attach the high-pressure inlet of the pressure regulator to the air supply. Tighten the connection to prevent air leakage. Do not over tighten.
4. Check that the pressure regulator shut-off valve is closed (full clockwise). Check that the pressure regulator pressure-adjusting knob is full counterclockwise to close the internal needle valve (no flow through the pressure regulator).
5. Attach an air hose quick connect coupling to the pressure regulator air delivery nipple using the appropriate interconnecting fittings as required.
6. Attach the inlet quick connect coupling on a 150-psi ALB controller to the air hose quick connect nipple.

7. Attach the inlet quick connect nipple on a safety inline relief valve to the delivery quick connect coupling on a 150-psi ALB controller. Check that the safety inline relief valve shut-off valve is closed (full clockwise).
8. If using a dual deadman 150-psi ALB controller, attach the inlet quick connect nipple on a second safety inline relief valve to the second delivery quick connect coupling on the dual deadman 150-psi ALB controller. Check that the safety inline relief valve shut-off valve is closed (full clockwise).
9. Attach an air hose quick connect nipple to the safety inline relief valve delivery quick connect coupling using the appropriate interconnecting fittings as required. Connect additional lengths of air hose of the same color as required.
10. If a second G2 safety inline relief valve is used, attach the air hose quick connect nipple to the second G2 safety inline relief valve delivery coupling using the appropriate interconnecting fittings as required. A different colored air hose should be used to permit the rapid and positive identification of the lift bag connected to each side of the controller. Connect additional lengths of air hose of the same color as required.
11. Attach a lift bag nipple to the air hose quick connect coupling.
12. If a second lift bag is being used, attach the second lift bag nipple to the other air hose quick connect coupling.

Breakdown

1. After the lift bag(s) has been removed from its lift/displacement position and the interconnected system components are gathered together, check that the supply pressure gauge and delivery pressure gauge on the pressure regulator indicate 0 psi:
   - If the supply pressure gauge indicates a pressure other than 0 psi, turn off the air supply. Any residual system air pressure will be relieved through the controller. If a significant pressure is still indicated, the air supply shut-off valve is probably defective and air leakage should be anticipated when the air supply is disconnected from the pressure regulator.
   - If the delivery pressure gauge on the pressure regulator indicates a pressure other than 0 psi, be sure the air supply is turned off and press the deflate side of the rocker lever to exhaust air from the system.
2. Turn the safety locking ring on the air hose quick connect coupling, interconnecting the lift bag, to the unlocked position. Disengage the coupling lock ring to release the lift bag from the air hose.
3. Turn the safety locking ring on the safety inline relief valve quick connect coupling, interconnecting the air hose, to the unlocked position. Disengage the coupling lock ring to release the air hose from the safety inline relief valve.

4. Turn the safety-locking ring on the 150-psi ALB controller quick connect coupling, interconnecting the safety inline relief valve, to the unlocked position. Disengage the coupling lock ring to release the safety inline relief valve from the 150-psi ALB controller.
5. If a dual deadman 150-psi ALB controller is used with two safety inline relief valves and associated lift bags, repeat preceding steps 2–4.
6. Turn the safety locking ring on the air hose quick connect coupling, interconnecting the pressure regulator to the unlocked position. Disengage the coupling lock ring to release the air hose from the pressure regulator.
7. As required, turn the safety locking ring on the air source fitting quick connect coupling, interconnecting the pressure regulator to the unlocked position. Disengage the coupling lock ring or other fitting to release the pressure regulator from the air source.
8. If the components are not to be immediately reused, perform the post-operation inspection and storage in accordance with the manufacturer's recommendations.

Maintenance

Because of the contaminants present where an ALB system is generally used (maintenance sites, construction sites, accident sites, etc.), it is important that the system components be thoroughly cleaned, inspected, and prepared for their next use before being placed in storage.

Cleaning

Do not use any petroleum-based product to clean components of the ALB system. Petroleum-based products could adversely react with the non-metallic parts of the system components and may result in a component failure when none should be expected or tolerated.

Keep the exterior of all components clean of all dirt, grit, oil, and grease accumulations. Except for the lift bag(s), wipe the exterior surfaces with a lint-free cotton machinery-wiping towel **lightly** dampened with soap and warm water solution. Be particularly careful to remove all dirt, sand, and grit from quick connect couplings and nipples. Swirl in a bucket with the soap and water solution until clean. Rinse with a wiping towel **lightly** dampened with clean water. Then dry the surfaces thoroughly with a clean, dry wiping towel or low pressure compressed air. Also clean the lift bag with a soap and warm water solution, but scrub the lift bag with a stiff bristle broom or brush and rinse by spraying with cold water. If the cleaning solution or rinse water gets into the lift bag through the nipple, allow the lift bag to dry thoroughly before its next use.

Inspection

1. While the lift bag is still wet with the cleaning solution, inflate to 30 psi and check for air bubbles denoting a leak(s). Except for air leakage from between

the air inlet fitting and the male nipple, replace rather than attempt to repair a leaking lift bag.

2. Clean the interfacing threads and inspect the male nipple for visual damage.
3. Reconnect the lift bag to an air source, re-inflate to 30 psi and recheck for air leaks. If none are found, deflate the lift bag, disconnect the quick connect coupling and install the tethered protective cap over the male nipple in preparation for storage.
4. After a lift bag is clean and dry, thoroughly inspect all surfaces for cuts, abrasions, air bubbles and bulges (ply separation), and other similar damage. Remove all debris from the surface. Minor surface cuts and abrasion can be repaired with rubber cement and should not be considered a problem unless they are deep enough to expose the Kevlar reinforcement layer.
5. Inspect hose assemblies for cuts, cracks, crimps, and brittleness. Inspect the hose quick connect coupling and nipple for secureness of attachment and burrs, nicks, corrosion, and other similar damage that would prevent a leak-proof interconnection.
6. If during the last three months the ALB system and accessories have not been used for training or actual operational functions, field test them to ensure they do not leak and are fully operational in preparation for their next use.

Safety Issues

- Do not stack more than two ALBs, unless indicated as safe by the manufacturer.
- Do not overinflate ALBs.
- Provide adequate stabilization for the object being lifted.

Nail Gun

The following detailed information on setup, breakdown, maintenance, troubleshooting, and safety is adapted with permission from the Ridgid *Operator's Manual: Full Round Head Framing Nailer*.

Application

A nail gun is a pneumatic tool used to drive nails into wood or other material.

Setup

1. Under normal use conditions, the tool should be lubricated before connecting the tool to an air supply. Add 30 drops of oil into the swivel connector to lubricate the tool before its first use. After the initial lubrication, maintain the tool by adding oil daily. Add 10 drops once daily with minimal use or twice daily with heavy use. Only add oil as necessary. Excess oil will collect inside the tool and will be visible around the upper and lower exhaust.

2. Before using the tool, check the air compressor gauge to be sure it is functioning within the proper range of 70–120 psi, and ensure that the tool is fully operational by completing the required daily checklist as described in the manufacturer's operating manual. Do not use an improperly functioning tool.
3. This tool is designed to operate on clean, dry compressed air at regulated pressures between 70 and 120 psi. The correct air pressure is the lowest pressure that will do the job:
   - The tool and air hose must have a hose coupling that allows all pressure to be removed from the tool when the coupling is disconnected.
   - Connect the tool to the air supply with a ¼ inch female quick connector. A ⅜ inch female quick connector may be used in situations where a ¼ in. supply line is not available. For maximum tool performance, a ⅜ inch supply line and fittings are required.
4. With the nose of the tool pointed away from you, feed a strip of nails into the magazine. Be sure the nails are pointed downward and at the correct angle shown in the manufacturer's operating manual.
5. Slide the pusher all the way to the rear of the magazine. Release the pusher and allow it to push the nails up to the driving mechanism. The pusher will stop when it rests against the end of the nail strip.

   Note: Do not allow the pusher to snap back into place.

Setting the Air Pressure

- The amount of air pressure required will depend on the size of the nail and the workpiece material.
- Begin testing the depth of drive by driving a test nail into the same type of workpiece material used for the actual job.
- Drive a test nail with the air pressure set at 90–95 psi. Raise or lower the air pressure to find the lowest setting that will perform the job with consistent results.
- It may be possible to achieve the desired depth with air pressure adjustments alone. If finer adjustments are needed, use the drive depth adjustment on the tool.

Drive Depth Adjustment

- The driving depth of the nail may be adjusted. It is advisable to test the depth on a scrap workpiece to determine the required depth for the application.
- To determine depth of drive, first adjust the air pressure and drive a test nail. To achieve the desired depth, use the drive depth adjustment on the tool:
  - Disconnect the tool from the air supply.
  - Turn the depth selector left or right to change the driving depth.

- Reconnect the tool to the air supply.
- Drive a test nail after each adjustment until the desired depth is set.

Breakdown

1. Turn off the air supply.
2. Bleed the pressure from the airlines and tool.
3. Disconnect the tool and hoses and prepare for storage.

Maintenance

Lubrication

Frequent but not excessive lubrication is required for the best performance. Oil for pneumatic fastening tools added through the air line connection will lubricate the internal parts. Do not use detergent oil or additives because these oils will cause accelerated wear to the seals and bumpers in the tool, resulting in poor tool performance and frequent tool maintenance.

Cold Weather Operation

For cold weather operation, near and below freezing, the moisture in the air line may freeze and prevent tool operation. The manufacturer recommends the use of air tool oil or permanent antifreeze (ethylene glycol) as a cold weather oil.

Air Supply Pressure and Volume

Air volume is as important as air pressure. The air volume supplied to the tool may be inadequate because of undersized fittings and hoses or from the effects of dirt and water in the system. Restricted air flow will prevent the tool from receiving an adequate volume of air, even though the pressure reading is high. The results will be a slow operation or reduced driving power. Before evaluating tool problems for these symptoms, trace the air supply from the tool to the supply source for restrictive connectors, low points containing water, and anything else that would prevent full volume flow of air to the tool.

Troubleshooting

Refer to Table 2.2 for troubleshooting information.

Table 2.2: Troubleshooting

Problem	Possible Cause	Solution
Air leak near the top of the tool or in the trigger area	• Inadequate lubrication • Loose screws • Worn or damaged O-rings or seals	• Lubricate tool • Tighten screws • Install overhaul kit
Air leak near the bottom of the tool	• Inadequate lubrication • Loose screws • Worn or damaged O-rings or bumper	• Lubricate tool • Tighten screws • Install overhaul kit
Tool does nothing or operates sluggishly	• Inadequate air supply • Inadequate lubrication • Worn or damaged O-rings or bumper	• Verify adequate air supply • Lubricate tool • Install overhaul kit
Tool jams frequently	• Incorrect fasteners • Damaged fasteners • Loose magazine • Dirty magazine • Worn or damaged driver	• Verify that fasteners are the correct size • Replace fasteners • Tighten screws • Clean magazine • Install driver maintenance kit

Safety Issues

- Do not force the tool. Use the correct tool for an application. The correct tool will do the job better and safer at the rate for which it is designed.
- Do not use the tool if the trigger does not actuate properly. Any tool that cannot be controlled with the trigger is dangerous and must be repaired.
- Check the operation of the workpiece contact mechanism frequently. Do not use the tool if the workpiece contact mechanism is not working correctly because accidental driving of a fastener may result. Do not interfere with the proper operation of the workpiece contact mechanism.
- Store idle tools out of the reach of children and other untrained persons. Tools are dangerous in the hands of untrained users.
- Maintain tools with care. Follow the maintenance instructions. Properly maintained tools are easier to control.
- Check for misalignment or binding of moving parts, breakage of parts, and any other condition that may affect the tool's operation. If damaged, have the tool serviced before using. Many accidents are caused by poorly maintained tools.

- Use only fasteners that are recommended for the model being used.
- Keep the tool and its handle dry, clean, and free from oil and grease. Always use a clean cloth when cleaning. Never use brake fluids, gasoline, petroleum-based products, or any strong solvents to clean the tool. Following this rule will reduce the risk of loss of control and deterioration of the enclosure plastic.

Palm Nailer

The following detailed information on setup, breakdown, maintenance, troubleshooting, and safety is adapted with permission from the Ridgid *Operator's Manual: Palm Nailer*.

Application

A variation on the nail gun is the palm nailer, which is a lightweight, handheld pneumatic nailer that straps to the hand. It is convenient for working in tight spaces where a conventional nailer will not fit and is flexible enough to drive either short nails into metal straps or 6-inch nails into timber. By repeated hammer action (of around forty hits per second), the fastener is driven into the material by a more constant palm pressure (as opposed to a conventional nail gun, which drives the nail against the inertia of the nail gun).

Setup

1. Under normal use conditions, the tool should be lubricated before connecting the tool to an air supply. Add air tool lubricant into the air fitting on the tool once daily with minimal use or twice daily with heavy use. Only a few drops of oil at a time is necessary. Too much oil will only collect inside the tool and will be noticeable in the exhaust cycle.
2. Before connecting the tool, check the air compressor gauge to be sure it is functioning within the proper range of 50–120 psi:
   - This tool is designed to operate on clean, dry compressed air at regulated pressures between 50 and 120 psi. The correct air pressure is the lowest pressure that will do the job. **Note:** Air pressure that is higher than 120 psi may damage the tool.
   - The tool and air hose must have a hose coupling that allows all pressure to be removed from the tool when the coupling is disconnected.
   - Connect the tool to the air supply with a ¼ inch female quick connector. A ⅜ inch female quick connector may be used in situations where a ¼ inch supply line is not available. For maximum tool performance, a ⅜ inch supply line and fittings are required.
3. With the nose of the tool pointed away from you, feed a nail into the nosepiece. Be sure the nails are pointed downward and at the angle shown in the manufacturer's operating manual.
4. Do not hold the tip or head of the nail when feeding it into the nosepiece.

Setting the Air Pressure

- The amount of air pressure required will depend on the size of the nail and the workpiece material.
- Begin testing the depth of drive by driving a test nail into the same type of workpiece material used for the actual job.
- Drive a test nail with the air pressure set at 50–55 psi. Raise or lower the air pressure to find the lowest setting that will perform the job with consistent results.
- It may be possible to achieve the desired depth with air pressure adjustments alone. If finer adjustments are needed, use the drive depth adjustment on the tool.

Driving Nails

- Place the tip of the nail against the workpiece.
- Push the tool firmly with your palm. Keep the nail in line with the nosepiece as the nail is driven.
- Remove the tool from the nail when complete.

Breakdown

1. Shut off the air supply.
2. Bleed the pressure off the tool.
3. Disconnect the hoses and prepare for storage.

Maintenance

Lubrication

Frequent but not excessive lubrication is required for the best performance. Oil for pneumatic fastening tools added through the air line connection will lubricate the internal parts. Do not use detergent oil or additives because these lubricants will cause accelerated wear to the seals and bumpers in the tool, resulting in poor tool performance and frequent tool maintenance.

Cold Weather Operation

For cold weather operation, near and below freezing, the moisture in the air line may freeze and prevent tool operation. The manufacturer recommends the use of air tool lubricant or permanent antifreeze (ethylene glycol) as a cold weather lubricant.

Air Supply Pressure and Volume

Air volume is as important as air pressure. The air volume supplied to the tool may be inadequate because of undersized fittings and hoses or from the effects of dirt and water in the system. Restricted air flow will prevent the tool from receiving an adequate volume of air, even though the pressure reading is high. The results will

be a slow operation or reduced driving power. Before evaluating tool problems for these symptoms, trace the air supply from the tool to the supply source for restrictive connectors, low points containing water, and anything else that would prevent full volume flow of air to the tool.

Troubleshooting

Refer to Table 2.3 for troubleshooting information.

Table 2.3: Troubleshooting

Problem	Possible Cause	Solution
Tool does nothing or operates sluggishly	• Inadequate air supply • Inadequate lubrication • Worn or damaged O-rings or bumper	• Verify adequate air supply • Lubricate tool • Install overhaul kit and replace O-rings
Tool jams frequently	• Incorrect fasteners • Damaged fasteners	• Verify that fasteners are the correct size • Replace fasteners

Safety Issues

- Know your pneumatic tool. Read the operator's manual carefully. Learn its applications and limitations, as well as the specific potential hazards related to this tool. Following this rule will reduce the risk of electric shock, fire, or serious injury.
- Make sure the hose is free of obstructions or snags. Entangled or snarled hoses can cause loss of balance or footing and may become damaged.
- Use the tool only for its intended use.
- Use the pneumatic tool only for the purpose for which it was designed.
- Do not use hardened nails in this tool.
- Use only the fasteners recommended for this tool. Use of the wrong fasteners could result in poor fastener feeding, jammed fasteners, and nails leaving the tool at erratic angles. If fasteners are not feeding smoothly and properly, discontinue their use immediately. Jammed and improperly feeding fasteners could result in serious personal injury.
- Never use this tool in a manner that could cause a fastener to be directed toward anything other than the workpiece.
- Do not use the tool as a hammer.
- Always carry the tool by the handle. Never carry the tool by the air hose.
- Do not alter or modify this tool from the original design or function without approval from the manufacturer.

- Always be aware that misuse and improper handling of this tool can cause injury to yourself and others.
- Never leave a tool unattended with the air hose attached.
- Do not operate this tool if it does not contain a legible warning label.
- Do not continue to use a tool that leaks air or does not function properly.

Paratech Rescue Support Systems (RSS)

The following detailed information on application, setup, breakdown, maintenance, and safety is adapted with permission from the Paratech *Operation and Maintenance Manual for Rescue Support Systems*.

Application

The RSSs are designed for use in rescue situations involving collapse, containment, or stabilization. These situations include such diverse incidents as building collapse, structural containment, vehicular extrications, industrial entrapment, and excavation collapse and containment.

Setup

1. Once the proper support configuration is determined and the individual components (extendable strut, extension [if necessary], and base plates) are selected, it is only necessary to sufficiently clean, where required, the individual components (strut components in addition to pressurized components) to clear them of any contamination that would prevent their full engagement and proper locking to each other.
2. Depending on the optional accessories being used, inspect the inlet and outlet fittings on the interconnecting hoses, regulator 300 psi Compressed Gas Association (CGA), single strut controller G2/dual deadman RSS controller G2, single strut controller/dual deadman strut controller, and manual air compressor/air cylinder for any damage that will allow air leakage. Do not use any accessory that exhibits an air leakage condition.
3. If using an optional regulator 300 psi CGA, close the outlet shut-off valve assembly and turn the adjusting knob assembly full counterclockwise to close the internal needle valve (no flow through the pressure regulator).
4. If using an optional single strut controller G2/dual deadman RSS controller G2, single strut controller/dual deadman strut controller depress the “DOWN” marking side of the rocking lever to prevent flow through the controller.
5. Connect the regulator 300 psi CGA to the optional air cylinder. Be sure the hand tightening knob/nut on the regulator 300 psi CGA is tightened sufficiently to prevent leakage.
6. Connect the desired length delivery hose to the regulator 300 psi CGA outlet quick disconnect delivery coupling and the single strut controller G2/dual deadman RSS controller G2, single strut controller/dual deadman strut

controller inlet quick disconnect nipple. Be sure each quick disconnect mechanism is fully engaged and locked in position to ensure a leak-free connection.

7. Connect one or two desired length delivery hose(s) to the single strut controller G2/dual deadman RSS controller G2, single strut controller/dual deadman strut controller quick disconnect delivery coupling(s). Be sure each quick disconnect mechanism is fully engaged and locked in position to ensure a leak-free connection. Do not connect the LockStroke/AcmeThread strut(s) inlet quick disconnect delivery nipple(s) to the delivery hose(s) until complete configuration of the strut(s) is determined, the components are assembled, and the assembled strut is ready for placement.

   Note: Different tools require different air pressures. Make sure the regulator is set for the tool based on manufacturer recommendations.

Breakdown

1. At the conclusion of use, close the air cylinder 3,000 psi supply valve.
2. Bleed the outlet hose(s) going to the strut(s) from the controller. Press the red "DOWN" pushbutton(s) or rocking lever on the controllers until the gauge reads 0.
3. Disconnect the outlet hose(s) to the strut from the controller:
   - *Pushbutton Style:* Bleed the regulator 300 psi CGA and the inlet hose by pushing the green "UP" and red "DOWN" pushbuttons on the single strut controller/dual deadman strut controller at the same time until the gauges on the regulator 300 psi CGA reads 0.
   - *Rocker Style:* Bleed the regulator 300 psi CGA and the inlet hose by pushing the green "UP" on the rocking lever for the single strut controller G2/dual deadman RSS controller G2 (the outlet coupling is an open coupling) until the gauges on the regulator 300 psi CGA reads 0.
4. Disconnect the air inlet hose from the controller and the regulator 300 psi CGA.
5. Disconnect the regulator 300 psi CGA from the air cylinder 3,000 psi.

Maintenance

- Keep the exterior of all components clean of all dirt, grit, oil, and grease accumulations. Wipe exterior surfaces with a lint-free cotton machinery wiping towel lightly dampened with clean water. Then dry the surfaces thoroughly with a clean, dry lint-free cotton machinery wiping towel or low pressure compressed air. Compressed air may be used for cleaning in less accessible areas.
- If cleaned with a soap and water solution, lubricate O-rings/seals with grease and lock pins/couplings with WD40.

Troubleshooting

If air leaks from inside the strut while pressuring, bleed off pressure. Remove the piston end from the strut and check the cup seal. If the cup seal appears to be in working condition, flex the edges repeatedly and replace the piston end into the cylinder end of the strut and reuse. If it is still leaking, take it out of service for repair.

Safety Issues

In collapse rescue situations struts are not designed to accept more than two extensions 3 feet (91.44 centimeters) in length. Additional safety issues include the following:

- Do not connect any pressurized hose to a strut. Bleed off any pressure from the strut and/or hoses before connecting or disconnecting hoses.
- Never point a strut toward yourself or other personnel. Accidental activation could cause the strut to extend rapidly and forcibly resulting in serious injury or possible death. Do not activate a strut unless it is between two work surfaces.
- Do not use any accessory that exhibits an air leakage condition. Any reduction of air pressure could result in collapse and endangerment of personnel.
- Do not adjust the pressure regulator to exceed the maximum pressure rating of any component in the system apparatus.

Paratech HydraFusion Strut (HFS)

The following detailed information on application, setup, maintenance, and safety is adapted with permission from the Paratech *Instruction Sheet: HydraFusion Strut (HFS) Kit*.

Application

The Paratech HFS gives the ability to lift up to 10 U.S. tons (9 metric tons) with a Safety Factor (SF) of 2:1 and to stabilize up to 20,000 pounds (9,071 kilograms) with an SF of 4:1.

Setup

1. Couple the HFS tube end down onto any compatible Paratech base plate and make sure the lock pin is secure.

   Note: The HFS can be used in any orientation; however, tube end down is preferred to facilitate lock collar adjustment and eliminate trip hazards by keeping the hydraulic hose at ground level.

2. To prevent movement and/or sliding, connect a ratchet belt or chain to an opposing base plate. An optional stake or picket to secure the base plate to the ground can be used where applicable, otherwise refer to the officer in charge for alternate methods.

3. Select the appropriate Paratech strut, extension, or extension converter with base for the application and insert it tube end down into the dual shaft end adapter. Make sure the lock pin is properly engaged. The dual end shaft adapter was engineered to accept Paratech LongShore, AcmeThread, or LockStroke products. **Do not insert strut screw ends into the dual shaft end adapter.** Inserting screw ends can jam the retaining ring in the HFS and require the equipment to be placed out of service. Bases can be used on the dual end shaft adapter with a Paratech extension converter (PN 22-796035).
4. To maximize the hydraulic lift efficiency and safety, always position the HFS at a 60- to 80-degree angle or greater with respect to the ground and object being lifted. Always install stabilization struts first and use them for backup at 45–55 degrees with respect to the ground and the object being lifted.
5. Connect the pump to the HFS by first wiping clean the no-spill coupler ends. Relieve pressure on the hose before connecting by turning the pump control knob counterclockwise. Push the no-spill couplers together until they lock and then turn the lock collar to prevent accidental disconnection.
6. To unlock the pump handle, pull the handle lock strap down then out. This places the handle in an open or working position. To lock the handle, pull the strap down and hook it on the latch.
7. To extend the HFS, turn the pump control knob clockwise (hand tight) to the closed position and work the handle up and down to build pressure.

   Note: The pump can be operated in a horizontal position or in a vertical position with the head pointing downward.
8. To release pressure, open the pump control knob by *slowly* turning counterclockwise to control the load descent.
9. As the load is lifted, turn down the lock collar to make contact with the HFS tube body, shoring the load. (**Note:** The maximum lift height is slightly more than the maximum stabilizing height to prevent system lockout in application.) Once the maximum lift is achieved, open the pump control knob *slowly* until the lock collar is seated onto the HFS tube body.
10. To retract the HFS, ensure the pump control knob is completely closed and use the pump to extend the HFS enough to take the load off the lock collar.
11. Slowly open the pump control knob while rotating the lock collar away from the HFS tube body. The lock collar should never get more than 1 inch away from the tube body as the load is lowered for safety reasons.
12. After use or before disconnecting the hose from the pump or strut, make sure to relieve pressure from the system by turning the pump control knob counterclockwise and allowing the strut to fully retract.

Breakdown

Reverse the setup operation.

Maintenance

- Bleeding air from the hydraulic system is recommended at initial set-up and after prolonged use. To remove the air, position the HFS at a lower level than the pump and with the dual shaft end adapter down. Extend and retract the HFS several times without putting a load on the system. Air will be released into the pump reservoir and can be removed by loosening the pump filler cap.
- Check the hydraulic fluid level in the pump reservoir periodically. When the pump is level and resting horizontally, the oil level should come to the bottom edge of the filler hole. The HFS should be fully retracted before checking the fluid level in the pump. Replenish fluid levels with Paratech hydraulic fluid (PN 22-790051).
- Apply grade 10 motor oil or grease to all pivot and rubbing points on the pump regularly.
- Periodically lubricate the AcmeThread shaft, lock collar, and dual shaft end adapter with a high quality dry spray lubricant, such as DuPont Teflon dry lubricant, and keep free of dirt and debris.
- Replace worn, kinked, leaking, or cut hose as required.
- To clean, wipe all exposed surfaces with clean warm water and a soft cloth.

Safety Issues

- Do not exceed the rated capabilities of the HFS, pump, or hose. Excess pressure may result in personal injury.
- Control the load at all times with stabilization struts. Always install stabilization struts first at a lower angle with respect to the ground and the object being lifted; 45–55 degrees is optimal.
- Always perform a lift using the HFS at a 60- to 80-degree angle or greater with respect to the ground and the object being lifted.
- A vertical lift using the HFS directly under a load is acceptable at 90 degrees.
- Make sure the HFS lock collar follows the load at all times by adjusting the lock collar down as the HFS is extended. The lock collar should never get more than 1 inch away from the tube body.
- *Do not* rapidly drop a load supported by the HFS. Lower the load carefully by *slowly* opening up the pump control knob.
- Before adding hydraulic fluid, fully retract the HFS to prevent overfilling of the pump reservoir. Overfilling may cause personal injury due to excess reservoir pressure created when an HFS is retracted.
- To maintain optimal oil level in the pump, extend and retract HFSs using the same pump assembly. Each pump assembly has the oil capacity to extend up to 26 inches of HFS travel.

- Do not use the pump hose to move attached equipment. Stress may damage the hose and fittings, which could cause personal injury and equipment failure.

Breakers

The following detailed information on setup, maintenance, troubleshooting, and safety is adapted with permission from the Chicago Pneumatic *Safety and Operating Instructions: Handheld Pneumatic Breakers CP 1210, CP 1230, CP 1240*.

Application

Pneumatic breakers are used for breaching and breaking concrete and asphalt. These tools are used primarily when trailer-mounted air industrial compressors are available. The wide availability of these tools makes them a tool of choice for larger concrete breaking operations.

Setup

1. Blow any impurities out of the compressed air hose before connecting it to the machine.
2. Select the correct dimension and length for the compressed air hose:
   - For hose lengths up to 100 feet (30 meters), a hose with a minimum internal diameter of ¾ inch (19 millimeters) should be used.
   - If the hose length is between 100 and 330 feet (30 and 100 meters), a hose with a minimum internal diameter of 1 inch (25 millimeters) should be used.
3. Place the proper inline oiler tools between the tool and the compressor.
4. Use whip checks and pins on all connections.

Breakdown

1. Shut down the compressor.
2. Bleed off the air pressure.
3. Disconnect the hoses.
4. Clean tools for storage.

Maintenance

- Before undertaking any maintenance or changing the insertion tool on pneumatic machines, always switch off the air supply and bleed the machine by depressing the start and stop device. Then disconnect the air hose from the machine.
- Clean and inspect the machine and its functions each day before the work commences.
- Check the tool retainer for wear and function.

- Conduct a general inspection for leaks and damage.
- Check that the air inlet nipple is tightened and that the claw coupling is free from damage.

Troubleshooting

If the pneumatic machine does not start or has low power or uneven performance, check the following points:

- Check that the insertion tool being used has the correct shank dimension.
- Check that the pneumatic machine is getting the correct amount of lubricant. Too much lubrication can cause starting problems, low power, or uneven performance.
- Check that the compressed air system supplies the machine with sufficient air pressure to give full power.
- Check that the dimension and length of the air hose are according to the recommendations.
- If there is a risk of freezing, check that the machine's exhaust ports are not blocked.
- If the machine function is still not satisfactory after this procedure, contact an authorized service workshop.

Safety Issues

- Check that the compressed air hose and the connections are not damaged; replace if necessary.
- Check that all compressed air connections are properly attached.
- Never carry a pneumatic machine by the air hose.
- Never attempt to disconnect a compressed air hose that is pressurized. First switch off the compressed air at the compressor and then bleed the machine by activating the start and stop device.
- Never point a compressed air hose at yourself or anyone else. To avoid the risk of getting injured, never use compressed air to blow dust or dirt (for example) from your clothes.
- Do not use quick disconnect couplings at the tool inlet. Use hardened steel (or material with comparable shock resistance) threaded hose fittings.
- Whenever universal twist couplings (claw couplings) are used, the manufacturer recommends that lock pins are installed and whipcheck safety cables are used to safeguard against possible hose to tool and hose to hose connection failure.
- Never start the machine while changing the insertion tool.

- Before changing the insertion tool or accessories, stop the machine, switch off the power supply, and bleed the machine by activating the start and stop device.
- Never point the inserted tool at yourself or anyone else.
- Make sure that the insertion tool is fully inserted and the tool retainer is in a locked position before the machine is started.
- Check the locking function by pulling the inserted tool outward forcefully.

Torches

Cutting with a torch is the process of mostly oxidizing and melting metal with oxygen and fuel to effect separation. Ferrous metals (i.e., structural steel) are the only metals able to be cut using this process.

This process heats the material to its ignition temperature by placing the torches preheat flame close to the metal. When the metal is heated to a bright orange, the cutting oxygen lever is depressed. This starts the cutting process. This leaves a thin kerf in the metal.

Acetylene is the most common fuel gas. The Petrogen torch uses unleaded gasoline for fuel. With a multi-fuel adapter, the torch can use many different fuels (e.g., diesel, biodiesel, kerosene, jet A liquid fuels, JP5, JP8, and JP24).

Oxygen/Acetylene Torch System

Application

Oxygen/Acetylene has been the most widely used metal burning technology in the industry for many years.

The benefits of oxygen/acetylene include the following:

- There are a wide range of torches, accessories, and gases available from most welding and gas suppliers.
- It is the industry standard used by most fabrication shops and at most construction or demolition sites.

Oxygen/Acetylene does have some disadvantages:

- Acetylene has one of the widest flammable ranges of any fuel gas (2.5-81 percent) and is extremely hazardous at pressures exceeding 15 pounds per square inch gauge (psig).
- Acetylene gas requirements for proper handling, use, and storage must be followed at all times.

- The oxygen/acetylene burning operation can create large amounts of molten slag when cutting thick steel:
  - This slag can fuse back into the cuts and cause problems for the burner if clean cuts are not made.
  - Slag may also ignite spot fires and can be a hazard to the operator.

Setup

1. Inspect tanks and hoses for damage.
2. Before regulators are attached, crack cylinders to remove dirt/debris and to ensure there is gas in the cylinders.
3. Make sure regulator adjustment screws are backed off and spin freely.
4. Set oxygen and fuel pressures while gas is flowing.
5. Perform a leak check based on the manufacturer's guidelines.
6. Ensure tank valves are off and pressure gauges are at 0.
7. Ensure torch valves are off.
8. Slowly turn on the oxygen cylinder valve. Be sure to turn it on *slowly* to prevent the regulator from exploding. Stand to the side of the cylinder when opening.
9. Slowly turn on the acetylene cylinder valve ½ to ¾ turn.
10. Set the pressure on each regulator according to the manufacturer's recommendations.
11. Purge each hose by opening the valves one at a time for a few seconds.
12. Connect the torch to the hoses, being careful not to overtighten the fittings. Always use flashback arresters on both the fuel and oxygen lines.
13. Open the acetylene torch valve ⅛-¼ turn. Not opening the valve enough will cause acetylene black soot floaters.
14. Use a torch striker to light the torch. Open the acetylene valve until the smoke just goes away from the flame and so that the flame is not jumping away from the tip.
15. Open the oxygen torch until the inner cone is defined.

Breakdown

1. Turn off the fuel gas torch valve.
2. Turn off the oxygen torch valve.

   Note: Some torch brands have instructions to turn off the oxygen first. Be sure to follow manufacturer's instructions.
3. Turn off the oxygen and acetylene cylinder valves.

4. Purge the oxygen line by opening the torch oxygen valves one at a time until the gauge pressure reads 0. Close the valve.
5. Back out the oxygen regulator pressure screw until it is loose.
6. Purge the acetylene line by opening the torch acetylene valve until the gauges read 0.
7. Back out the acetylene regulator pressure screw until it is loose.

Maintenance

1. Perform leak testing.
2. Test internal check valves.

Troubleshooting

Refer to Table 2.4 for troubleshooting information.

Table 2.4: Troubleshooting

Problem	Solution
Preheat flame pops periodically	• Tip nut loose: Tighten the tip nut to manufacturer's recommendations. • Damaged seating surface on tip or torch head: Replace the tip or ream out the head.
Preheat flame changes when the high-pressure oxygen valve is open	• Faulty cutting oxygen valve: Replace the cutting oxygen valve. • Worn or missing packing in the cutting oxygen valve: Replace the cutting oxygen valve. • Internal leakage: Test the torch for internal leaks and repair as required. • Improper oxygen pressure: Check the oxygen setting.
Torch performance is sluggish or penetration is insufficient	• Wrong tip size: Check for the proper tip. • **Oxygen regulator not delivering proper pressure: Replace the cylinder or regulator.** • Cylinder is being overdrawn: Creates a risk of drawing the liquid acetone out of the cylinder. • Restriction in cutting oxygen orifice: Clean the cutting oxygen orifice. • Oxygen hose pinched or clogged: Clear the hoses.

Table 2.4: Troubleshooting (continued)

Problem	Solution
Neutral preheating flame cannot be adjusted or low pressure oxygen supply cannot be shut off	• Cone end between cutting attachment and torch is not seating properly: Replace the cone end or ream the head. • Cone end O-rings worn or missing: Replace the O-rings.
Leak around the valve stem	• Loose packing nut: Tighten the packing nut. • Damaged packing: Replace the valve stem assembly.
Flame flickers during use	Loose stainless steel balls in the control valves: Replace the valve stem assembly.
Torch pops excessively	• Obstructions in tip: Clean or replace the tip. • Regulator is delivering insufficient gas: Replace the cylinder or regulator. • Low cylinder pressure: Replace the cylinder. • Improper regulator setting: Check for proper regulator setting. • Internal leaks in torch: Test the torch per welding torches test procedure.
Difficulty in maintaining a neutral flame	• Regulator not functioning properly: Test and repair the regulator. • Hoses pinched or clogged: Clear the hoses. • Control valves damaged: Replace the control valves.

Safety Issues

Acetylene

Acetylene becomes unstable when compressed in its gaseous state above 15 psig. Acetylene gas requires a special cylinder that must have a porous core that is saturated with liquid acetone. Acetylene gas is pumped into the cylinder and absorbed by the acetone, which keeps the gas stable while under pressure. Acetylene cylinders must always be stored and used in an upright position to keep the liquid acetone properly contained.

The maximum safe delivery pressure for acetylene is 15 psig. **Never** exceed regulated pressures above 15 psig or the acetylene gas will become very unstable. Only one-tenth of the total capacity of an acetylene cylinder should be withdrawn per hour. This is controlled by the tip size being used and regulated fuel gas pressure. If more than one-tenth of the total capacity is withdrawn from the cylinder per hour, it may also withdraw the liquid acetone.

Never completely drain all of the gas out of the cylinder. Always change out cylinders before they are completely empty, leaving some measurable amount of gas product in the cylinder. If responders completely drain the cylinder, they may run the risk of contaminating the cylinder with mixed gases by allowing gas to travel down through the hose into the mixing chamber of the torch and then back down through the other hose into the empty cylinder. If this goes unnoticed by the welding gas supplier, the next time the tank is filled the cylinder will contain mixed gases that may be explosive. Friction generated during filling or opening the high pressure cylinder may cause the cylinder to explode. This is the reason for using one-way check valves and flashback arrestors on the regulators and torch.

Oxygen

Grease and oil must never come in contact with any component of an oxygen system, cylinder, regulator, hose, or torch. The grease and oil can combust and burn violently in the presence of pure oxygen.

Oxygen/Gasoline Torch System

The following detailed information on setup, breakdown, maintenance, and troubleshooting is reprinted with permission from the Petrogen Advanced Cutting Torch Systems *Liquid Fuel Cutting Torch System Reference Manual* (Version 1.1).

Updates to this manual can be found online (https://petrogen.com/pages/training). For additional information or clarification, please contact Petrogen at:

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Application

Oxygen/Gasoline torch systems are commonly referred to by the brand name, Petrogen. These systems operate somewhat differently from the oxygen/acetylene systems that most torch operators are accustomed to. They use all of the same oxygen components and safety guidelines and the torches look and operate in much the same way, but they utilize their fuels differently. In the oxygen/gasoline system, the gasoline stays liquid until it reaches the cutting tip where it is heated and turned into a vapor in much the same way a propane stove or lantern works.

Oxygen/Gasoline systems have many advantages:

- They can cut steel up to 14 inches thick.
- They will cut through various sized air gaps.
- Cut pieces are less likely to fuse themselves back together.
- Oxygen/Gasoline burns cleaner and with little slag.
- They are not limited by fuel cylinder size.
- Gasoline is readily available and is safer than acetylene.
- They can be used under water with special tips.

Oxygen/Gasoline torches are very popular because of the lack of disadvantages. One disadvantage, however, is that oxygen/acetylene is used by many industries, including construction, and is more readily available.

Setup

Before assembling your system or after prolonged storage check that all components are present, serviceable, and undamaged. It is also best practice to check system components for serviceability before each use and to perform a leak check before operation.

Torch Assembly

1. Slide tip nut over chosen tip. Place tip's seating surface into torch head.
2. Tighten the tip nut in a clockwise manner using an adjustable wrench. DO NOT OVERTIGHTEN.
3. Attach the oxygen flashback arrestor (found in the Standard Spare Parts Kit) to the torch's oxygen hose connector (labeled OXY). Use an adjustable wrench to snug the oxygen flashback arrestor to the torch.

Packing Nut Check

1. Use the included Packing Nut Wrench found in the Standard Tool Kit to check the following packing nuts for snugness:
   - Pre-Heat Oxygen Packing Nut: located under the Pre-Heat Oxygen Knob on the Torch
   - Fuel Control Packing Nut: located under the Fuel Control Knob on the Torch
   - With the Adjustable Wrench, check the Fuel Valve Packing Nut: located under the Fuel Valve on the Liquid Fuel Tank
2. The packing nuts should be snug at all times to ensure proper valve seal. If desired, knob tension can be adjusted by increasing the tightness of the packing nuts.

Oxygen Regulator and Oxygen Hose

1. Inspect the Regulator inlet and Oxygen Bottle Valve port for debris. Ensure the oxygen valve is clear by briefly opening (crack open) the Oxygen Bottle, allowing oxygen to expel any debris. **WARNING:** Any debris between the Regulator and Oxygen Bottle Valve can create combustion inside the Regulator which may violently exit through the regulator gauges.
2. Connect the Regulator to the Oxygen Bottle. Snug the fitting with the Adjustable Wrench.
3. Attach one end of the green Oxygen Hose to the Oxygen Flashback Arrestor on the Torch and the other end to the Regulator. Snug both fittings with an adjustable wrench (All Oxygen fittings have a standard right hand thread and cannot be confused with fuel fittings which have a left hand thread).

Oxygen Hose Pressurization

1. It is best practice to pressurize the oxygen line before the fuel line. Maintaining positive pressure throughout the oxygen system safeguards the oxygen line against fuel contamination. If fuel is allowed to enter the Oxygen Hose, a flashback may occur. Purging the Torch before light up further protects the operator against oxygen line flashback.
2. When opening the Oxygen Bottle Valve, ALWAYS FACE AWAY FROM THE GAUGES. Open the valve slowly and fully.

Oxygen Pressure Settings

The oxygen pressure setting is based on the Tip size selected. Each Tip has a specified range of acceptable oxygen pressure. Begin with the lower pressure indicated and increase the pressure if necessary. Using incorrect oxygen pressure will greatly affect performance and consumption, however it will not create a hazard.

- The gauge on the left indicates the amount of pressure being delivered to the Torch. The gauge on the right indicates the amount of pressure inside the Oxygen Bottle.
- To increase the amount of pressure delivered to the torch, turn the Regulator Control Valve clockwise. To decrease the amount of pressure delivered to the torch, turn the Regulator Control Valve counter clockwise while depressing the High Pressure Oxygen Trigger on the Torch.

Fuel Tank Filling

1. Select Fuel - For best performance, use clean fresh fuel. If the only fuel available is old or fouled the system can still be operated without damage. Fuels suitable for use include gasoline of any grade, white gas, camping fuel, and stabilized (tool or small engine) fuels. When using the Multi-Fuel Adaptor, diesel, biodiesel, kerosene, Jet-A, JP-8, JP-5 and JP-24 can be used.
2. Remove Filler Cap from the Fuel Tank - If there is pressure in the Fuel Tank, open the cap slowly until you hear the pressure venting through the machined

groove in the cap body. Let the tank completely vent its pressure before removing the cap completely.

3. Fill the Fuel Tank to specified level - It is important to fill your Fuel Tank to the specified level. This leaves the optimum amount of air space in the Fuel Tank for proper pressurization. Overfilling the Fuel Tank will cause the pressure to fall rapidly. Under filling the Fuel Tank will require in excessive pumping to obtain optimum pressure.
   - Place the Fuel Tank on the ground to avoid static discharge while fueling.
   - Fill the Fuel Tank directly from a fuel pump OR from an approved fuel container.
     - 2.5 Gallon Fuel Tank (Standard): Fill to 2 gallon Weld Line, indicated by the welded seam on the upper half of the tank.
     - 2 Quart Fuel Tank (PCS.): Fill with 1.5 quarts.
4. Replace the filler cap and secure snugly by hand

Fuel Tank Pressurization

1. Pump the Fuel Tank to the pressure specified for your system (If your system requires 50 or 100 psi, this will be indicated on the Filler Cap).
   - Standard Systems: 20 psi
   - Multi-Fuel Adaptor Systems: 50 psi
   - Underwater System: 100 psi

   Pumping a standard 2.5 gallon Fuel Tank should require between 80 and 100 plunges to reach 20 psi. The standard 2 quart Fuel Tank should require between 15 to 25 plunges to reach 20 psi.
2. During cutting operations, ensure the Fuel Tank pressure remains above 10 psi. When the Fuel Tank pressure reaches 10 psi, re-pressurize the Fuel Tank to 20 psi. This will ensure the fastest activation of the Fast Flow Check Valve.
3. All Petrogen pressure vessels are fitted with an automatic pressure relief valve inside the Filler Cap. Do not attempt to adjust or modify the pressure relief valve. If you believe the valve has been tampered with, return the Filler Cap assembly to Petrogen for re-calibration.
4. When conducting overhead cutting in excess of 30 feet, it may be necessary to compensate by increasing the fuel tank pressure. This may require a Filler Cap with a higher activation setting. If this type of cutting is common it is recommended that operators install the tank Automatic Pressure Kit, which uses an external compressed Air Carry Tank, eliminating the need for hand pumping.

Fuel Line Purge

1. Purging the fuel line eliminates air bubbles. If air bubbles are left in the Fuel Hose, the flame may go out during the first minutes of operation. Purging the line may take up to 2 minutes per 25 feet of hose.
2. Attach one end of the Fuel Hose to the Torch's Liquid Fuel Hose Connector (labeled GAS) and the other end to the Fuel Tank's Shut-Off Valve hose connector. Snug both fittings with the provided Adjustable Wrench. All Fuel Hose fittings have a left hand tightening thread identified with a hash mark to indicate counter-clockwise tightening.
3. Slowly turn the Fuel Tank's Shut-Off Valve ¼ turn allowing fuel to flow out of the tank into the hose. Opening the Shut-Off Valve too quickly will activate the Fast Flow Check Valve, stopping fuel flow. If this happens, fuel will not leave the tank and cutting will not be possible. To reset the valve, close the Shut-Off Valve on the tank fully, and tap the top of the knob. Slowly re-open the knob ¼ turn.
4. Hold the Torch above the Fuel Tank and oscillate/ agitate the Fuel Hose to speed the movement of the fuel through the Fuel Hose and help eliminate air bubbles.
5. Open the Fuel Control Knob on the Torch. This step is necessary to allow air in the fuel line to escape. Be prepared for a small amount of fuel (approximately 1–2 Tbsp) to come out of the torch tip while the air is purging. Use a metal can or other approved fuel container to catch the fuel.
6. Close the Fuel Control Knob on the Torch.
7. Once the line is purged, completely open the Shut-Off Valve on the Fuel Tank. The Shut-Off Valve should remain completely open during operation.

Lighting the Torch

1. PREP THE SPARK STRIKER - Ensure that your spark striker is engaging the flint and creating adequate sparks before beginning the light up process. Doing so will prevent excess fuel from being lost.
2. CONTROL SURFACES - There are three control surfaces to activate on the Petrogen Torch when performing light up.
   - Pre-Heat Oxygen Knob - Open precisely ½ turn.* If using tips 6, 7, or 8 open ¼ turn.
   - High Pressure Oxygen Trigger - Purge by fully depressing for 3 to 5 seconds.
   - Fuel Control Knob - Open precisely ½ turn.*

   * Use the '+,-' decals to execute a precise ½ turn.
3. LIGHT UP PROCEDURE - The recommended light up sequence (½ turn - Purge - ½ turn), creates a suitable preheat mixture for light up and also helps to protect from oxygen flashback.

Note: A ½ turn of fuel with older Petrogen torches may produce too rich of a mixture. New torches have been designed to operate specifically with the ½ turn for both fuel and preheat oxygen settings to simplify the lighting procedures.

4. LIGHTING THE TORCH - When lighting the Torch, strike the sparker directly at the tip. Striking sparks too far away will slow or even prevent ignition.
5. WARM UP (IMPORTANT) - After ignition, rest the Tip directly on the steel at a 45 degree angle for 5 to 10 seconds. The reflected heat will bring the Tip to its operating temperature allowing the fuel to fully vaporize inside the Tip. Make no flame adjustments during this period. Failing to allow the Tip to fully heat will prevent proper flame adjustment. As the Tip warms, the yellow and orange in the flame will disappear.

   Increase efficiency by warming the Tip on the cut line, effectively preheating the metal while bringing the Tip to cutting temperature.
6. FINAL FLAME ADJUSTMENT - With the Tip still touching the steel, use the Fuel Control Knob to make the final adjustment. When using the recommended light-up setting (½ turn oxygen / ½ turn fuel), the preheat flame will be slightly rich. Using the Fuel Control Knob, adjust the flame so that the preheat jets slightly oscillate.
   - RUN IT RICH - The Petrogen preheat flame should look and sound more aggressive than the flames of compressed gas cutting torches. Running the Torch with a rich flame setting is critical to unlocking the performance of the system. Running the torch with a lean (wispy) setting will overheat the head, reduce performance and increase maintenance and repair.
   - WHY RUN IT RICH? - A rich setting al lows more liquid fuel to enter the head of the torch. The natural cooling effect created by the liquid fuel evaporation protects the Mixer and Tip against overheating. Additionally, the liquid fuel rapidly increases in volume as it expands into a gas, creating a greater oxy/fuel velocity as it leaves the Tip, ultimately driving more BTUs into the steel.

Shutting Down the Torch

1. Close the Fuel Control Knob on the torch by turning it clockwise fully.
2. Purge the torch by depressing the High Pressure Oxygen Trigger for 3 to 5 seconds.
3. Close the Pre-Heat Oxygen Valve by turning it clockwise fully.

Breakdown

1. Before the last cut of the day, close the fuel shutoff valve. During the last cut the pressure in the fuel line will be relieved, reducing spillage during disassembly. Perform the steps listed in “Normal Shutdown.”
2. Disconnect the Oxygen Hose from the Torch and Regulator.

3. Remove the Regulator from the Oxygen Bottle.
4. Install the transport safety cap on the Oxygen Bottle and secure the bottle in an approved storage area.
5. Unscrew the Fuel Tank Filler Cap until the sound of escaping air can be heard. Once the pressure has been completely relieved, remove the Filler Cap completely.
6. Remove the Fuel Hose from the Fuel Tank and place the hose end into the Fuel Tank. This is easiest when done with two people. Hold the Torch above the level of the Fuel Tank and open the Fuel Control Knob on the Torch to eliminate any vacuum which might keep fuel in the line or Torch.
7. Working from the Torch to the Fuel Tank, push any remaining fuel out of the hose by holding the line above the Fuel Tank. Repeat this until no fuel drains from the hose into the Fuel Tank.
8. Remove the torch from the fuel line and allow both to fully air dry. **IMPORTANT:** NEVER STORE ANY OXY/FUEL SYSTEM IN AN AIRTIGHT CONTAINER OR COMPARTMENT. FLAMMABLE FUMES MAY COLLECT AND EXPLODE.
9. Drain the contents of the Fuel Tank into an approved storage container. If no container is available, the Petrogen Fuel Tank actually meets or exceeds the requirements for flammable liquid storage containers in most areas. It is a UL tested, ASME code pressure vessel.

Maintenance

The Petrogen system requires very little day-to-day maintenance when operated properly. Most problems occur as a result of using a flame adjustment that is too lean (too much oxygen and not enough fuel). As described previously, using a slightly rich flame adjustment eliminates this problem and significantly enhances overall performance.

Tip Maintenance

Perform Tip maintenance when preheating performance and/or cut cleanliness has been noticeably reduced.

A cleaner Tip will produce a cleaner cut. Clean the preheat flutes to produce a more consistent preheat flame. Clean the high pressure oxygen center hole to improve cut edge quality. Though cleaning the preheat flutes will produce a more stable flame, cleaning the high pressure oxygen center hole directly affects cut edge quality by enhancing laminar flow of the oxygen jet.

1. Tip Removal: Using an adjustable wrench, loosen the Tip Nut by turning it counterclockwise. Remove the Tip Nut and Tip from the head of the torch, being careful not to drop the tip core. Note: To cool a hot Tip before removal, take the following actions. Briefly open the torch fuel control valve. The evaporating fuel will quickly cool the Tip to room temperature. Once the fuel exiting the Tip becomes a liquid immediately close the fuel valve.

2. Tip Reamer: Used to remove deposits from the slot inside of the tip shell.
3. Two Part Tip Brush: Used to remove slag from the Tip shell and the flutes of the Tip core. **DO NOT** use this brush or any abrasives on the seating surface of the Tip core where it mates with the Mixer inside the Torch Head.
4. Tip Drill Set: Used to clear debris from the high pressure oxygen center hole. The nine drills in the set correspond to the nine Tip sizes. The brass brush can be used to clean the Tip core flutes as well as remove slag from around the high pressure oxygen center hole.

Packing Nut Maintenance

Packing Nut maintenance should be performed regularly between uses or if valve leaking/weeping is observed.

Use the included Packing Nut Wrench found in the Standard Tool Kit to check the following packing nuts for snugness:

- Pre-Heat Oxygen Packing Nut - located under the Pre-Heat Oxygen Knob on the Torch.
- Fuel Control Packing Nut - located under the Fuel Control Knob on the Torch.
- With the Adjustable Wrench, check the Fuel Valve Packing Nut - located under the Fuel Valve on the Liquid Fuel Tank.

Troubleshooting

- Difficulty lighting the torch:
  - Check Torch settings
  - Check Regulator settings
  - Check Fast Flow Check Valve
  - Check Mixer Wick
- Fuel leaks:
  - Tip: Fully close the torch Fuel Control Valve
  - Tip nut/ torch head:
    - Loosen and retighten the Tip Nut
    - Check Mixer O-ring(s)
  - Torch handle weep hole/s: Contact Petrogen for warranty service
  - Fuel control knob: Tighten the packing nut under the knob
  - Fuel hose / torch hose connector: Remove the Fuel Hose and clean the threads and mating surfaces
  - Fuel hose /tank fuel hose connector: Remove the Fuel Hose and clean the threads and mating surfaces

  - Shut-off valve: Tighten the compression fitting below the Fuel Control Knob
  - Pump cylinder:
    - If fuel is leaking past the Pump Cylinder Check Valve, the first indication will be the pump handle raising by itself.
    - Release the Fuel Tank pressure by unscrewing the Filler Cap until air begins to escape
    - Replace the Pump Check Valve Seal
- Oxygen leaks:
  - Tip: Check High Pressure Oxygen Valve
  - Pre-heat oxygen knob: Tighten packing nut under the knob
  - Oxygen hose / torch hose connector: Remove the Oxygen Hose and clean the threads and mating surfaces
  - Oxygen hose / regulator: Remove the Oxygen Hose and clean the threads and mating surfaces
  - Regulator / oxygen bottle valve:
    - Use a plastic bristle brush to clean the threads of the Regulator Valve Connector and the threads of the Oxygen Bottle Valve
    - Never use liquids or abrasives to clean this connection
    - Carefully inspect the components for debris before reassembling
- Fuel tank pressure:
  - Difficulty pressurizing the fuel tank:
    - Check the Leather Pump Cup
    - Check the fuel level in the Fuel Tank
    - Use smooth, complete strokes when pumping
  - Fuel tank loses pressure when not in use
    - Make sure the Filler Cap Gasket is in place
    - Contact Petrogen Customer Service for warranty repair
- Popping:
  - Loosen and retighten the Tip Nut
  - Inspect the seating surfaces of the Tip and replace the Tip if necessary

- Flickering or unstable flame:
  - Clean the tip
  - Check torch settings
  - Check mixer wick

Note: This is the end of the information from the Petrogen Advanced Cutting Torch Systems *Liquid Fuel Cutting Torch System Reference Manual* (Version 1.1).

Safety Issues

As with all burning and cutting, the use of oxygen/gasoline equipment has special risks. Fuel leaks are a main concern. Create a safe environment by:

- Performing leak checks after assembly and prior to lighting
- Looking for liquid fuel on the ground and at couplings
- Securing the fuel tank in the upright position (fuel cannot flow with tank on its side)
- Using a flashback arrestor on the oxygen line, although one is not required for the fuel line

Manual Tools

Come-Along

The following detailed information on setup, breakdown, maintenance, and troubleshooting is adapted with permission from the Lincoln Hoist *Cable Hoist Operating Manual*.

Application

A come-along, or portable cable-winch hoist, is a hand-operated winch and ratchet used to lift or pull objects. Come-alongs come with a rated capacity from 0.5 to 6 tons and weigh from 7 to 35 pounds.

Setup

Most come-alongs take less than 100 pounds of pull on the lever to lift the rated load. If it takes two people to work the lever, the come-along is overloaded. Never use a handle extender (cheater pipe) to increase leverage.

Lifting or Pulling

1. Hang the hoist freely from adequate support.
2. Place the reverse lever in the lift/pull position to engage the u-frame pawl in the drum teeth.
3. Operate the handle in steady strokes to lift or pull. (Do not overload the hoist!)

Lowering or Backing Off

1. Place the reverse lever in the lower/back-off position and operate the handle to disengage the u-frame pawl from the drum teeth.
2. Operate the handle until the u-frame pawl disengages the main pawl from the drum tooth.
3. Operate the handle in the reverse direction until the main pawl engages the drum tooth again.
4. Repeat until the load is free.

Free Release

1. Do not release under the load.
2. Place the reverse lever in the lower/back-off position and operate the handle to disengage the u-frame pawl from the drum teeth.
3. Press and hold the main pawl to disengage it from the drum teeth.
4. Pull the cable out from the drum.

Breakdown

Lifting or Pulling

When lifting or pulling with a rapid lowering hoist, place the rapid lowering thumb lever in the “off” position to operate the hoist normally.

Free Release

When pulling the cable out without a load, place the rapid lowering thumb lever in the “off” position.

Lowering

1. When operating the hoist in the rapid mode, the operator should be in a position to keep the handle under control throughout the full stroke.
2. With the rapid lowering thumb lever in the “off” position, operate the hoist normally to lower one drum tooth at a time.
3. With the rapid lowering thumb lever in the “on” position, the hoist will lower the load four drum teeth at a time. The first stroke may lower the load from one to four drum teeth with the subsequent strokes being four drum teeth each.

Maintenance

- Never perform maintenance when there is a load on the hoist!
- Inspect the hoist before each use. Check for wear, damage, distortion, and cleanliness.
- Keep the hoist clean from dirt and debris; clean out immediately.
- Replace worn or damaged parts before any further use.

- When in use, take care to avoid dragging the wire rope in dirt or around objects that will scrape, nick, crush, or induce sharp bends.
- Replace wire rope if any kinking, crushing, birdcaging, or any other damage resulting in distortion of the wire rope structure is present.

Troubleshooting

Refer to Table 2.5 and Table 2.6 for troubleshooting information.

Table 2.5: Hoist Does Not Lower/Back Off Under Tension

Cause	Remedy
U-pawl engaged	Move the reverse lever to disengage the u-pawl.
Broken main pawl spring	Replace the main pawl spring.
Main pawl spring has lost tension	Replace the main pawl spring.
U-pawl button slips by main spring	Inspect the u-pawl for bending or excess button wear. Replace if needed. Straighten or replace the u-frame if needed.
U-pawl hits main frame	Straighten or replace the u-frame.
Distorted or broken main pawl	Replace the main pawl.
Broken tooth on drum	Replace the drum.

Table 2.6: Hoist Does Not Lift/Pull

Cause	Remedy
U-pawl not engaged	Move the reverse lever to engage the u-pawl.
Main pawl spring does not hold pawl engaged	Replace the main spring. Check the frame for a loose spring anchor.
Distorted or broken main pawl	Replace the main pawl.
Broken tooth on drum	Replace the drum.

Safety Issues

Few manufacturers publish the SF incorporated in their rated capacity, so use these devices with extreme caution. One manufacturer lists an SF of 3 and notes as a warning that the handle will bend when overloaded. In most cases, the length of the handle and one's ability to move it provide an overload limit device.

Chain Fall

The following detailed information on setup, maintenance, and safety is adapted with permission from the Columbus McKinnon Corporation *Operating, Maintenance, and Parts Manual: CM Rigger Manually Lever Operated Chain Hoist*. Information on troubleshooting is adapted with permission from the Harrington Hoists and Cranes *Owner's Manual: Lever Operated Chain Hoist LB Series*.

Application

Chain falls and chain hoists can be very useful when awkward and uneven loads and situations are encountered. They may be used to adjust sling lengths for awkwardly shaped loads, balance and level odd-shaped loads when slings cannot be positioned to fully capture the Center of Gravity (CG), and better maneuver a load, especially when access is an issue.

Chain hoists, falls, and ratchet levers have rated capacities of up to 6 tons, which, in some cases, can be achieved with a 100-pound pull. Use ratchet chain devices that are rated for lifting applications and are not just pullers. Ratchet chain hoists can have large (up to 10 feet) take-up capacities but are relatively heavy and expensive. They are strongly preferred when adjustment under load is required.

Setup

Free Wheeling

In this condition the chain can be pulled through the rigger in either direction by hand. This allows quick and easy attachment of the load. Set the directional lever to the unload position and release pawls.

Attachment to the Load

The CM Rigger can be used in any position provided it is rigged to pull in a straight line from hook to hook. It is important that the frame is free to swivel on the upper hook. Under no condition should the frame be allowed to touch the load or bear on any support when in use because this might cause bending of the hook or frame and possible failure. When operating in limited areas, it is recommended that attachments or slings be used to keep the frame and handle from being obstructed.

Operation

After attachment of the load, the slack in the chain can be taken up by pulling on the end ring attached to the loose end of the chain. Set the directional lever to the "load." Operate the handle up and down and the load will be pulled or tensioned. Shift the directional lever to the "unload" position and the load will be loosened one tooth at a time by the same operation of the handle. When operating the handle, make certain that the load is retained by the rigger before releasing the handle.

Breakdown

Reverse of the setup.

Maintenance

Inspection

To maintain continuous and satisfactory operation, a regular periodic inspection procedure must be initiated so that worn or damaged parts can be replaced before they become unsafe. The frequency of inspection must be determined by the individual application.

For normal usage under normal conditions, these inspections are to be performed daily, monthly, or quarterly and should include the following items:

- Holding and driving pawls for proper operation and engagement with the teeth of the liftwheel: daily
- Load chain for lubricant, wear, damaged links or foreign material: daily
- Hooks for damage, cracks, twists, latch engagement and latch operation: monthly
- Chain for excessive wear or stretch: every three months
- Worn, cracked, or distorted parts such as hook blocks, frame, hoist hanger, chain guide, direction lever, springs, handle, cover, sheave wheel, liftwheel, and driving pawl shaft: every three months
- Loose or missing screws, nuts, and snap rings: every three months

When the unit is subjected to heavy usage or dusty, gritty, moist, or corrosive atmospheric conditions, shorter time periods must be assigned. Inspection must be made of all parts for unusual wear, corrosion, or damage, in addition to those specifically mentioned in the schedule.

Any parts that are deemed unserviceable are to be replaced with new parts before the unit is returned to service. It is very important that the unserviceable parts be destroyed to prevent their possible future use as a repair item and properly disposed of.

Preventive Maintenance

In addition to the periodic inspection procedure, a preventive maintenance program should be established to prolong the useful life of the tool and maintain its reliability and continued safe use. The program should include the periodic inspections with particular attention being paid to the lubrication of various components using the recommended lubricants.

Troubleshooting

Refer to Table 2.7 for troubleshooting information.

Table 2.7: Troubleshooting

Symptom	Cause	Remedy
Hoist will not lift (slight clicking)	Improper assembly of ratchet disc; disc installed backwards and making incorrect contact with the pawl	Reassemble the pawl and ratchet disc properly. Ensure that clicking sounds are heard before reuse.
Hoist will not lift (not clicking)	• Pawl not engaging ratchet disc due to dirt or corrosion between pawl and pawl shaft • Faulty pawl spring • Improper selector lever fit due to missing selector pawl spring or assembled incorrectly (wrong direction) • Loose selector pawl spring	• Clean and lubricate the pawl and pawl shaft. • Replace the pawl spring. • Reassemble properly and ensure the selector lever clicks before reuse. • Perform hoist maintenance.
Hoist will not lift: lever will not operate	Gear improperly timed	Reassemble gears properly and ensure smooth operation before reuse.
Hoist with slip clutch Hoist will not lift: lever will operate but load will not move	Slip clutch activated	Reduce the load to less than rated capacity.
Hoist with slip clutch Hoist will not lift under rated capacity	Slip clutch malfunction (due to frequently operating hoist with greater than rated load)	Replace the friction clutch. Do not frequently operate the hoist with greater than rated load.
Hoist will lift intermittently (slight or irregular clicking)	• Poor pawl movement caused by faulty pawl spring; spring is loose or damaged • Misassembled pawl spring	• Perform maintenance and/or repair. • Reassemble it properly and ensure to check click sound of the pawl before reuse.
During operation, hoist idles or load drifts	Poor contact of load sheave and load chain caused by improper chain-reeving	Reassemble properly and ensure proper lifting before reuse.

Table 2.7: Troubleshooting (continued)

Symptom	Cause	Remedy
Hoist will not lift without load	• Misassembled brake spring • Insufficient angle to set the spring will cause a poor braking	Reassemble properly.
Hoist will not lift all the way (multiple fall hoists)	Capsized hook	Reset the capsized hook.
Load will not go down	• Over tightened brake • The hoist left under load for a long period • Shock loaded during operation • Brake rusted tight	• Set the selector lever to the down position and reset the brake by pulling harder on the lever. • Replace the rusty components and perform hoist maintenance.
Load drifts or slips when lowering	• A foreign object between friction surfaces • Brake slip caused by significant rust • Misassembled of friction plates • Cracked friction plate caused by overload • Friction plate wear caused by very frequent and long-term use • Misassembled female thread and cam guide	• Remove the object and clean the surfaces. Replace if the friction surface is scarred. • Replace the rusty component and perform hoist maintenance. • Reassemble properly and ensure hoist functions properly before reuse. • Replace the friction plate and use the hoist properly within rated capacity. • Perform hoist maintenance. • Reassemble the female thread and cam guide properly.
Free chain knob does not move in and out	Damaged or deformed friction plate	Perform hoist maintenance.

Table 2.7: Troubleshooting (continued)

Symptom	Cause	Remedy
Hoist will not free wheel	• Load chain pulled to hard and brake engaged • Misassembled free chain spring or chain spring twisted at excessive angle	• Pull the load chain with less force. • See the symptom of "Hoist will not lift without load."
Load drifts or slips when selector lever is set in free chain mode	Misassembled free chain spring or poorly tightened brake caused by insufficient twist angle	See the symptom of "Hoist will not lift without load."
Hard to reset the hoist out of free chain mode	Misassembled free chain spring or insufficient twist angle	Reassemble properly.

Safety Issues

- The hoist must be kept clean to ensure proper operation of the pawls and liftwheel. Before use, check to be sure both pawls are free and engage the ratchet. Lubricate the unit after cleaning. The cover must be flat and firmly in place at all times. Make sure there is no foreign material in the ratchet, cover, and pawl area before operating.
- When preparing to lift or move a load, be sure that the attachments to both hooks are firmly seated in the saddles of the hooks. Avoid off-center loading of any kind, especially loading on the point of the hook. Do not load the hook latch as it is to retain slack chain as an aid in hook-up only.
- When pulling or tensioning, move the load only enough to load the unit, then check to be sure the holding pawl is engaging and that the attachments to hooks and the load are firmly seated. Continue movement only after you are assured the load is free of all obstruction.
- Do not load beyond the rated capacity. Overload can cause immediate failure or cause damage resulting in future failure even at a less than rated capacity.
- The hoist has been designed for hand-powered operation only. Do not use an extension on the handle. A handle pull of approximately 100 pounds will result in rated capacity on the unit, any greater pull is an indication of either an overload or an incorrectly maintained unit.
- Under no condition should the holding pawl be pried out of engagement when a load is on the unit, since this will allow the load to be released in a sudden and uncontrolled manner.
- Do not use this or any other materials handling equipment for lifting or moving persons.

- Warn other personnel of your intention to move a load in their area.
- Do not leave a load on the unit unattended.
- Do not take up the load chain to the point where the end ring or hook block becomes jammed against the frame.
- Read warnings and instructions on the handle before each use.
- **Do not wrap the load chain around the load or bring the load in contact with the tool.**
- Do not operate the rigger unless it is rigged to pull in a straight line from hook to hook and the frame is free to swivel on the upper hook.
- Refer to the latest American Society of Mechanical Engineers (ASME) B20.21 Lever Hoist Safety Standards for additional safety information.

Griphoist

The following detailed information on setup, breakdown, maintenance, troubleshooting, and safety is adapted with permission from the Griphoist Inc. *Griphoist®: Manual Hoists Use and Maintenance* manual for the TU-32 Griphoist.

Application

A Griphoist is a special type of cable come-along, sometimes referred to as an endless come-along. It uses a length of wire rope that is pulled through two sets of gripping jaws. These devices are rated for either overhead lifting of materials (8,000 pounds) or for the lifting of people (6,000 pounds).

Griphoists are also used for pulling, traversing, and guying.

Setup

1. Remove the anchor locking pin and withdraw the anchor pin.
2. Push in and maintain the pressure on the lock button and start pushing the rope release lever toward the anchor pin end of the machine. Release the lock button. Pull the release lever further until it locks itself into the open position. Both pairs of jaws are now open.
3. Push the reversing lever toward the anchor pin end of the machine. Insert the Griphoist wire rope at the entry at the opposite end from the anchor pin end and push until it comes out of the other end.
4. Pull the slack wire rope through the machine by hand (wear gloves), until it becomes nearly tight on the load. (Allow some extra length for anchoring the machine.)
5. Position the anchor sling and refit the anchor pin through the eyes of the sling. Refit the anchor locking pin in the locking position. Ensure that the rope passes beneath the anchor pin. Anchor the wire rope hook. Check that the wire rope hook latch is closed.

6. To close the jaws on the wire rope, slightly push the rope release lever toward the anchor pin. Push in and maintain pressure on the lock button and allow the release lever to slowly return to the initial position. Release the lock button. The machine is now ready for use.
7. Place the telescopic handle on the lever to lift or pull or on the lever to lower or slacken the wire rope. Twist the handle to ensure that it is in the locked position.
8. To remove the wire rope from the machine, slacken the rope by operating the lever before operating the release lever as in step 2.

Breakdown

As the jaws are locked by the effort on the wire rope, the tension must first be removed. Slacken the rope completely by a few clicks on the reversing lever. When the tension has been removed, open the jaws by placing the release lever to the open position and remove the wire rope by hand. Always handle wire rope with gloves to avoid injury.

Maintenance

Although the casing provides good protection, dust and dirt can penetrate into the mechanism through the openings of the casing, as well as through the guide holes of the wire rope. The machine should, therefore, never be left lying about in mud and the wire rope should be cleaned before it is introduced into the machine.

For storage, the Griphoist machine should be left with its release lever in the closed working position and well oiled. This will extend the life of the pre-gripping springs.

Refer to the operator's manual for instructions on replacing the shear pins in the handle if the Griphoist is overloaded.

Lubrication

- Lubricate the machine frequently, including each time before the machine is rigged or used.
- For normal lubrication, squirt Society of Automotive Engineers (SAE) 90 to 120 motor oil through the openings of the casing. To allow the lubricant to penetrate to all the parts of the mechanism, alternately operate the forward lever and the reversing lever, preferably with the jaws open (if not under the load). Lubrication may also be provided without releasing in operating conditions. Without wire rope in the machine, it is important that, for total penetration of oil into the jaw assembly, the release lever be open. Otherwise oil does not easily get into the gripping mechanism.

Note: An excess of lubrication will not cause the wire rope to slip. Lack of lubrication is the greatest cause of malfunction.

General Maintenance Cleaning

Dip the machine into a cleaning solvent that will not attack nylon or rubber. Shake well to dislodge foreign materials and turn the machine quickly upside down to drain. Then do not fail to thoroughly lubricate as indicated.

Thorough Cleaning of Very Dirty Machine

For thorough cleaning of the machine, it is necessary to unbolt and remove the casing and to fully lubricate after cleaning.

Troubleshooting

Griphoist machines are designed to be trouble free. However, from time to time, certain problems may occur. These mainly result from insufficient oiling and lack of cleaning or from damaged wire ropes.

Pumping

A lack of lubricant in a Griphoist sometimes causes a condition known as pumping. As the forward lever is moved to and fro, the machine moves up and down (if used for lifting) by about 1 inch. Pouring motor oil inside the casing, if the situation allows, should remedy it. If this cannot be done, then lower the machine or the load back to the ground by operating the reversing lever, which is not affected by this trouble. The Griphoist should then be thoroughly lubricated with motor oil and it will be ready again for service.

Jerking

Another symptom of the lack of lubrication is jerking when lowering a load. Thorough oiling will cure that trouble.

Other Problems

Should damage or badly maintained wire rope become jammed in the machine, place another lifting or pulling device or load line into a safe position in order to take the load and remove the faulty unit with rope. Then, if the rope is blocked inside the machine, cut it outside the casing, leaving the short damaged wire rope inside, and send back the equipment to Griphoist Inc., or to one of its authorized repairers.

Safety Issues

- All levers must be free to move without obstruction.
- **Caution:** If you use one or more pulleys to change the direction of the effort, ensure that you can properly evaluate the strength of the anchoring point of such pulleys and that they are strong enough for the applied load.
- Ensure that the rope exit is clear of obstruction so that the wire rope will not be forced back into the machine.
- Ensure that there are no obstructions around the machine that could prevent the rope, machine, and suspension point from operating in a straight line.

Electric Tools

Electric tool systems have three general parts: power generation, transmission, and tool. It is the Structural Collapse Specialist's responsibility to understand the operation of each part and know where it fits in the operational envelope. It is also important to understand the terms and units of measure concerning electricity. This information is often displayed on the tool:

- *Volt* is a measure of electric potential. It refers to the energy that could be released if electric current is allowed to flow.
- *Amperage* (amp) is used to express the flow rate of an electric charge. All appliances have a specific amount of amps required to make them work efficiently.
- *Alternating Current (AC)* is an electric current in which the flow of electric charge periodically changes direction.
- *Direct Current (DC)* is an electric current in which the flow of electric charge is only in one direction and is usually produced by sources such as batteries.
- *Watt* is used to express the rate of energy conversion or transfer over time. Wattage is calculated by multiplying amps and volts.

Generator

Generally, people get electric power from an outlet supplied by the electric company. This serves well at home, but in the field responders need to make and distribute electricity by their own means. Portable generators are the life blood in the US&R environment. The electrical system is protected by circuit breakers and responders are protected from the potential of electrical shock by Ground Fault Interrupters (GFI).

The following detailed information on setup, breakdown, and troubleshooting is adapted with permission from the Honda Motor Company *Owner's Manual: Generator EU6500is*.

Application

Generators are used to provide portable power for all electrical equipment used during a response. When using generators in the field, there are some potential and actual issues that need to be considered:

- Any time the generator is going to be transported, be sure to shut off the fuel valve. If left on, gasoline may get into the crankcase and dilute the oil. If it is going to be stored for more than two months, drain the fuel from the carburetor float bowl, drain the fuel from the sediment cup, and add fuel stabilizer to the fuel left in the tank.
- Electrical production is accomplished when the motor turns a set of windings. In a 110/220-volt generator, there are two of them. Each one of these windings is rated at half the total load of the generator. In 120-volt mode, each winding supplies certain portions of available outlets. In the 120/220-volt

mode, they supply the 120-volt outlets and they are combined at the 220-volt outlet to supply its needs. It is important to understand this theory and look at the wiring arrangement for the model the TF is using. Some of the Honda EB models have two duplex outlets, each one fed from a different winding. This is important to know when plugging in tools and equipment because users have the opportunity to spread the load out between the windings. Instead of overloading one winding with the draw of two big tools, they can opt to split that load between the two windings and allow the generator to operate better with less chance of breakdown.

- All generators have two output ratings: Max and Rated output. The label usually reflects the Max output (marketing value). The Rated output is what should be followed; it is the amount of power the generator can produce over an extended period of time without damage. The Max rating is for peak periods of short duration like tool startup.
- Circuit breakers protect the generator and specific outlets from overload. Honda EB model generators generally have a main breaker to protect the windings from accumulative overload and outlet-specific breakers to protect each circuit individually. They also have a GFI circuit protector that is designed to protect humans from shock. The GFI compares the amount of electricity sent out on the hot wire to the amount received back on the neutral wire; if there is a 5 millivolt difference, it will trip and stop the electric flow. This should be quick enough to stop personnel from electrocution but is enough to cause muscle reflex, which could be dangerous.
- Most generators have an Auto Idle switch. When turned on, this mode allows the generator to go to idle speed when it senses that there is no electric draw from any of its outlets. This idle mode saves fuel and generator wear and tear. When electricity is requested (by turning on a light or pulling the trigger on a tool), the generator will come up to full speed and supply the requested energy.

Setup

Check the Engine

1. Check the oil level. A low oil level will cause the oil alert system to shut down the engine.
2. Check the air filter. A dirty air filter will restrict air flow to the carburetor, reducing engine and generator performance.
3. Check the fuel level. Starting with a full tank will help to eliminate or reduce operating interruptions for refueling.

Battery Maintenance Cover

Never operate the generator without the battery maintenance cover in place, because poor engine and generator performance will result.

Starting the Engine

1. Make sure that all appliances connected to the generator are turned off. The generator may be hard to start if a load is connected.
2. Set the voltage selector switch to match the voltage requirements for the application.
3. Turn the fuel valve lever to the “on” position.
4. Make sure the eco-throttle switch is in the “off” position, or more time will be required for warm-up. If you wish to use the eco-throttle system, turn the eco-throttle switch to the “on” position after the engine has warmed up for 2 or 3 minutes.
5. Turn the engine switch to the “start” position and hold it there until the engine starts. When the engine starts, release the key, allowing the switch to return to the “on” position. If the engine fails to start within 5 seconds, release the key and wait at least 10 seconds before operating the starter again.

Breakdown

To stop the engine in an emergency, simply turn the engine switch to the “off” position. Under normal conditions, use the following procedure:

1. Unplug all appliances from the generator AC receptacles.
2. Turn the engine switch to the “off” position.
3. Turn the fuel valve lever to the “off” position.

Maintenance

Honda generators use regular unleaded gas with a recommended minimum octane rating of 86. They also have a low oil sensor that will shut down the motor or refuse to let it start if it senses that the oil is low. This sensor is good for the motor but can cause undue problems if its operation is overlooked. The oil does not have to be very low for this sensor to operate.

Troubleshooting

Refer to Table 2.8, Table 2.9, and Table 2.10 for troubleshooting information.

Table 2.8: Engine Will Not Start

Possible Cause	Correction
Fuel valve lever off	Turn the lever on.
Engine switch off	Turn the engine switch to on.
Out of fuel	Refuel.

Table 2.8: Engine Will Not Start (continued)

Possible Cause	Correction
Bad fuel; generator stored without treating or draining gasoline or refueled with bad gasoline	Drain the fuel tank and carburetor and refuel with fresh gasoline.
Low oil level caused oil alert to stop engine	Add oil. Turn the engine switch to off and restart the engine.
Spark plug faulty, fouled, or improperly gapped	Gap or replace the spark plug.
Spark plug wet with fuel (flooded engine)	Dry and reinstall the spark plug.
Fuel filter restricted, carburetor malfunction, ignition malfunction, valves, stuck, etc.	Take the generator to an authorized Honda servicing dealer or refer to the shop manual.

Table 2.9: Engine Lacks Power

Possible Cause	Correction
Air filter restricted	Clean or replace the air filter.
Bad fuel; generator stored without treating or draining gasoline or refueled with bad gasoline	Drain the fuel tank and carburetor and refuel with fresh gasoline.
Fuel filter restricted, carburetor malfunction, ignition malfunction, valves, stuck, etc.	Take the generator to an authorized Honda servicing dealer or refer to the shop manual.

Table 2.10: No Power at the Receptacles

Possible Cause	Correction
Output indicator is off and overload indicator is on	• Check the AC load. Stop and restart the engine. • Check the cooling air inlet. Stop and restart the engine.
Circuit protector(s) tripped	Check the AC load and reset circuit protector(s).
Faulty power tool or appliance	• Replace or repair the power tool or appliance. • Stop and restart the engine.
Faulty generator	Take the generator to an authorized Honda servicing dealer or refer to the shop manual.

Safety Issues

Since the generator uses a gasoline or diesel motor, consideration should be given to proper ventilation; only use a generator in a well-ventilated area and not in a closed room. Generators can create a great amount of heat as well; again, care should be given to hot exhaust pipes and other hot surfaces. Electrical shock can occur during the use for a generator, all modern generators have GFIs to protect the user.

Electric Distribution

Application

Electricity distribution systems consist of power cords and splitter boxes to provide power to the tools. Electric tools require a predetermined amount of electricity to operate correctly. Supply less voltage or amperage because of wire mismatch, resistance, or cord length and the tool will not be able to do its job. Most tools used by the Rescue Team have an electric motor somewhere inside the housing. Electric motors require a much greater amount of electricity (amperage and voltage) to start than to run. This can be seen when users start a tool and the lights dim or the motor on a generator bogs down to accommodate the required draw. Once the tool is up to speed, its electrical requirements generally fall to those listed on its housing. This initial startup draw can cause circuit breakers to blow if the circuit is near its rated capacity. It can also cause a GFI to operate or trip because of voltage leakage in the tool.

All tools have an operating envelope that meets their design criteria. Trying to make a tool work faster by forcing it into a cut, pushing it harder into concrete or steel, and overloading its blade will only cause it to heat up internally and fail in the long run. Although a Federal Emergency Management Agency (FEMA) cache is very large, the Rescue section tool numbers are very small, two 1½ in. hammer drills is all they travel with. If responders overdrive and force it to work outside its normal operating range, it will work more slowly, heat up, and in the end stop working. This would leave the whole Rescue Team and its entombed victims with one hammer drill to get the job done. Working a tool with the right amount of force can only be learned during training. It is important to understand this theory and work to find the correct operating forces for all the tools in the cache.

Generator auto idle was discussed in the generator section but needs a quick review here. The auto idle mode is good when there is a lot of stand-around time or very little tool use; however, when tools are constantly being cycled on and off and the generator is running up and down, it can cause undue tool damage. This damage is caused when the trigger is pulled and the tool motor starts to turn. Since the generator is idling, it is producing very low voltage and amperage and the tool is requesting normal voltage and high amperage to get the motor turning. This delay can cause heat to build up in the tool. Any time responders are using the auto idle, they should let the tool and the generator come up to full speed before putting the tool to work. If there will be a lot of on/off cycles, it is best to turn off the auto idle and allow the generator to run at full speed all the time.

Setup

Setup is typically easy and quick. The shorter the cords, the better for amperage loss to the tool.

Breakdown

After use, clean and inspect for broken or frayed cords. Check the plugs for signs of shorting or arcing.

Maintenance

- Clean and inspect.
- Check the GFI for function by tripping and resetting.

Troubleshooting

It is important to note that the twist lock connector on a Honda EB generator is a 30 amp twist lock. A 20 amp twist lock looks like it will fit and, if pushed hard enough, it will come close but it will not twist or lock in place. This is not a safe operation. Responders must be sure to match 20 amp male to 20 amp female plugs. Having to push connectors or bend outlet prongs to make them fit should not happen. All the tools in the standard cache have regular house plugs so it is important for the rescuer to get all the needed adapters from the cache before leaving the Base Camp and heading to a job site. The need for male and female house to male and female 20 amp twist lock along with splitter boxes cannot be overlooked.

Safety Issues

Shock potential cannot be overlooked, especially when operating in wet conditions. Care should be taken to keep the distribution system out of standing water and the tools should be kept as dry as possible.

Breakers

There are many different techniques for defeating the various building materials. For breaching, concrete breakers are used to create openings to extricate trapped people. Breakers can be powered by electric, battery, and hydraulic or pneumatic energy.

Application

Breakers are typically used during the dirty breach operation. The advantage of the electric breaker is the easy set up and use. In addition, the only support needed is power.

Setup

Note: Use an insert tool of a length suitable for your body height.

1. Unplug the breaker from the power source.
2. Check that the connection end of the chisel is clean and lightly greased.

3. Check that the chuck and locking bar are clean and undamaged.
4. Push the insert tool into the chuck and pivot the retaining bar to the locking position.
5. Check that the chisel has engaged correctly by pulling it.
6. Plug the cord into the power source.
7. Place the tip of the chisel at the point where chiseling is to begin.
8. Press the on/off switch fully

Breakdown

1. Check the breaker for wear.
2. Check the tightness of the nut and screws.
3. Check the bit for damage including stress cracks and mushrooming of the shank on the end of the bit.

Maintenance

- Check all external parts of the power tool for damage at regular intervals.
- Check that all controls operate faultlessly. Do not operate the power tool if parts are damaged or when the controls do not function faultlessly.

Troubleshooting

Refer to Table 2.11 for troubleshooting information.

Table 2.11: Troubleshooting

Fault	Solution
The power tool does not start.	• It may take up to 4 seconds to initialize. Switch the power tool off and on again. • There is a faulty power source. Plug in another electric appliance and check whether it works. • Have the power supply cord checked by a trained electrical specialist and replace if necessary. • The generator is in sleep mode. Apply a load to the generator by connecting another appliance (e.g., a lamp). Subsequently switch the power tool off and on again.
There is no hammering action.	Allow the power tool to warm up to the minimum operating temperature.

Table 2.11: Troubleshooting (continued)

Fault	Solution
The power tool does not start or cuts out during operation and the Light-Emitting Diode (LED) blinks red.	Release the switch and allow the power tool to cool down or connect it to a different electric supply.
The power tool does not start or cuts out during operation and the LED lights red constantly.	Have the power tool serviced or repaired by the manufacturer's service department.
The power tool does not start and the indicator lamp blinks yellow.	Use the theft protection system key to unlock the power tool.
The power tool does not start or cuts out during operation.	Use an extension cord of an approved length and/or of adequate gauge.

Safety Issues

- Safety instructions for breakers:
  - Wear ear protection.
  - Use auxiliary handle(s), if supplied with the tool.
  - Hold power tools by insulated gripping surfaces when performing an operation where the cutting tool may contact hidden wiring or its own cord.
- Personal safety:
  - Always hold the power tool securely with both hands on the grips provided. Keep the grips dry, clean, and free from oil and grease.
  - If the insulation on the grips or parts of the casing is damaged, replace the parts before operating the power tool.
  - Wear breathing protection and if the work creates dust and you are an allergy sufferer, wear clothing that covers the skin.
  - Improve the blood circulation in your fingers by relaxing your hands and exercising your fingers during breaks between working.
  - Always lead the supply cord and extension cord away from the power tool to the rear while working. This helps to avoid tripping over the cord while working.

Hammer Drill

Application

The hammer drill, or rotary hammer, is typically used during the dirty breach operation. The advantage of the electric hammer drill is the size of the tool. Typically the electric chipping hammer is smaller than the breaker, making it

easier to use in certain environments. The chipping hammer is easy to set up and use and the only support needed is power.

During rescue operations it is important to create an inspection hole prior to conducting any breach. This inspection opening allows the placement of a camera in the space or void to check for victims and their location. The opening also acts as a diagnostic opening allowing responders to check the thickness of the material to be breached, hazards in the void, and atmospheric conditions. Basically, all breaches require an inspection hole.

Setup

1. Disconnect the hammer drill from the power source.
2. Check that the connection end of the chisel is clean and lightly greased.
3. Check that the sealing lip of the dust shield is clean and in good condition.
4. Push the chisel into the chuck and rotate it while applying slight pressure until it engages in the guide grooves.
5. Push the chisel further into the chuck until it is heard to engage.
6. Check that the chisel has engaged correctly by pulling it.
7. Plug the hammer drill into the power source.
8. Press the on/off switch.

Operation

1. Working at low temperatures:

   Note: The hammering mechanism works only when the power tool has reached a minimum operating temperature.

   – Bring the tip of the drill bit or chisel into contact with the workpiece and allow the power tool to run under no load until it reaches the minimum operating temperature.

   – If necessary, repeat this procedure until the hammering mechanism begins to operate.
2. Turn the function selector switch until it engages in the hammer drilling position.
3. Bring the side handle into the desired position and check that it is fitted correctly and secured.
4. Plug the hammer drill into the power source.
5. Position the power tool and drill bit at the point where the hole is to be drilled.
6. Press the control switch slowly (drill at a low speed until the drill bit centers itself in the hole).
7. Press the control switch fully to continue working at full power.

8. Do not apply excessive pressure. Lower pressure extends the life of the insert tool.
9. Reduce drilling speed shortly before breaking through in order to avoid damage to the surface at the rear side.

Breakdown

1. Disconnect the hammer drill from the power source.
2. Open the chuck by pulling back the locking sleeve.
3. Pull the chisel out of the chuck.
4. After use, conduct a post-use inspection and cleaning. Check the diamond tip of the core bit for wear.

Maintenance

- Clean off dirt and dust deposits from the insert tools and protect them from corrosion by wiping the insert tools from time to time with an oil-soaked rag.
- Clean the dust shield on the chuck with a dry, clean cloth at regular intervals. Replace the dust shield if the sealing lip is found to be damaged.

Troubleshooting

Refer to Table 2.12 for troubleshooting information.

Table 2.12: Troubleshooting

Fault	Solution
The power tool does not start.	• It may take up to 4 seconds to initialize. Switch the power tool off and on again. • There is a faulty power source. Plug in another electric appliance and check whether it works. • Have the power supply cord checked by a trained electrical specialist and replaced if necessary. • Have it checked by a trained electrical specialist and replaced if necessary. • The generator is in sleep mode. Apply a load to the generator by connecting another appliance (e.g., a lamp). Subsequently switch the power tool off and on again.
There is no hammering action.	Allow the power tool to warm up to the minimum operating temperature.

Table 2.12: Troubleshooting (continued)

Fault	Solution
The power tool does not start and the LED lights red.	• A fault has occurred in the tool. If necessary, the power tool should be repaired by the manufacturer's service department. • The power source is providing too much voltage. Use a different power outlet. Check the electric supply. • Allow the power tool to cool down. Clean the ventilation slots.
The power tool does not start and the indicator lamp blinks yellow.	Use the theft protection system key to unlock the power tool.
The power tool does not achieve full power.	• Press the power selector switch (observe the power level indicator). Switch the power tool off and on again. • Use an extension cord of an approved length and/or of adequate gauge. • Connect the power tool to a different power source. There is not enough voltage.
The chisel cannot be released from the chuck.	Pull the chuck back as far as it will go and remove the insert tool.

Safety Issues

- Hammer safety warnings:
  - Wear ear protection.
  - Use auxiliary handles, if supplied with the tool.
  - Hold the power tool by insulated gripping surfaces, when performing an operation where the cutting accessory may contact hidden wiring or its own cord.
- Personal safety:
  - When not in use, store power tools in a secure place.
  - Always hold the power tool securely with both hands on the grips provided. Keep the grips dry, clean, and free from oil and grease.
  - Improve the blood circulation in your fingers by relaxing your hands and exercising your fingers during breaks between working.
  - Always lead the supply cord and extension cord away from the power tool to the rear while working. This helps to avoid tripping over the cord while working.

Reinforcing Bars (Rebar) Cutter

The following information for application, setup, breakdown, maintenance, and safety is adapted with permission from the Benner-Nawman *BNCE-20 The Cutting Edge Saw™: Operation & Instruction Manual*.

Application

During dirty breaching operations in concrete, after the concrete is removed there is usually rebar that must be cut and removed to gain access to the void. The US&R cache utilizes an electric rebar cutter as one of its many options to cut and remove the rebar.

Actual areas of application the cutting edge saw is used for are as follows:

- ⅜ inch to ¾ inch or 10 millimeter to 19 millimeter grade 60 rebar
- Up to ½ inch Inner Diameter (I.D.) pipe
- ¾ inch Outer Diameter (O.D.) copper water pipe
- ¾ inch O.D. tubing
- ½ inch conduit
- ¾ inch square steel tubing and bar
- Up to ⅞ inch O.D. all-threaded or coil rod

Setup

1. Do not force the power tool. Use the correct power tool for your application. The correct power tool will do the job better and safer at the rate for which it was designed.
2. Do not use the power tool if the switch does not turn it on and off. Any power tool that cannot be controlled with the switch is dangerous and must be repaired.
3. Do not allow untrained users to operate power tools. They are dangerous in the hands of untrained users.
4. Use the power tool, accessories, and tool bits in accordance with these instructions, taking into account the working conditions and the work to be performed. Use of the power tool for operations different from those intended could result in a hazardous situation.

Breakdown

1. Disconnect the plug from the power source and/or the battery pack from the power tool before making any adjustments, changing accessories, or storing power tools. Such preventive safety measures reduce the risk of starting the power tool accidentally.
2. Store idle power tools out of the reach of children and do not allow persons unfamiliar with the power tool or these instructions to operate the power tool.

3. Maintain power tools. Check for misalignment or binding of moving parts, breakage of parts, and any other condition that may affect the power tool's operation. If damaged, have the power tool repaired before use. Many accidents are caused by poorly maintained power tools.
4. Keep cutting tools sharp and clean. Properly maintained cutting tools with sharp cutting edges are less likely to bind and are easier to control.

Maintenance

Always unplug the saw from the electric outlet before attempting any maintenance. Clean the entire unit occasionally by removing dust, debris, and oils. Occasionally remove the flush cutting bottom plate; then remove any cutting chips that remain lodged in the area the cutting blade rotated.

It is also recommended that the cutting blade be removed and inspected for any materials that did not exit out the chip exhaust area. This should be done after 4–8 hours of use. Most material cutting chips would normally exit out the chip exhaust area and into the cutting chip catch bag. It is recommended that the cutting chip catch bag be emptied when it becomes two-thirds full of cut material.

Troubleshooting

Refer to Table 2.13 for troubleshooting information.

Table 2.13: Troubleshooting

Issue	Possible Problem	Solution
Cutting rod is stuck	• Insufficient oil • Contamination • Weak return spring	• Check oil. • Inspect and clean the cutting rod. • Replace the return spring.
Cutting power is weak	• Insufficient oil • Contact between cylinder and release valve is not correct	• Check oil. • Inspect and repair the contact between the cylinder and release valve.

Table 2.13: Troubleshooting (continued)

Issue	Possible Problem	Solution
Oil leaks	• Damaged seals • Loose bolts	• Inspect and replace damaged seals. • Inspect and tighten loose bolts.
Motor does not move	• Incorrect voltage • Carbon brushes damaged • Armature damaged • Armature bearings defective	• Inspect and correct the voltage. • Replace the carbon brushes. • Inspect and replace armature. • Inspect and replace armature bearings.

Safety Issues

The cutting edge is not a waterproof power tool. If it becomes wet, the power source system may become faulty or the operator may get an electric shock. Therefore, when it is raining or snowing, never operate this saw outdoors, on top of buildings, or under roofs where rain or snow enters freely. Do not use where water accumulates or where water splashes.

The following describe the general cautions on operating the tool. Always observe the cautions stated in each item:

- Do not press the operation switch if the tool is pointed toward anyone. Operating the tool by holding it toward anyone may cause injury from contact with the blade.
- Do not apply the cutting edge saw for purposes it is not intended.
- Do not use the tool for lifting or hammering, etc., instead, only use this tool for cutting. Otherwise, the main unit may be broken or damaged, causing injury.

Grinder

Application

Grinders have several applications the Structural Collapse Specialist will find useful during a response. The tool can cut rebar or concrete depending on the type of wheel/disc used. Due to its light weight and durability, the tool can be used in tight areas.

Setup

Installing Collets

1. Place the collet on an even surface. Take the nut and place it over the collet.
2. Position the nut squarely over the collet.
3. Snap the nut and the collet together by firmly applying downward pressure onto the assembly with the palm of hand.

Installing Grinding Points

1. Remove dust and debris from the collet body before inserting grinding points.
2. Insert the collet with the collet nut attached into the collet body. Thread the collet nut onto the spindle but do not tighten it yet.
3. Clean the grinding point mandrel, then insert it a minimum of ¾ inch into the collet. The mandrel will overhang the collet and the grinding point about ½ inch.
4. Hold the spindle shaft steady with a ½ inch open-end wrench and securely tighten the collet nut with an $^{11}/_{16}$ inch open-end wrench.

Breakdown

1. To disassemble the collet from the nut, hold the nut firmly with one hand and press the collet to one side with the other hand.
2. To remove the grinding point, reverse the installation procedure.

Maintenance

- Clean dust and debris from vents.
- Use only mild soap and a damp cloth to keep the tool handles clean, dry, and free of oil or grease.
- Adopt a regular maintenance program.
- Examine the general condition of the tool:
  - Inspect guards, switches, tool cord set, and extension cord for damage.
  - Check for loose screws, misalignment, binding of moving parts, improper mounting, broken parts and any other condition that may affect its safe operation.
  - If abnormal noise or vibration occurs, turn the tool off immediately and have the problem corrected before further use.

Troubleshooting

- No power:
  - Check the batteries, if applicable.
  - Check the cord and plug for damage.

- Slow revolutions: Check the attachment of the nut to the center spindle.
- Smoke:
  - Immediately turn off the tool and disconnect it from the power source.
  - Remove the wheel from the spindle and clean all components.
  - Check that the disc is the correct size.
- Unusual noise: Make sure the power supply is adequate.
- Overheating: Check the motor for a fault.

Safety Issues

- **Use wheels only for recommended applications.**
- Always use undamaged wheel flanges that are of correct size and shape for the selected wheel.
- Do not use worn-down wheels from larger power tools.
- Do not jam the cut-off wheel or apply excessive pressure. Do not attempt to make an excessive depth of cut.
- Do not position your body in line with and behind the rotating wheel.
- When the wheel is binding or when interrupting a cut for any reason, switch off the power tool and hold the power tool motionless until the wheel comes to a complete stop. Investigate and take corrective action to eliminate the cause of wheel binding.

Reciprocating Saw

Application

The reciprocating saw is used during collapse rescue responses to create openings, create inspection openings, and to cut various materials to gain access to trapped patients. By selecting the proper blade for the material to cut, the reciprocating saw can defeat most materials except concrete.

Setup

1. To start the tool, grasp the handle firmly and pull the trigger.
2. To vary the speed, increase or decrease the pressure on the trigger.
3. To stop the tool, release the trigger. Make sure the blade comes to a complete stop before removing the blade from a partial cut or laying the tool down.

Breakdown

Broken blades can be removed by the following methods:

1. Remove the battery pack before removing blades.
2. Point the tool downward, twist the collar, and shake the tool up and down (do not turn the tool on while your fingers are holding the blade clamp open). The shank of the broken blade should drop out of the clamp.
3. If shaking the tool does not work, in most cases, a corner of the broken blade will extend beyond the blade clamp. Twist the collar and pull the broken blade out of the clamp by this corner.
4. If the broken stub does not extend far enough to be grabbed by its corner, use a thin blade with small teeth (such as a metal cutting blade) to hook the blade that is jammed in the clamp while twisting the collar and pull it out.

Maintenance

- Clean dust and debris from the charger and tool vents.
- Keep tool handles clean, dry, and free of oil or grease. Use only mild soap and a damp cloth to clean the tool, battery pack, and charger.
- If the tool does not start or operate at full power with a fully charged battery pack, clean the contacts on the battery pack.

Troubleshooting

Refer to Table 2.14 for troubleshooting information.

Table 2.14: Troubleshooting

Issue	Cause	Solution
Saw does not start	No power	Plug saw into power source
Cutting is difficult	Blade is blunt	Replace saw blade
Inconsistent reciprocation	Broken gears	Replace gear
Blade cannot be removed	Saw dust in clamp slot	Clean clamp slot with brush

Safety Issues

- Recharge only with the charger specified by the manufacturer.
- Use power tools only with specifically designated battery packs.
- When the battery pack is not in use, keep it away from other metal objects like paper clips, coins, keys, nails, screws, or other small metal objects that can make a connection from one terminal to another.
- Under abusive conditions, liquid may be ejected from the battery; avoid contact. If contact accidentally occurs, flush with water. If liquid contacts the eyes, seek medical help.

Circular Saw

Application

The circular saw has many uses in the collapse environment; the Structural Collapse Specialist may use it extensively during building shoring operations. The FEMA cache has both the 7¼ inch and 10¼ inch saws. Both saws are very dangerous to operate and are on the Occupational Safety and Health Administration's (OSHA) list of the most dangerous tools used in industry. The circular saw is typically used at the cutting table to cut wood to construct and build shores at the proper length.

The speed and quality of the cut depends on the condition of the saw blade. Users should never cut with a dull, rusty, or damaged blade. It is recommend that they use a thin-kerf carbide-tipped combination blade, which can be used for crosscuts and rip cuts in solid wood and plywood. With the saw unplugged or the battery removed, users should adjust the saw's depth of cut so the blade extends no more than ¼ inch past the board's edge.

Circular saws are not just woodcutting tools. When fitted with the proper blade, the saw can also saw through various types of metal and through masonry such as brick, stone, and concrete. There is no hard-and-fast rule regarding which direction to make the cut, but whenever possible users should position the saw with its motor facing *toward* the larger section of board that is not falling away when cut. That way, the saw's base plate, or shoe, will be fully supported throughout the cut and they will not have to hold up the weight of the saw as the severed piece drops away.

Setup

1. Attach the blade.
2. Adjust the blade depth.
3. Check the 90-degree cutting angle between the blade and the bottom plane of foot with a square.
4. Adjust bevel.
5. Verify the line guide is straight.

Breakdown

As with all tools, a post-use inspection is required. Check the tool and the power cord for damage.

Maintenance

1. Examine carbon brushes for wear.
2. Replace bearings after about 300–400 hours of operation or at every second brush change.

3. Clean with compressed dry air.
4. Clean or replace blades.

Troubleshooting

If the tool will not operate, check the power supply or battery. If the blade will not cut the material, check to be sure the proper blade was selected.

Safety Issues

Electrical shock is a consideration when using any electrically driven or supplied power tool. Use only tools and generators that have GFI circuits to protect the user.

Tool reaction should be a consideration during the use of any power tools. Place the shoe of the tool against the material being cut to control the reaction forces.

Chain Saw

Application

The chain saw is one of the most frequently used tools in the TF's cache and may be one of the most dangerous to operate. The US&R cache has both electric- and gasoline-powered chain saws. The large exposed cutting surface requires the operators to be skilled at using a chain saw, for their safety as well as the victim's safety. It is, therefore, important to know not only about the maintenance aspects of the saw but the possible reactive forces involved in cutting.

Setup

1. Install the mounting guide bar and chain.
2. Use chain oil to lubricate the chain.
3. Start the chain saw by grasping the front handle with your left hand and the rear handle with your right hand. Push in the power trigger lockout using your right thumb and squeeze the power trigger.
4. Stop the chain saw by releasing the power trigger.

Breakdown

As with all tools, a post-use inspection is required. Check the tool and the power cord for damage. Inspect the chain and check for dullness, missing tips, and tightness. Refill the bar oil reservoir after each use.

Maintenance

- Check the power supply cable and plug for damage or cracking.
- Clean the chain brake and check that it functions properly.
- Check that the chain catcher is in good condition and replace if necessary.

- Check air intakes and clean away dust and/or chips with a dry brush if necessary.
- Check that the bar and chain are well oiled.
- Turn the bar daily to ensure even wear. Check that the oil hole in the bar is not blocked. Clean the chain guide.
- Sharpen the chain and check that it is correctly tensioned and in good condition.
- Check that there is no excessive wear on the chain drive sprocket.
- File off any burrs on the sides of the bar.

Troubleshooting

If the electric chain saw will not operate, check the power cord and generator. If the cutting is slow or has stopped, check the chain for dullness. If there is smoke from the chain and bar, again check the bar oil reservoir.

Safety Issues

There are three main reactive forces the operator may encounter during cutting. They are pushback, pull-in, and a kickback.

A pushback occurs when the chain on top of the guide bar gets pinched, which suddenly stops the chain movement. The saw will tend to push back toward the operator.

The opposite of this is a pull-in, in which the chain on the bottom of the guide bar gets pinched and the saw is pulled into the work.

Lastly, the kickback occurs when the tip of the bar comes in contact with a solid object or when its movement is restricted. Kickback can happen in an instant with explosive force. When cutting wood that may be under stress, a relief cut should first be made in the area of the wood that is under compression. The deepness of the cut depends on the thickness of the material to be cut. For example, a 2 inch × 4 inch piece of wood may just have to be nicked and a large log may require a cut of several inches. In either case, users do not want the wood to begin to flex from this cut. The next cut will then be on the tension side of the material completing the cut.

Use the chipper chain when cutting trees, the carbide-tipped chain will not clear the kerf. The carbide chain works better on kiln dried lumber and mixed layers (i.e., asphalt roof coverings).

Handheld Metal Detector

The following detailed information for setup and troubleshooting is reprinted with permission from the Zircon Corporation *MetalliScanner® MT 6 Electronic Metal Locator* instruction booklet.

Application

Prior to breaching any structural material, it is a good practice to scan the material for the presence of metal objects. The objects could be rebar, electrical circuits, or some other metal that could be a hazard. The goal is to identify where the hazard is and to then avoid the hazard. By not drilling or cutting through rebar when identified, the speed of the core hole is rapidly increased. The FEMA US&R cache utilizes a Zircon MT 6 handheld metal detector for the location of ferrous and non-ferrous materials.

Setup

The Display

The display has indicators that indicate status and show information about detected objects (targets).

There are 3 status indicators: low battery, audible, and silent icons. The low battery icon is displayed when the battery has less than five hours of use remaining. The AUDIBLE icon will always be on when the unit is in the AUDIBLE mode. In the SILENT mode, the SILENT icon will be active.

The remaining icons indicate information about a target:

- The magnetic icon is displayed whenever the unit detects magnetic material, such as iron. If non-magnetic material (copper, for example) is detected, the icon will show a line through the magnet. Neither icon is displayed until the MT 6 detects metal at less than 6 in. (15 cm) deep.
- The depth bars represent the depth of the target. Depth is indicated in both inches and centimeters. The bars begin from the bottom of the display and sequentially turn on as the MT 6 gets closer to the metal. The depth numbers correspond to the depth to the top surface of the metal target.
- The plus sign indicates that you are moving toward metal, while the minus sign indicates movement away from it. If the unit is stationary, the icon indicates the most recent movement. When a target is passed, the plus sign changes to the minus sign and the MT 6 beeps (in the AUDIBLE mode).

Turning the Device On

The 3 position mode select switch turns the MT 6 on and off and selects either AUDIBLE or SILENT operation.

- Turn the unit on by moving the mode switch to either the AUDIBLE or SILENT position. This should be done in air and away from any metal.

- The MT 6 performs a calibration immediately after it is turned on.

  Note: If the unit fails to calibrate, you will hear a long, low-pitched tone and all the depth bars will be displayed. If this happens, check the area for any large metal objects and remove them or move the unit to a different location. Then try turning the unit on again.

- To turn the MT 6 off, move the mode switch to the OFF position.
- The auto power off feature turns off the MT 6 after five minutes of inactivity. After it turns off, the unit loses its calibration.

Recalibration for Maximum Depth Accuracy

The MT 6 automatically calibrates when turned on. However, depth accuracy is dependent on the materials in the vicinity of the measurement, in particular, when the materials may contain metal or metallic minerals, as is common with various mixes of concrete. Thus, it is often beneficial to recalibrate after prescanning targets before making a final determination of depth. Recalibration will not affect the positioning accuracy.

To recalibrate:

- Locate an area on the surface where there is no indication of metal.

  Note: If a grid pattern exists, such as may occur with rebar in concrete, there may be no area free of metal. In this case, best results may be obtained by calibrating midway between targets. However, accuracy may be affected and recalibration may not improve overall depth accuracy.

- Press and release the PRESS TO RECALIBRATE switch. All icons on the display will light momentarily during calibration.
- Rescan target areas. A final determination of depth can now be obtained from the depth indicator.

Breakdown

If the tool is to be removed from service for an extended period of time, remove the batteries from the device. Keep the tool clean and dry.

Maintenance

Keep the device clean and dry.

Troubleshooting

Refer to Table 2.15 for troubleshooting information.

Table 2.15: Troubleshooting

Situation	Probable Causes	Solutions
Difficulty detecting metal accurately.	Metal spaced too closely together prevents calibration.	• Avoid wearing any jewelry, including watches, when using the MT 6 and move large metal tools away from target, when feasible. • Use constant, light pressure during scan. • Allow 5 to 10 minutes for temperature to stabilize before operating if unit has been moved to an area with a 10°F (-12ºC) change or greater (e.g., from air conditioned building to outdoors on a warm day).
Inaccurate calibration and/or depth reading because magnetic/ non-magnetic objects positioned side-by-side or on top of each other.	• Calibrated directly over a metal target. • Concrete and rebar are in segments that could have been poured at different times.	• Calibrate away from metal to accurately determine depths. Move the unit over a few centimeters and recalibrate. • Make sure the MT 6 touches the surface it is scanning. • Do not rely on single calibration for the entire area. Prescan each segment separately; calibrate and determine depth of targets for each segment of concrete. • For maximum accuracy on concrete, make sure concrete is fully cured.
Calibration is lost.	Unit was turned off or mode changed.	Recalibrate every time you change mode or turn on unit.

Table 2.15: Troubleshooting (continued)

Situation	Probable Causes	Solutions
Beep doesn't seem relative to targets.	• Scanning near the edge of a piece of concrete. • Target is more than 4 in. (10 cm) deep; unit will not beep at the same time as plus/minus change and maximum depth bars appear.	Ignore beep and rely on depth bars to locate target.
Unit makes long, low-pitched tone and display does not return to normal.	Calibration error has occurred.	Reposition the MT 6 and recalibrate.
Low battery indicator.	Battery has less than 5 hours of use remaining.	Replace with brand new 9V alkaline battery to maintain sensitivity.

Safety Issues

None

Note: This is the end of the information from the Zircon Corporation *MetalliScanner® MT 6 Electronic Metal Locator* instruction booklet.

Cutting Table

Application

During shoring operations the use of a cutting table provides a stable and safe platform area to cut lumber for the construction of shores.

Setup

A cutting table can be preconstructed or constructed on site. Typically it is constructed from a 4 inch × 8 inch sheet of plywood and framed with 2 inch × 4 inch lumber. It is typically 32–36 inches off the ground and has guides mounted on the table to assist in cutting the wood.

Breakdown

Not applicable

Maintenance

Check the legs of the table periodically to ensure tightness.

Troubleshooting

Not applicable

Safety Issues

Keep the area under and around the cutting table free of debris and clutter.

Gas-Powered Tools

The predominant engine used for most gasoline-powered rescue tools is the two-cycle engine. The two-cycle engine has many advantages over the conventional four-cycle engine for rescue work, but requires distinct starting and maintenance considerations. By understanding the operating characteristics of a two-cycle engine, the Structural Collapse Specialist can better prepare for and troubleshoot maintenance issues.

Chain Saw

The following detailed information for setup, maintenance, and safety is adapted with permission from the Unifire instruction manual for *High Performance Ventilation Chain Saws*.

Application

As previously mentioned, the chain saw is one of the most frequently used tools in the TF's cache and may be one of the most dangerous to operate. The gasoline-powered chain saw is to be used when conditions or distance make the use of an electric-powered chain saw difficult.

Setup

Mounting Guide Bar and Chain

Always wear gloves when working with the chain, in order to protect your hands from injury!

1. Check that the chain brake is in the disengaged position by moving the front hand guard toward the front handle.
2. Take off the bar nuts and remove the clutch cover. Take off the transportation ring.
3. Fit the bar over the bolts. Place the bar in its rearmost position. Place the chain over the drive sprocket and in the groove on the bar. Begin on the top side of the bar. Make sure that the edges on the cutting links are facing forward on the top side.
4. Fit the clutch cover and locate the chain adjuster pin in the hole on the bar. Check that the drive links of the chain fit correctly on the drive sprocket and that the chain is in the groove on the bar. Tighten the bar nuts finger tight.
5. Tension the chain by using the combination wrench. Turn clockwise. The chain should be tensioned until it fits snugly.

6. Hold up the tip of the bar and tighten the chain. The chain is correctly tensioned when there is no slack on the underside of the bar, but it can still be turned easily by hand. Hold up the bar tip and tighten the bar nuts with the combination wrench.
7. When fitting a new chain, the chain tension has to be checked frequently until it is run-in. Then check the tension on a regular basis.

Starter Device Assembly

1. Assemble the starter device by pulling the starter cord out first, then place the starter against the crankcase. Then slowly release the starter cord so that the pulley engages with the pawls.
2. Assemble and tighten the screws, which hold the starter.

Adjustment of Oil Pump

1. The oil pump is adjustable. Adjustments are made by turning the screwdriver or combination spanner.
2. Turning the screw clockwise will reduce the oil flow; turning the screw counterclockwise will increase the oil flow.
3. Recommended settings:
   - Bar less than 15 inches: one turn from the closed position
   - Bar 15–18 inches: two turns from the closed position
   - Bar 18–24 inches: three turns from the closed position
   - Bar greater than 24 inches: four turns from the closed position

Breakdown

As with all tools, a post-use inspection is required. Check the tool for damage. Inspect the chain and check for dullness, missing tips, and tightness. Refill the bar oil reservoir after each use.

Maintenance

- Check the throttle trigger for smooth operation. If any binding occurs or if the engine fails to return to idle, take the saw to a dealer before it is used again. Also be sure that the trigger cannot be pulled until the throttle trigger lockout is depressed.
- Clean the chain brake and check its function according to the instructions. Make sure that the chain catcher is undamaged. Otherwise replace it immediately.
- Clean or replace the air filter as necessary. Check for damage or holes.
- Turn the bar daily for more even wear. Check the lubrication hole in the bar to be sure it is not clogged. Clean the bar groove. If the bar has a sprocket tip, this should be lubricated.

- Check the function of the oiler to be sure the bar and chain receive proper lubrication.
- Sharpen the chain and check its tension and condition. Check the drive sprocket for wear. Replace if necessary.
- Check the starter and starter cord for wear or damage. Clean the air intake slots on the starter housing.
- Check for loose nuts and screws and retighten if necessary.

Troubleshooting

Refer to Table 2.16 for troubleshooting information.

Table 2.16: Troubleshooting

Situation	Solutions
Chain saw will not start	• Make sure the switch is in the “on” position and the choke is set properly. • Replace the fuel with a fresh gas/oil mixture at the proper ratio. • See if the spark plug is damaged or coated with soot. If so, replace it.
Engine idles roughly or stalls	Adjust the carburetor following the directions in the owner’s manual.
Engine lacks power	• Make sure the chain brake is not engaged. • Clean the air filter and see if the spark plug is fouled. • Adjust the carburetor.
Engine smokes	• Make sure the choke is off. • Clean the air filter. • Add fresh fuel with the proper gas/oil ratio. • Adjust the carburetor.
Chain does not move	• Make sure the chain brake is not engaged. • Check the tension of the blade. • Adjust the carburetor.
Chain clatters	Increase the chain tension.

Safety Issues

- Never start the saw engine without the bar, chain, and clutch cover assembled.
- Always move saw away from the fueling area.
- Place the saw on clear ground, and make sure you have secure footing

Circular Saw

Application

Gas-powered circular cut off saws are high speed, fast cutting power tools that will make access to trapped or entombed victims quicker. Care must be taken to ensure a safe working area is maintained due to many factors including but not limited to:

- Saw kickback
- Debris thrown by saw operation
- The unprotected area of the saw blade

Setup

1. Check the spindle shaft and flange washers for damage.
2. Check that the arbor bushing corresponds with the center hole of the cutting blade.
3. Check the direction of the blade rotation. The blade should rotate in the direction indicated by the arrow.
4. Adjust the blade guard so that the rear section is flush with the workpiece.
5. Use unleaded or leaded fuel.

Breakdown

1. Clean the circular saw daily by rinsing it with clean water after the work is finished.
2. Clean the cooling air intake when needed.

Maintenance

- Check that the nuts and screws are tight.
- Check the tension of the drive belt.
- Check the carburetor air filter for cleanliness.
- Check the starter cord for wear.
- Check that the fuel cap and its seal are not damaged.
- Check the clutch center, drive gear, and clutch spring for wear.

Troubleshooting

Refer to Table 2.17 for troubleshooting information.

Table 2.17: Troubleshooting

Situation	Solutions
Loss of blade tensioning or core cracking	• The blade is too hot. Allow it to cool. • The blade is too hot. Check for sufficient air flow around the blade.
Engine knocking	The fuel has too low of an octane level. Use fuel with octane level of 90 or more.
Low power, difficult to start, or runs poorly at idle speed	• Check that the spark plug cap and ignition lead are undamaged. • Check for a dirty spark plug. • Check air filter.

Safety Issues

- Wear proper Personal Protective Equipment (PPE) while operating the circular saw.
- Use the proper blade for the material being cut.
- Never wear loose clothing that can get entangled in the working parts of the tool.
- Ensure there are no flammable liquids in the area when cutting metal as sparks will be produced that may ignite.
- Inspect wheels and blades before each use.

Drills

The following detailed information for maintenance, troubleshooting, and safety is adapted with permission from the Nikko Tanaka Engineering *TED-270PFL/PFLS/TED-270PFR/PFRS TED-270PFHS/PFHD/TED-270PFDLS Owner's Manual*.

Application

Drills have many uses in the US&R environment. They are used to set anchors, insert cameras for technical search, and, in the breaching and breaking environment, to defeat or weaken concrete. The gas-powered drill is used when the use of electric drills is not practical.

Setup

1. Use a fuel-oil mixture.
2. Insert the drill bit and tighten the chuck.

Breakdown

1. Allow the machine to cool, empty the fuel tank, and secure the machine before storing or transporting it in a vehicle.
2. Clean and maintain the unit carefully and store it in a dry place.

Maintenance

- Daily maintenance:
  - Clean the exterior of the unit.
  - Check that the drilling attachment is properly centered, sharp, and without cracks.
  - Check that the drilling attachment is sufficiently tightened.
  - Check that nuts and screws are sufficiently tightened.
- Weekly maintenance:
  - Check the starter, especially the cord and return spring.
  - Clean the exterior of the spark plug.
  - Remove the spark plug and check the electrode gap.
  - Clean the cooling fins on the cylinder and check that the air intake at the starter is not clogged.
  - Check that the angle gear is filled with grease up to ¾ mark.
  - Clean the air filter.
- Monthly maintenance:
  - Rinse the fuel tank with gasoline.
  - Clean the exterior of the carburetor and the space around it.
  - Clean the fan and the space around it.

Troubleshooting

Refer to Table 2.18 for troubleshooting information.

Table 2.18: Troubleshooting

Situation	Solutions
Engine knocking	Fuel has too low of an octane level. Use fuel with octane level of 87 or more.
Low power, difficult to start, or runs poorly at idle speed	• Check that the spark plug cap and ignition lead are undamaged. • Check for a dirty spark plug. • Check the air filter.

Safety Issues

- Inspect the entire unit/machine before each use and replace damaged parts.
- Maintain the unit/machine according to recommended procedures.
- Empty the fuel tank before storing.
- Partially depress the trigger to cycle the piston at a low rate and permit easier starting of the drill bit into the work surface.
- Never wear loose clothing that can get entangled in the working parts of the tool.

Ring Saw

Application

The ring saw gives the Structural Collapse Specialist the ability to cut deeper into concrete than traditional circular saws. A 14 inch ring saw has a maximum cutting depth of 10.6 inches compared to the 5 inch depth of a traditional circular saw.

Setup

1. Fit the blade.
2. Attach the water hose.

Breakdown

1. Store and transport the ring saw and fuel so that there is no risk of any leakage or fumes coming into contact with sparks or naked flames.
2. When storing the machine for long periods, empty the fuel tank.

Maintenance

- Perform external cleaning daily by rinsing it with clean water after the work is finished.
- Clean the cooling air intake when needed.
- Check/Replace spark plugs.
- Perform a general inspection to ensure that nuts and screws are tight.
- Check/Replace the air filter.

Troubleshooting

Refer to Table 2.19 for troubleshooting information.

Table 2.19: Troubleshooting

Problem	Probable Cause
The blade does not rotate.	• Roller knobs are not tightened fully. • The blade is not fitted on the guide rollers correctly. • Rollers are tensioned too much.
The blade rotates too slowly.	• Roller knobs are not tightened fully. • The drive wheel is worn. • The V-shaped inner diameter of the blade is worn. • The springs on the guide rollers are weakened. • The roller bearings are defective.
The blade jumps out of its position.	• Roller setting is too loose. • The guide rollers are worn. • The blade is not fitted on the guide rollers correctly. • The blade is damaged.
The blade warps.	• The rollers are tensioned too much. • The blade is overheating.
Segments break.	• The blade is bent, twisted, or badly maintained. • Continue to use the blade only if one segment is missing or leave for reconstruction when the blade is worn (maximum 50 percent).
The blade cuts too slowly.	The blade is wrong for the material in question.
The blade slips.	• The guide rollers do not move in and out freely. A seized roller cannot press the blade hard enough against the drive wheel. • The drive wheel is Worn. Abrasive material and too little water when cutting increases the wear on the wheel. • The guide roller flange is worn. When more than half of the width of the flange is worn, the blade slips. • The blade's groove and inner edge are worn. This wear is caused by inferior flushing of abrasive material and/or a worn drive wheel causing the blade to slip.

Safety Issues

- Always use water cooling to prevent overheating.
- Use a lower feed pressure to prevent the blade from becoming out of round and vibrate.
- Never cut above shoulder height. Use a platform or scaffold when working at high altitude.
- Prevent kickback by adhering to the following:
  - Never use the kickback zone of the blade for cutting.
  - Keep a good balance and a firm foothold.
  - Always cut at maximum speed.
  - Take care when inserting the blade in an existing cut. Never cut in a narrower pre-cut cut.
  - Be alert to movement of the workpiece or anything else that can occur, which could cause the cut to close and pinch the blade.

Vehicle Extrication Tool Set

The current FEMA US&R cache has three Genesis E-Force battery-powered tools: C-236 a hydraulic cutter, S-45 a hydraulic spreader, and a hydraulic ram. These self-contained and portable tools are powered by a 28-volt battery that drives a small sealed hydraulic power unit built into the tool housing. These tools require little maintenance outside typical hydraulic rescue tool care.

Application

Vehicle extrication is the process of removing a vehicle from around a person who has been trapped during a traffic accident or, in Structural Collapse Specialists' case, a collapse situation. A delicate approach is needed to minimize injury to the victim during the extrication because during a collapse situation, the person(s) is trapped due to the top of the vehicle being pushed down into the passenger compartment.

Setup

1. Place a 28-volt battery on the tool in the battery compartment located at the handle end of the tool.
2. Activate the "on/off" button to turn on.
3. Operate like a typical hydraulic rescue tool. An optional battery pack is available for extended operations.

Breakdown

After use, clean and inspect the tool. Give particular attention to the cutting surfaces and look for chips and burrs on the blades or tips.

Maintenance

- The power unit that supplies the power is sealed and not field repairable.
- Maintenance consists of cleaning and inspecting the tool after use.
- The battery should be changed with a fully charged battery and the used battery placed on a charger.
- The center bolt on the spreader should be checked and torqued to the manufacturer specifications.
- The blades on the cutter are field replaceable and require only a punch and hammer to change.

Troubleshooting

If the Genesis E-Force tool fails to operate, the likely cause is a weak or dead battery. Replace the battery with a freshly charged battery and retry the operation.

Safety Issues

Rescue operations will not only be pushing against the vehicle itself but the structure also, so awareness of stability is a must.

Stanley Tool Set

Application

The Stanley tool set provides the Structural Collapse Specialist with many options from one power source. It allows for the breaking and breaching of concrete and also the dewatering of areas while operations are in progress. The Stanley tool set is the most powerful tool carried in the cache. The Stanley power unit is a gas-powered machine that allows responders to operate two hydraulic tools simultaneously.

Setup

1. Check the engine crankcase oil level.
2. Check the fuel level.
3. Connect hydraulic hoses.
4. Check hydraulic fluid.
5. Make sure battery cables are tight and that charging circuit functions are operating properly.

Breakdown

1. Ensure the flow control levers are in the off position.
2. Move the ignition switch to the off position.
3. Clean the unit thoroughly before storage. Do not use water pressure.
4. Always store the unit in a clean and dry facility.

5. If the unit will be stored for a prolonged period (over thirty days), put a fuel additive in the fuel tank to prevent the fuel from gumming. Run the engine for 2 minutes to circulate the additive throughout the fuel system.
6. Replace the crankcase oil with new oil.
7. Remove spark plugs and pour approximately 1 ounce (30 milliliters) of engine oil into each cylinder. Replace the spark plugs and crank the engine slowly to distribute the oil.
8. Check hydraulic reservoir for water. If water is found, change the oil and circulate it through the tool hose and tool.
9. Disconnect tool hoses.

Maintenance

- Perform fuel system emissions by checking for leaks or cracks.
- Perform hydraulic system maintenance by checking hydraulic fluid levels daily, removing condensed moisture, inspecting for leaks or kinks, and checking/replacing filter.
- Perform battery maintenance for power level/voltage and recharge or replace as needed.

Troubleshooting

Refer to Table 2.20 for troubleshooting information.

Table 2.20: Troubleshooting

Problem	Solution
Engine will not start	• Check to see if battery is connected. Attach battery cables and check wires. • Test battery. Charge or replace. • Add fuel. • Check/Replace fuel filter. • Remove spark plugs, check gap, and clean or replace. • Check oil level. • Check to see if flow control levers are in the “on” position. Move the levers to the “off” position.

Table 2.20: Troubleshooting (continued)

Problem	Solution
Fluid blowing out of fluid reservoir vent	• Check/Correct the hydraulic fluid level. • Check pump suction connections. Tighten if necessary.
Hydraulic tool will not operate	• Check that the flow control lever(s) are in the “on” position. • Make sure the tool hose circuit goes from left (pressure) fitting to tool and back to the right fitting (return). • Quick disconnect fittings defective: Detach quick disconnect fittings from hose, connect set together, and check for free flow. • Check for correct hydraulic fluid level. Fill using the recommended fluid. • Adjust or replace relief valve. • Make sure suction hose from fluid reservoir to pump inlet has a smooth curve.

Safety Issues

- The Stanley tool set power unit is cumbersome and heavy, so use caution when moving it.
- Exhaust from the gasoline engine can create a hazardous atmospheric condition.
- Each tool has its own safety concerns and members must become familiar with each of those in the cache.

Summary

As a Structural Collapse Specialist, you will be required to work with a large variety of tools that operate using a variety of power sources. It is important for you to thoroughly understand the operation and safety issues associated with tool and power source. To gain this understanding, read the operator’s and user’s manuals that came with the tools and equipment in your cache.

Activity 2.1: Pneumatic Tools

Purpose

Slide 7

The purpose of this activity is to introduce participants to the various pneumatic tools that the Structural Collapse Specialist may use during a US&R response.

Participant Directions

1. The instructor will discuss each tool. This information is also located throughout this module in your participant guide.
2. Practice setting up and breaking down each tool and perform assigned maintenance tasks.

Activity 2.2: Torches

Purpose

The purpose of this activity is to introduce participants to the tools the Structural Collapse Specialist may use during a US&R response for cutting, moving objects, and tiebacks.

Participant Directions

1. The instructor will discuss each tool. This information is also located throughout this module in your participant guide.
2. Practice setting up and breaking down each tool and perform assigned maintenance tasks.

Activity 2.3: Electric Tools/Manual Tools

Purpose

The purpose of this activity is to introduce participants to the various electric-powered tools that the Structural Collapse Specialist may use during a US&R response.

Participant Directions

1. The instructor will discuss each tool. This information is also located throughout this module in your participant guide.
2. Practice setting up and breaking down each tool and perform assigned maintenance tasks.

Activity 2.4: Gas-Powered Tools

Purpose

The purpose of this activity is to introduce participants to the various gas-powered tools that the Structural Collapse Specialist may use during a US&R response.

Participant Directions

1. The instructor will discuss each tool. This information is also located throughout this module in your participant guide.
2. Practice setting up and breaking down each tool and perform some assigned maintenance tasks.

Activity 2.5: Patient Packaging

Purpose

The purpose of this activity is to introduce and allow participants to practice patient packaging.

Participant Directions

1. The instructor will discuss and demonstrate each patient packaging method:
   - Stokes litter,
   - Yates Spec Pak, and
   - backboard and sked.
2. Practice securing a patient using each method.


NATIONAL US&R RESPONSE SYSTEM
DEPARTMENT OF HOMELAND SECURITY
FEMA

Module 3

Shoring

Shoring—Introduction

Slides 1–2

Emergency shoring used in Urban Search and Rescue (US&R) incidents is defined as the temporary stabilization or resupport of damaged structural members or systems subject to continued movement or collapse. The shoring support is applied as necessary to only a section of, a structural element of, or a part of the compromised structure. Shoring is used in order to provide a safer and more efficient working environment while conducting victim search and rescue operations. If hazards exist that cannot be mitigated by other means (i.e., avoidance, minimizing exposure, or removal), then shoring can be used to reduce the risk environment for the collapse incident's victims, as well as the rescue personnel.

Rescue shoring is to properly resupport the structurally damaged or unstable element by receiving and collecting loads from damaged elements and transmitting and/or distributing loads to structural elements in the remaining part of the building that are sound and capable of handling the additional collapse-caused loads.

Effective shoring includes:

- adjustability;
- positive connections;
- lateral bracing;
- ductility; and
- warning of overload.

This module will give you the opportunity to build the basic types of shores that you will be required to create in the field.

Shoring—Administration

Duration

20 hours:

- Classroom: 1 hour
- Field exercises: 19 hours:
  - Activity 3.1: Cutting Table Setup (1 hour)
  - Activity 3.2: Class 1 Shoring (2 hours and 30 minutes)
  - Activity 3.3: Class 2 Shores—Two-Post Shore (2 hours and 30 minutes)
  - Activity 3.4: Class 2 Shores—Windows and Doors (2 hours and 30 minutes)
  - Activity 3.5: Class 3 Shoring—Laced Post Shore (2 hours and 30 minutes)
  - Activity 3.6: Class 3 Shoring—Sloped Floor Shore (2 hours and 30 minutes)
  - Activity 3.7: Class 3 Shoring—Raker Shore (2 hours and 30 minutes)

Terminal Learning Objective (TLO)

Upon the successful completion of this module, participants will be able to construct a variety of shoring systems for structure stabilization.

Enabling Learning Objectives (ELO)

1. Discuss shoring progression.
2. Construct a Class 1 shoring system.
3. Construct a Class 2 shoring system.
4. Construct a Class 3 shoring system.

Resources

- LCD projector with remote
- PowerPoint presentation for module 3

Note: The following lists the materials and quantities needed for the entire module. Refer to individual activities for materials and quantities needed for each station.

- Application 3.1: Sloped Floor Shore Build
- 4, 5-kilowatt (kW) or larger generators

- Fuel for generator (4, 5 gallon containers)
- 4 squad boxes, each containing the following items and quantities:
  - 6 tool belts
  - 6 framing hammers
  - 6, 25-foot tape measures
  - 6 marking pencils or lumber crayons
  - 6 speed squares
  - 2 framing squares
  - 2 nail pullers
  - 2 sheet rock knives (for sharpening pencils/crayons)
  - 2 chalk lines
  - 2 torpedo levels
- Lumber:

  Note: Lumber lengths are based on either a 10 foot ceiling height or a 12 foot insertion point. Adjust as needed for the ceiling height/window and door sizes of the training facility. Quantities are for every three squads.

  - 2 inch × 4 inch × 45 inch (4 pieces)
  - 2 inch × 4 inch × 8 foot (8 pieces)
  - 2 inch × 4 inch × 16 foot (14 pieces)
  - 2 inch × 6 inch × 16 foot (25 pieces)
  - 4 inch × 4 inch × 32 inch (8 pieces)
  - 4 inch × 4 inch × 8 foot (1 piece)
  - 4 inch × 4 inch × 16 foot (16 pieces)
  - 6 inch × 6 inch × 12 foot (1 piece)
  - 4 foot × 8 foot × ¾ inch plywood (19 sheets)
  - 24 wooden pallets
  - Lumber for optional shores:
    - 2 inch × 4 inch × 16 foot (1 piece)
    - 2 inch × 6 inch × 16 foot (9 pieces)
    - 4 inch × 4 inch × 16 foot (2 pieces)
    - 4 inch × 6 inch × 12 foot (1 piece)
    - 6 inch × 6 inch × 12 foot (6 pieces)
    - 4 foot × 8 foot × ¾ inch plywood (2 sheets)

- Nails (**Note:** Quantities are for every three squads.):
  - 8d duplex nails (50 pounds)
  - 16d duplex nails (50 pounds)
  - 8d nails (60 pounds)
  - 16d nails (70 pounds)
- Nails for optional shores:
  - 8d nails (15 pounds)
  - 16d nails (20 pounds)
- Tools:
  - 4, 7¼ inch electric circular saws with blade
  - 4, 10¼ inch electric circular saws with blade
  - 2 rotary hammers with ½ inch drill bit
- Equipment:
  - 6 extension cords
  - Cutting table (if available) (from Activity 3.1)
  - 2 shore clamps
  - 1 jack wrench
  - 2, 8-pound sledgehammers
  - 8, 1 inch × 36 inch pickets
  - 8, ½ inch × 18 inch pins

Instructor-to-Participant Ratio

1 instructor to 8 participants:

- Minimum: 16 participants
- Maximum: 72 participants (more participants acceptable if hosting site can accommodate)

Reference List

U.S. Army Corps of Engineers (USACE) Urban Search and Rescue Program. (2022, May). *Field Operations Guide* (Edition 9). Retrieved January 26, 2023, from http://www.disasterengineer.org/LinkClick.aspx?fileticket=XU03iAKbt20%3d&tabid=57&mid=394

Practical Exercise Statement

Participants will work as individuals and as squads to construct the three classes of shores.

Assessment Strategy

Instructors will assess participants through observation of proper techniques, questioning, and discussion.

Shoring Sequence

Slides 3–4

Shoring systems have been engineered as well-braced and reliable systems that can be rapidly constructed in emergency conditions. It is important to understand how shoring is built in the National US&R Response System so that the process is always consistent and efficient.

To ensure the safety of rescuers and victims during shoring operations, Structural Collapse Specialists should use the Lookouts, Communications, Escape routes, and Safety zones (LCES) strategy. Once the size up has been completed, the basic shoring sequence should go as follows:

1. Develop and share a shoring plan.
2. Shore from outside in, from safe into unsafe regions.
3. In very dangerous areas, reduce risk by quickly installing Class 1 shores.
4. If operations require, follow with Class 2 shores.
5. To further reduce risk, ensure that all shoring has all posts braced in two directions as Class 3 shores using the following process:
   - Place T or double-T shores.
   - Place pairs of two-post verticals or double-T shores 4 feet apart.
   - Finally, tie the two-post verticals or double-T shores together as laced posts.

The following sections will provide some additional details on completing the shoring size up and considerations for the use of:

- multi-story buildings shoring;
- gusset plates;
- shoring nails; and
- raker shores.

Shoring Size Up

Slides 5–6

The shoring size up provides a survey of structural damage and potential victim locations in buildings identified during the initial building triage and structure/hazards evaluation process. The two main objectives of a shoring size up are:

- Maintain the integrity of all structurally unstable elements.
- Properly transmit or redirect the collapse loads to stable ground or other suitable structural elements capable of handling the additional loads.

Specific tasks to meet these objectives include:

- Identify structural hazards, damage, and potential victim locations.
- Determine the best method to mitigate the structural hazards and damage: avoid, remove, shore, or monitor.
- Determine the type and placement of shoring systems in relation to structural hazards, damage, and potential victim location.

The shoring size up must be extensive, accurate, and continue throughout the rescue operation. A Structures Specialist (StS), a Rescue Team Manager (RTM), and/or a Rescue Squad Officer should perform the shoring size up.

Shoring Placement Considerations—Multi-Story Structures

Slide 7

When shoring a single damaged floor in multi-story, sound, existing building, the following procedure may be used:

- For wood-frame structures, one undamaged floor can support one damaged floor.
- For steel-frame structures, it takes two undamaged floors to support one damaged floor.
- For reinforced concrete, it takes three undamaged floors to support one damaged floor.
- For precast concrete, the shoring should extend to the slab that is supported by the ground.

This procedure assumes that the structure is a reasonable structure, not heavily loaded with furniture, storage, or debris. It does not apply to structures that are under construction or subject to cascading/progressive collapse. This also does not apply to structures that have collapsed suddenly without any apparent cause.

Shoring primary structural supporting elements such as walls, girders, columns, and arches will more effectively utilize shoring materials and existing construction features of the building.

The Structural Collapse Specialist must examine and shore the area beneath the main debris pile to provide additional support to the existing, loaded structural elements before any personnel can be committed to rescue operations on top of the debris pile. Also, the Structural Collapse Specialist must shore up the area directly underneath the victim(s) and rescue forces before significant debris removal operations are attempted. Shores may need to be re-tightened continually as debris is removed.

Shoring systems must be located where they will not interfere with the removal of the victim(s). All loads transferred to the earth (or another structural element capable of handling the additional load) require the shoring systems to be located where they will bear on each other.

The best strategy for multi-story shoring is to start directly under the damaged floor and work down. Access into the building may require shoring to be started from the point of entry to where the victim is located. Sections of shoring may have to be built to create safe zones and safe passageways.

In the most dangerous conditions, it is best to use a phased approach, where Class 1, spot shores (double-T is preferred) are placed first to reduce risk. These shores may be followed by Class 2, two-dimensional shores, and then Class 3, three-dimensional shores, as risk is further reduced.

Use of Gusset Plates in Interior Shoring

Slide 8

In disasters where any type of vibration or shock loading is possible, it is very important to make the connections strong enough to resist repeated impacts and lateral movement.

To make strong connections, it is necessary to:

- Provide a half-gusset or 2 inch × 6 inch bracing connection on each side at the bottom of each post in order to confine the wedges and prevent the sole from possible rollover.
- Provide a one-sided connection at the tops of these same posts if the header is no deeper than its width (4 inches × 4 inches and 6 inches × 6 inches). That is, on end posts the 2 inch × 6 inch bracing connection is adequate. For interior posts, one may use a half-gusset or the 2 inch (× 4 inch or × 6 inch) cleat on one side only.
- Nail the 2 inch × 6 inch post and half-gussets with standard nailing.
- Note that ⅝-inch or ¾-inch plywood or Oriented Strand Board (OSB) may be used for gussets, but should not be used in conditions where it will remain wet.

Shoring Nails

Slide 9

It is the best practice in timber construction that the number and size of nails should not split the wood. For FEMA shoring, Structural Collapse Specialists should use 8d nails to connect plywood gussets and braces and 16d nails (preferred reduced gauge coated sinkers or coolers) to connect the 2 inch (× 4 inch or × 6 inch) cleats and braces. The recommended sizes are:

- 8d common, coated (0.131 inch × 2½ inch) for plywood
- 16d sinkers/coolers, coated (0.148 inch × 3¼ inch)
- 16d box nails (0.135 inch × 3½ inch) (**Note:** If these nails are the only ones available, they are okay to use but Structural Collapse Specialists should add three nails in raker cleats.)

All nails should have full heads, but most gun-nails have the heads slightly offset from the shank in order to minimize the length of the clip. Heads with a small piece removed from one edge may be used without much loss of strength, however,

nails with a V-notch cut out should not be used, since they tend to cut into the wood.

Raker Shores

Slides 10–12

The main purpose of the raker shore is to support leaning or unstable walls and columns by transferring additional weight down the raker to the ground or other supporting members and away from the wall or column. Solid sole rakers should be erected following the procedure in the most current version of the U.S. Army Corps of Engineers (USACE) *Shoring Operations Guide* (SOG) or *Field Operations Guide* (FOG).

The two common angles used are 45 and 60 degrees:

- 60-degree angle is the maximum recommended angle.
- 60-degree angle is preferred for flying rakers and may be used for solid and split sole rakers.
- 45-degree angle is most often used for solid sole rakers and may be used for split sole.
- 30-degree angles have been used to brace some structures when adequate space was available.
- The wall plate should make contact with the wall as much as possible; it may be up to 10 degrees out of plumb without loss of performance.

Determining the height at which the raker shore needs to intersect the wall will identify the angle to work best with the available lengths of lumber. A 45-degree angle raker shore requires longer lumber than a 60-degree raker shore to reach the same insertion point. The following shows how to determine the needed length of a raker shore:

- *Length of a 45-degree angle raker shore:* Height of the raker shore support point in feet multiplied by 17 will give the length of the raker, tip to tip, in inches:

  8 feet × 17 = 136 inches or 11 feet 4 inches and the horizontal distance is 8 feet

- *Length of a 60-degree angle raker shore:* Height of the raker shore support point in feet multiplied by 14 will give the length of the raker, tip to tip, in inches:

  8 feet × 14 = 112 inches or 9 feet 4 inches and the horizontal distance is 8 × 7 inches = 56 inches or 4 feet 8 inches

Table 3.1 shows these dimension for a range of insertion points.

Table 3.1: Raker Dimensions Table

Insertion Point (Feet)	45° Raker Length Inches/Feet	60° Raker Length Inches/Feet	60° Horizontal Distance Inches/Feet
3	51 in. (4 ft. 3 in.)	42 in. (3 ft. 6 in.)	21 in. (1 ft. 9 in.)
4	68 in. (5 ft. 8 in.)	56 in. (4 ft. 8 in.)	28 in. (2 ft. 4 in.)
5	85 in. (7 ft. 1 in.)	70 in. (5 ft. 10 in.)	35 in. (2 ft. 11 in.)
6	102 in. (8 ft. 6 in.)	84 in. (7 ft. 0 in.)	42 in. (3 ft. 6 in.)
7	119 in. (9 ft. 11 in.)	98 in. (8 ft. 2 in.)	49 in. (4 ft. 1 in.)
8	136 in. (11 ft. 4 in.)	112 in. (9 ft. 4 in.)	56 in. (4 ft. 8 in.)
9	153 in. (12 ft. 9 in.)	126 in. (10 ft. 6 in.)	63 in. (5 ft. 3 in.)
10	170 in. (14 ft. 2 in.)	140 in. (11 ft. 8 in.)	70 in. (5 ft. 10 in.)
11	187 in. (15 ft. 7 in.)	154 in. (12 ft. 10 in.)	77 in. (6 ft. 5 in.)
12	204 in. (17 ft. 0 in.)	168 in. (14 ft. 0 in.)	84 in. (7 ft. 0 in.)
13	221 in. (18 ft. 5 in.)	182 in. (15 ft. 2 in.)	91 in. (7 ft. 7 in.)
14	238 in. (19 ft. 10 in.)	196 in. (16 ft. 4 in.)	98 in. (8 ft. 2 in.)
15	255 in. (21 ft. 3 in.)	210 in. (17 ft. 6 in.)	105 in. (8 ft. 9 in.)
16	272 in. (22 ft. 8 in.)	224 in. (18 ft. 8 in.)	112 in. (9 ft. 4 in.)
17	289 in. (24 ft. 1 in.)	238 in. (19 ft. 10 in.)	119 in. (9 ft. 11 in.)
18	306 in. (25 ft. 6 in.)	252 in. (21 ft. 0 in.)	126 in. (10 ft. 6 in.)
19	323 in. (26 ft. 11 in.)	266 in. (22 ft. 2 in.)	133 in. (11 ft. 1 in.)
20	340 in. (28 ft. 4 in.)	280 in. (23 ft. 4 in.)	140 in. (11 ft. 8 in.)

Sloped Floor Shoring

Slide 13

In normal sloped roof construction, sloped rafters are fabricated with horizontal bearings cut-in, so that the vertical gravity load can be directly transferred into the supporting structure.

When attempting to shore a damaged, sloped floor, however, the vertical gravity load is transferred from structure to shoring through a sloped surface where two forces are generated:

- A force that is perpendicular to the sloped surface
- A force that will act down the slope-slope force

In many cases, especially for reinforced concrete slabs, the slope force may be assumed to be resisted by:

- the connection of the sloped floor to the remaining structure at the top or
- the sloped floor is firmly embedded in rubble at the bottom.

Table 3.2 provides recommended differences in post height based on the post spacing and slope angle.

Table 3.2: Recommended Difference in Post Height Based on Post Spacing and Slope Angle

Slope (Degrees)	3 foot post spacing (inch)	4 foot post spacing (inch)	5 foot post spacing (inch)
5	3 2/16	4 3/16	5 4/16
6	3 13/16	5 1/16	6 5/16
7	4 7/16	5 14/16	7 6/16
8	5 1/16	6 12/16	8 7/16
9	5 11/16	7 10/16	9 8/16
10	6 6/16	8 7/16	10 9/16
11	7	9 5/16	11 11/16
12	7 10/16	10 3/16	12 12/16
13	8 5/16	11 1/16	13 14/16
14	9	11 15/16	14 15/16
15	9 10/16	12 14/16	16 1/16
16	10 5/16	13 12/16	17 3/16
17	11	14 11/16	18 6/16
18	11 11/16	15 10/16	19 8/16
19	12 6/16	16 8/16	20 11/16
20	13 2/16	17 8/16	21 13/16
21	13 13/16	18 7/16	23 1/16

Table 3.2: Recommended Difference in Post Height Based on Post Spacing and Slope Angle (continued)

Slope (Degrees)	3 foot post spacing (inch)	4 foot post spacing (inch)	5 foot post spacing (inch)
22	14 9/16	19 6/16	24 4/16
23	15 4/16	20 6/16	25 7/16
24	16	21 6/16	26 11/16
25	16 13/16	22 6/16	28
26	17 9/16	23 7/16	29 4/16
27	18 5/16	24 7/16	30 9/16
28	19 2/16	25 8/16	31 14/16
29	19 15/16	26 10/16	33 4/16
30	20 13/16	27 11/16	34 10/16
31	21 10/16	28 13/16	36 1/16
32	22 8/16	30	37 8/16
33	23 6/16	31 3/16	38 15/16
34	24 5/16	32 6/16	40 8/16
35	25 3/16	33 10/16	42
36	26 2/16	34 14/16	43 9/16
37	27 2/16	36 3/16	45 3/16
38	28 2/16	37 8/16	46 14/16
39	29 2/16	38 14/16	48 9/16
40	30 3/16	40 4/16	50 6/16
41	31 5/16	41 12/16	52 3/16
42	32 7/16	43 4/16	54

Table 3.2: Recommended Difference in Post Height Based on Post Spacing and Slope Angle (continued)

Slope (Degrees)	3 foot post spacing (inch)	4 foot post spacing (inch)	5 foot post spacing (inch)
43	33 9/16	44 12/16	55 15/16
44	34 12/16	46 6/16	57 15/16
45	36	48	60

Shoring Evaluation

Slides 14–16

Rescue shoring is not a perfect science. Shores are often built in imperfect environments and, therefore, do not always look like the pictures. In order to determine if shores are performing as expected, a shoring evaluation needs to be performed on each shore after it is built. This evaluation will focus on the performance expectations based on the principles of shoring rather than matching the picture in the USACE SOG or FOG.

The elements of the evaluation are:

- Double funnel symbol: Is it collecting the load or transmitting the load and redistributing the load to a stable foundation?
- PLS: Is it Plumb, Level, and Square? Shores are meant to be in this condition. If not, they may have to be de-rated.
- W2W L2R: Is there Wood to Wood contact from Load to Resistance? There should be a line of contact points from the load to the resistance. If not, shim or otherwise ensure there is contact.
- Adj.: Is it adjustable?
- + conn.: Are there positive connections at each wood to wood joint (at least one side at the top of the shore and both sides at the bottom)?
- X: Does it have adequate cross bracing and/or horizontal bracing?
- 8' max: Posts should be no more than 8 feet long (4 inches × 4 inches) between nailed joints in order to prevent buckling failure.
- Fuse: If not using wood shoring, is there a structural fuse in the system? Is there a wood header, sole plate, or set of wedges to see overloading?

This is a good start for the Structural Collapse Specialist to evaluate shores that may not look like any that have been built before.

Activity 3.1: Cutting Table Setup

Purpose

Slide 17

The purpose of this activity is to allow participants to understand the components of a cutting table and to construct a cutting table.

Participant Directions

1. The instructor will select a squad or group of participants to construct a cutting table. The remaining participants will observe.
2. Use the following general procedure to construct the cutting table:
   - Use the four 4 inch × 4 inch × 32 inch pieces of lumber as the legs of the table.
   - Create the frame using two 2 inch × 4 inch × 45 inch pieces of lumber and two 2 inch × 4 inch × 8 foot pieces of lumber. The total width of the frame will be 48 inches.
   - Attach the legs to the inside corners of the frame.
   - Attach plywood to the top of the frame.
   - Stand the table on its legs and use the remaining two 2 inch × 4 inch × 45 inch pieces of lumber and two 2 inch × 4 inch × 8 foot pieces of lumber to create bracing between the legs about half the distance to the ground.
   - Use three 2 inch × 4 inch × 8 foot pieces of lumber to create cutting guides on the table top as referenced in the USACE FOG.
3. Use the cutting table to cut wedges using any remaining lumber or scraps.

Activity 3.2: Class 1 Shoring

Purpose

The purpose of this activity is for participants to practice constructing a variety of Class 1 shores.

Participant Directions

1. Construct a T-shore (refer to Figure 3.1).

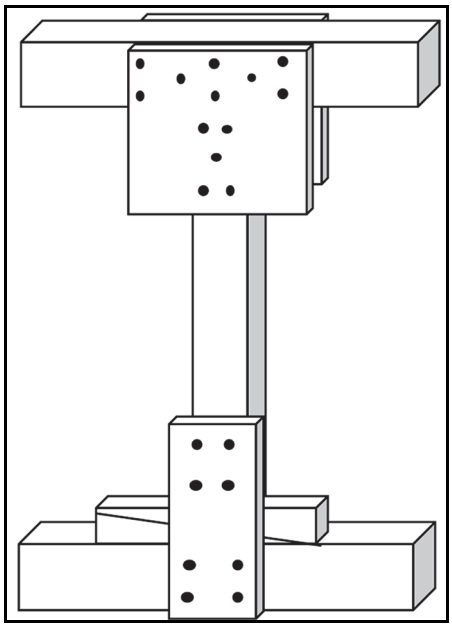

Figure 3.1: T-Shore
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2. Construct a double T-shore (refer to Figure 3.2).

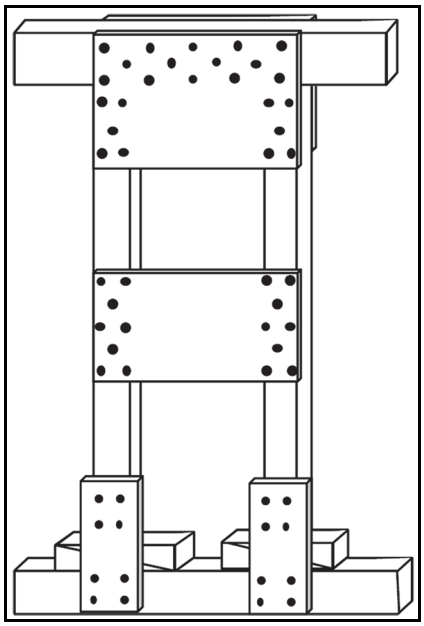

Figure 3.2: Double T-Shore
Property of USACE, reprinted with permission.

3. Construct a Paratech single-post shore (refer to Figure 3.3).

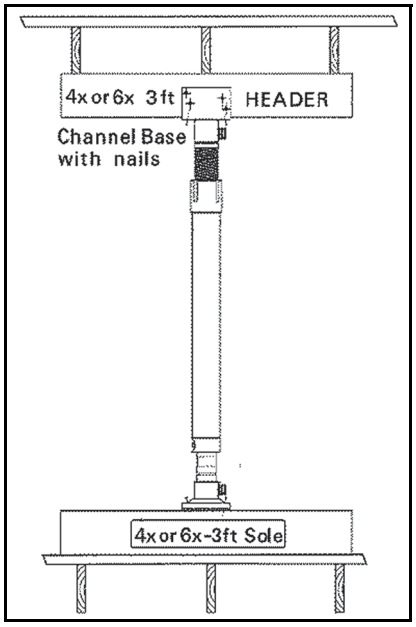

Figure 3.3: Pneumatic T-Shore
Property of USACE, reprinted with permission.

4. Construct a T-shore using shore clamps and a jack wrench.

5. Once each shore has been constructed and approved by your instructor, disassemble the shoring systems and stack the materials in an orderly fashion for the next squad.

Activity 3.3: Class 2 Shores—Two-Post Shore

Purpose

The purpose of this activity is for participants to practice constructing a Class 2, two-post shoring system.

Participant Directions

1. Construct a two-post shoring system (refer to Figure 3.4).

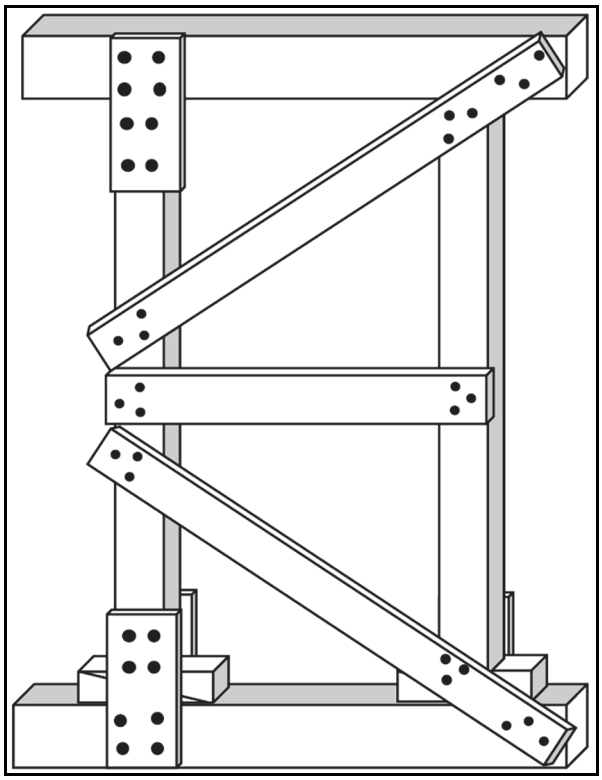

Figure 3.4: Two-Post Shore
Property of USACE, reprinted with permission.

2. Once the shore has been constructed and approved by your instructor, disassemble the shoring system and stack the materials in an orderly fashion for the next squad.

Activity 3.4: Class 2 Shores—Windows and Doors

Purpose

The purpose of this activity is for participants to practice constructing Class 2, window and door shoring systems.

Participant Directions

1. Construct shoring systems for a door and a window (refer to Figure 3.5).

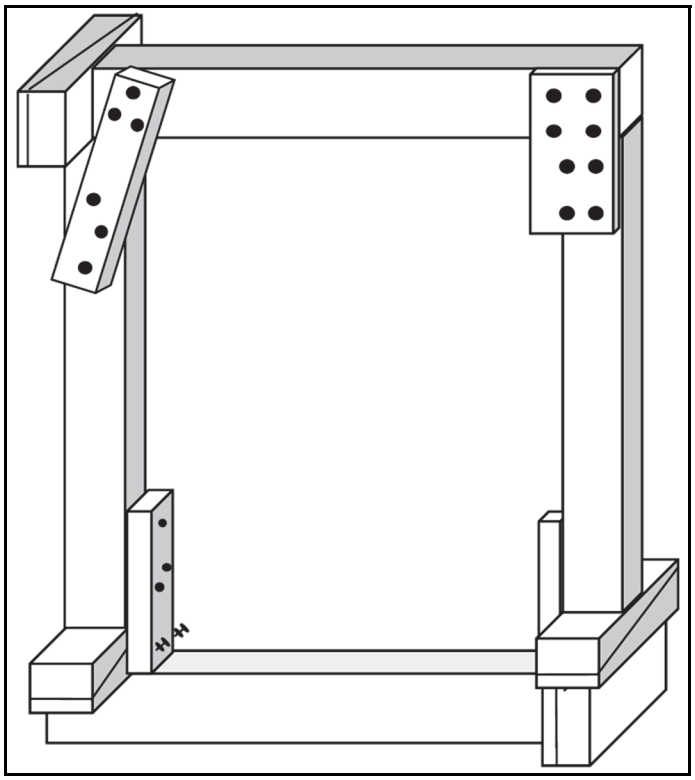

Figure 3.5: Window and Door Shore
Property of USACE, reprinted with permission.

2. Once the shores have been constructed and approved by your instructor, disassemble the shoring systems and stack the materials in an orderly fashion for the next squad.

Activity 3.5: Class 3 Shoring—Laced Post Shore

Purpose

Slide 18

The purpose of this activity is for participants to practice constructing a Class 3, laced post shoring system.

Participant Directions

1. Construct a laced post shoring system (refer to Figure 3.6).

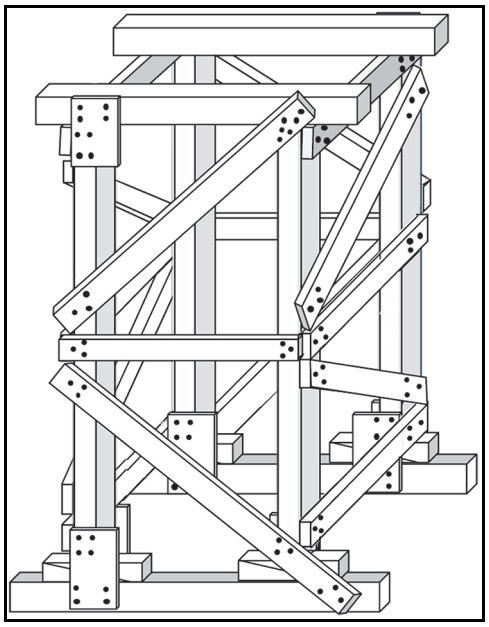

Figure 3.6: Laced Post Shore
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2. Once the shores have been constructed and approved by your instructor, disassemble the shoring systems and stack the materials in an orderly fashion for the next squad.

Activity 3.6: Class 3 Shoring—Sloped Floor Shore

Purpose

The purpose of this activity is for participants to practice constructing a Class 3, sloped floor shoring system.

Participant Directions

1. Construct a sloped floor shoring system (refer to Figure 3.7) using Application 3.1: Sloped Floor Shore Build.

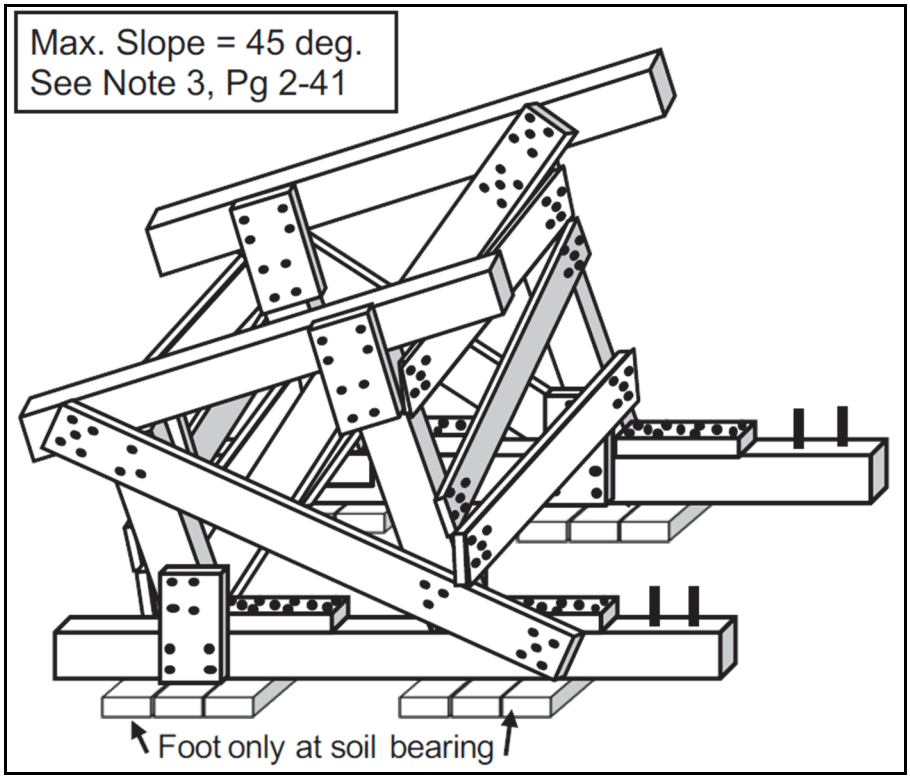

Figure 3.7: Sloped Floor Shore
Property of USACE, reprinted with permission.

2. Once the shore has been constructed and approved by your instructor, disassemble the shoring system and stack the materials in an orderly fashion for the next squad.

Application 3.1: Sloped Floor Shore Build

1. Install a temporary (Class 1 or 2) shore in the hazard area.
2. Determine the angle of the slab (In all cases it helps to read the angle against a longer board to remove variances of a smaller portion of the slab.):
   - Angle finder
   - Speed square and torpedo level:
     - Hold the speed square with pivot down and pivot torpedo level to level.
     - Read the angle on the square.
   - Speed square and plumb bob:
     - Hold speed square with pivot up and hold plumb bob on pivot.
     - Read the angle and subtract from 90.
   - Scribe two boards

   If using Table 3.2: Pick a shore length that will fit in the space, then look at the chart for the angle and post spacing and add/subtract number of inches for other post. Skip steps 3 through 5.
3. Determine the shore size (should be visualized in area needed):
   - Consider post spacing of 3, 4, or 5 feet
   - Shore spacing as needed
4. Identify the first post location and mark a reference point on floor.
5. Measure back (or forward) post spacing length and mark another reference point on the floor.
6. Measure from reference points to ceiling slab.

   Very important: These measurements must be plumb and very accurate. Consider using a plumb bob, then measuring the length of string or cord used. Any inaccuracies here will throw off the shore angle.
7. Exit the hazard area and figure the calculations as follows:
   - Post length minus 8 inches (for header/sole and wedges)
   - Header (square side) = post spacing + 2 feet for overhang
   - Sole (angle side) = post spacing + 1 foot overhang + 18 inches overhang for cleat + post spacing + angle additional length (**Note:** if small angle, small additional; if big angle, big additional)
   - Make two of everything for complete class three shore
8. Start construction in a safe area if possible.

9. Start with the header (square side). Measure from one end of the lumber. Add 1 inch for overhang, then post spacing.
10. Place the first post on the mark (use on center spacing) and toe nail to header.
11. Place the second post on the mark and toe nail to header.
12. Square up longer post to header using 3-4-5 method. Hold in place.
13. Square up shorter post to longer post using parallel measurement. Hold in place.
14. Move sole (angle side) into place without moving posts. Consider length behind longer post for cleat size. Once placed, toe nail posts to sole.
15. Measure for 2 inch × 6 inch cross braces.
16. Nail gussets in opposite corners (two only).
17. Nail once brace in non-gusset corners covering post to sole/header joint as much as possible.
18. Move the shore upright with sole (angle side) down.
19. Nail cleats in place.
20. Lay the shore on the ground with brace/gusset side down.
21. Nail the other brace and gussets on the up side.
22. Complete the other shore following the same process (steps 7 through 20).
23. Determine whether the shore should go into place in friction method or perpendicular method:
    - If slab is hinged, use perpendicular (angle side down)
    - If slab is floating, use friction (square side down)
24. Move the farthest shore into place and drive in until pressurized.

    If needed, shim above or below to create good wood-to-wood contact above and below posts.
25. Move closer shore into place and drive in until pressurized.

    If needed, shim above or below to create good wood-to-wood contact above and below posts.
26. Evaluate for tying shores together. There should be good nail contact between braces and post.

    If not, adjust the height of the shore that is not in line with the others by placing plywood or a 2 inch × 4 inch piece on top of the header/sole to make it taller.
27. Nail horizontal braces to shores and cross brace appropriately.
28. Shim where necessary to make good contact at the floor and ceiling.

29. Pin the angle side using pins (at least two) with 4 inch embedment into slab.
30. Evaluate the shore for effectiveness.

Alternatives:

- Whalers may be needed above the shore to capture the bottom of the narrow point, wide spread beams (double Ts).
- A nailed wedge pack may be placed between the post and the header during construction to create a structural fuse that can be seen. This generally will not be used for adjustment due to nailed cross braces.

Activity 3.7: Class 3 Shoring—Raker Shore

Purpose

The purpose of this activity is for participants to practice constructing Class 3 solid sole and split sole raker shores and lace them into a system.

Participant Directions

1. Construct a solid sole raker shoring system (refer to Figure 3.8).

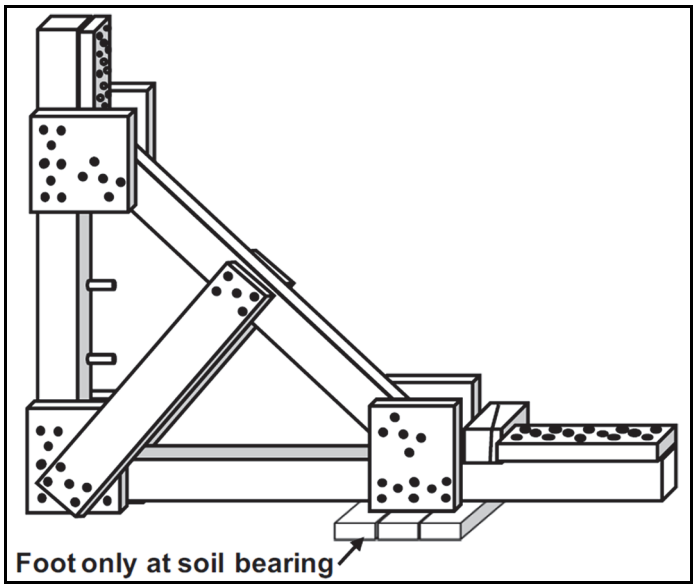

Figure 3.8: Solid Sole Raker
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2. Construct a split sole raker system (refer to Figure 3.9).

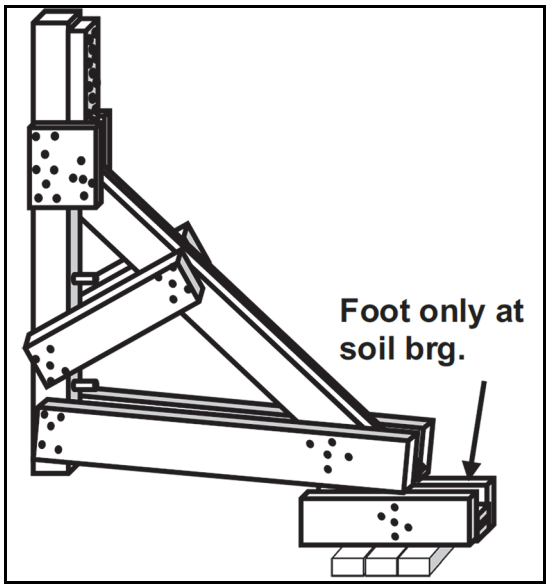

Figure 3.9: Split Sole Raker
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3. Once the shores have been constructed and approved by your instructor, disassemble the shoring systems and stack the materials in an orderly fashion for the next squad.


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Module

4

Breaking and Breaching

Breaking and Breaching—Introduction

Slides 1–2

Often, in structural collapse incidents in order to gain access to trapped victims, Structural Collapse Specialists must break, breach, or burn their way through structural elements. Breaking and breaching techniques are also regularly used to create search voids and form lifting points for debris removal.

This module will allow you to practice the skills, techniques, and methods to conduct breaking, breaching, and burning operations.

Breaking and Breaching—Administration

Duration

20 hours:

- Classroom: 1 hour
- Field exercises: 19 hours:
  - Activity 4.1: Drill and Breaker Workshop (2 hours)
  - Activity 4.2: Saw Workshop (2 hours)
  - Activity 4.3: Metal Cutting Workshop (2 hours)
  - Activity 4.4: Horizontal Breach (Clean and Dirty) (2 hours)
  - Activity 4.5: Vertical Breach (Clean and Dirty) (2 hours and 30 minutes)
  - Activity 4.6: Torch Application Workshop (2 hours)
  - Activity 4.7: Confined Space Breach (2 hours and 30 minutes)
  - Activity 4.8: The Funhouse (4 hours)

Terminal Learning Objective (TLO)

Upon the successful completion of this module, participants will be able to perform breaching and breaking operations to gain entrance into a collapsed structure.

Enabling Learning Objectives (ELO)

1. Demonstrate the use of drills for breaking and breaching operations.
2. Demonstrate the use of saws for breaking and breaching operations.
3. Demonstrate the proper use of Petrogen and oxyacetylene torches.
4. Perform both a clean and dirty horizontal breach.
5. Perform both a clean and dirty vertical breach.
6. Perform a breach into a confined space.
7. Use a Petrogen and/or oxyacetylene torch for breaking and breaching operations.

Resources

- LCD projector with remote
- PowerPoint presentation for module 4

Note: The following lists the materials and quantities needed for the entire module. Refer to individual activities for materials and quantities needed for each station.

- 1 trailer-mounted 185 cubic feet/minute industrial air compressor with 30-pound, 45-pound, and 90-pound breaker/chipper with bits and hoses (non-cache item)
- Tool oilers for compressor
- 5, 5-kilowatt (kW) or larger generators
- Water supply with feed mechanism (garden hose, pump sprayer, pump can, etc.) (2 sources)
- Tools:
  - 3 gas-powered core drills with 2 inch bit
  - 4 rotary hammers with various bits:
    - 4, ½ inch drill bits
    - 4 chisel bits
    - 4 bull (moil) points
  - 4 reciprocating saws with bi-metal blades
  - 2 rebar cutters
  - 2 Stanley hydraulic power units with tools, hoses, and bits
  - 2 electric breakers with various bits
  - 4 gas-powered rotary saws
  - 1 gas-powered ring saw
  - 1 grinder with blade
  - 1 chain saw with chain, chain oil, and tool
  - 4 tool maintenance kits:
    - Multi-wrench
    - Belts
- Equipment:
  - 13 extension cords
  - ½ inch [diameter] rebar for toggle (3 pieces; 6 inches long)
  - 1, 8-pound sledgehammer
  - 1 pry bar
  - 2 handheld metal detectors
  - 2, 8 foot pieces of 1-inch webbing

  - Spray paint (4 cans)
  - Soapstone or markers (for 2 stations)
- Lumber:
  - 4 inch × 4 inch × 18 inch cribbing (12 pieces)
  - 4 inch × 4 inch × 8 foot lumber (1 piece)
  - 4 inch × 4 inch wedges (2 sets)
- Materials to break and breach:
  - 4 foot × 8 foot × 6 inch (minimum) concrete slab with reinforcing bar (rebar) (7 pieces + 1 per squad)
  - 4 foot × 8 foot × 9 inch (minimum) concrete slab with two layers of rebar (1+ per squad)
  - Concrete pieces with exposed rebar (preferred) (15 pieces)
  - 20 feet #5 rebar
  - 36 inch diameter (minimum) pipe or other vault-type object as a confined space (2 pieces)
  - Scrap steel beams, rebar, and plate (enough for all squad rotations)
  - Rubble pile of previously used concrete slabs with rebar
  - 4 foot × 4 foot × ¼ inch plate steel (2 pieces)
  - 6-inch I-beam (20 feet long)
  - Equipment to secure beam in a cantilever orientation
- Fuels and oils:
  - Fuel for compressor (1, 5 gallon container)
  - Fuel for generator (2, 5 gallon containers)
  - Fuel for power units (1, 5 gallon container)
  - Mixed fuel (fuel and oil) for saws (1, 5 gallon container)
  - Hydraulic fluid for Stanley power unit (2, 1 gallon containers)
  - Bar oil for chain saws (1 quart container)
  - Torch fuel and oxygen for each cutting system
- Torches and equipment:
  - 2 oxygen/acetylene torch setups with tips
  - 2 Petrogen torch setups with tips
  - Tip chart (1 per participant)
  - 6 strikers

  - All standard torch-cutting safety equipment:
    - 6 sets leathers, Nomex, or fire-resistant cotton outerwear welding/cutting gloves
    - 6 pairs shade 3 or 5 goggles or glasses
    - Air-Purifying Respirators (APR) with P-100 cartridge and organic vapor cartridge (provided by participants)
    - Full face shield
    - 3 fire extinguishers
  - 1 atmospheric monitor
  - Miscellaneous tools for torch setup and minor repair:
    - Adjustable wrenches
    - Cleaners
    - Brushes
    - Spare tips
  - 1 ventilation fan
- Application 4.1: Performing a Step Cut
- Application 4.2: Performing a Stitch Cut
- US&R equipment cache
- 1–2 manikins or other items to represent victims
- Patient packaging equipment (if manikins are used):
  - 1 Stokes litter
  - 40 feet of 1 inch webbing
  - 1 Yates Spec Pak
  - 1 sked
  - 1 long backboard

Instructor-to-Participant Ratio

1 instructor to 8 participants:

- Minimum: 16 participants
- Maximum: 72 participants (more participants acceptable if hosting site can accommodate)

Reference List

None

Practical Exercise Statement

Participants will work as individuals and as squads to use a variety of tools and methods for breaking and breaching operations.

Assessment Strategy

Instructors will assess participants through observation of proper techniques, questioning, and discussion.

Breaking and Breaching Sequence

Slides 3–7

To ensure the safety of rescuers and victims during breaking and breaching operations, Structural Collapse Specialists should use the Lookouts, Communications, Escape routes, and Safety zones (LCES) strategy. To ensure that operations are conducted in a safe manner, there is a sequence of operations to be followed:

1. Identify the material.
2. Create an inspection hole to determine victim location, air quality, depth of material, and any hazards present.
3. Determine type of breach needed (clean or dirty, vertical or horizontal).
4. Calculate weight if needed for clean breaches.
5. Develop and share a breaking and breaching plan.
6. Identify confined space considerations including Personal Protective Equipment (PPE), air monitoring, and ventilation needs.

Activity 4.1: Drill and Breaker Workshop

Purpose

Slide 8

The purpose of this activity is for participants to become proficient in operating the different types of drills commonly used during Urban Search and Rescue (US&R) breaking and breaching operations.

Participant Directions

Note: Be sure to use proper body mechanics and be aware of tool and material reactions as you work.

1. Perform a pre-use inspection of the equipment. Be sure to check cords, bits, hoses, and overall condition.
2. In the area of concrete designated by your instructor, use each piece of equipment to drill horizontal and vertical holes and cut exposed reinforcing bar (rebar).
3. At the rubble pile, use each type of breaker.

Activity 4.2: Saw Workshop

Purpose

The purpose of this activity is for participants to become proficient in operating the different types of saws commonly used during US&R breaking and breaching operations.

Participant Directions

Note: Hearing protection is required at this station. Be sure to use proper body mechanics and be aware of tool and material reactions as you work.

1. Perform a pre-use inspection of the equipment. Be sure to check cords, blades, hoses, and overall condition.
2. In the area of concrete designated by your instructor, use each piece of equipment to cut vertical and horizontal lines in the concrete slabs.
3. Use the diamond-segmented chain saw from the Stanley power unit to perform a plunge cut in the concrete.
4. Be sure to use proper body mechanics and to be aware of tool and material reactions as you work.

Activity 4.3: Metal Cutting Workshop

Purpose

The purpose of this activity is for participants to become proficient in operating the different types of tools commonly used during US&R breaking and breaching operations.

Participant Directions

Note: Consider all steel hot and do not touch it without appropriate PPE. Be sure to use proper body mechanics and be aware of tool and material reactions as you work.

1. Perform a pre-use inspection of the equipment. Be sure to check hoses, torch, tips, extension cord, grinding wheels, rebar cutter blades, and overall condition.
2. In the area of steel designated by the instructor, use each piece of equipment to create multiple types of cuts in the various steel objects.

Activity 4.4: Horizontal Breach (Clean and Dirty)

Purpose

The purpose of this activity is for participants to perform horizontal breaches through concrete to gain access to a victim or create an access/egress point.

Participant Directions

Note: Be sure to use proper body mechanics and PPE during this exercise.

1. Complete a pre-use inspection of the equipment.
2. In the area of concrete designated by the instructor, select the appropriate tools and configurations to create a minimum 18 inch × 18 inch clean breach. A step cut may be required (refer to Application 4.1: Performing a Step Cut).
3. In the area of concrete designated by the instructor, select the appropriate tools and configurations to create a minimum 18 inch × 18 inch dirty breach.

Application 4.1: Performing a Step Cut

1. Mark the area you need removed and cut an inspection hole to observe the hidden side (refer to Figure 4.1).

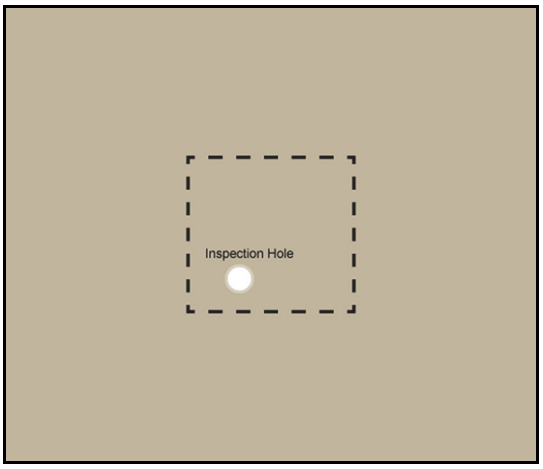

Figure 4.1: Step Cut, Step 1

2. Make another line 10–12 inches outside of the first (refer to Figure 4.2).

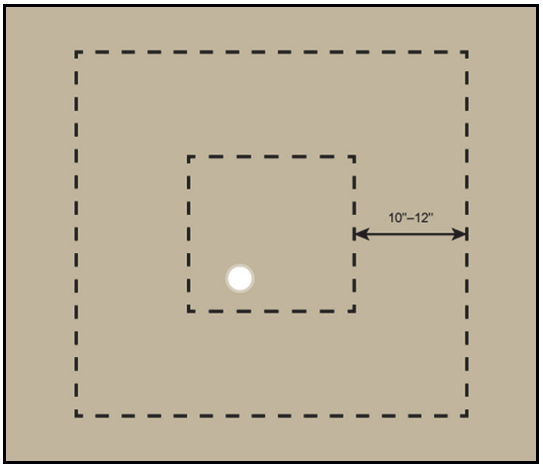

Figure 4.2: Step Cut, Step 2

3. Make relief cuts by cutting along the dotted lines. Cut all lines in one direction, then cut the perpendicular lines (refer to Figure 4.3).

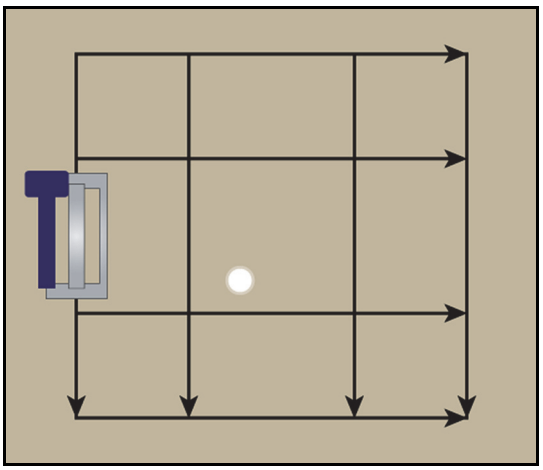

Figure 4.3: Step Cut, Step 3

4. Chip out the grayed areas, creating a valley (refer to Figure 4.4).

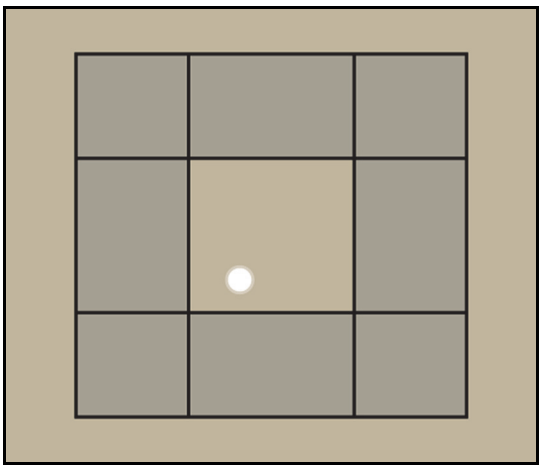

Figure 4.4: Step Cut, Step 4

   – Chip out the area between cuts (refer to Figure 4.5).

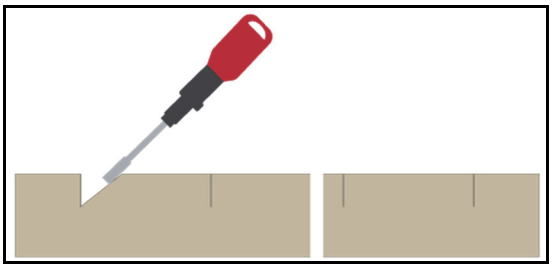

Figure 4.5: Step Cut, Step 4a

   – Chip toward the relief cuts (refer to Figure 4.6).

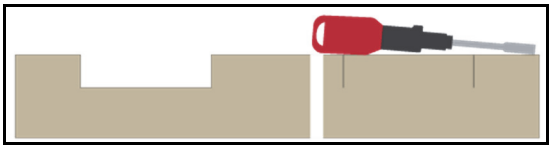

Figure 4.6: Step Cut, Step 4b

5. Drive a wedge anchor and eye nut in the center area (refer to Figure 4.7).

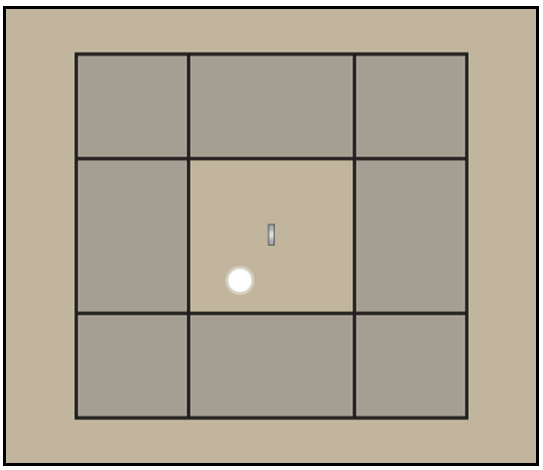

Figure 4.7: Step Cut, Step 5

6. Make angled cuts with a saw in the valley area on opposite sides. Then, cut two vertical cuts on the other sides (refer to Figure 4.8).

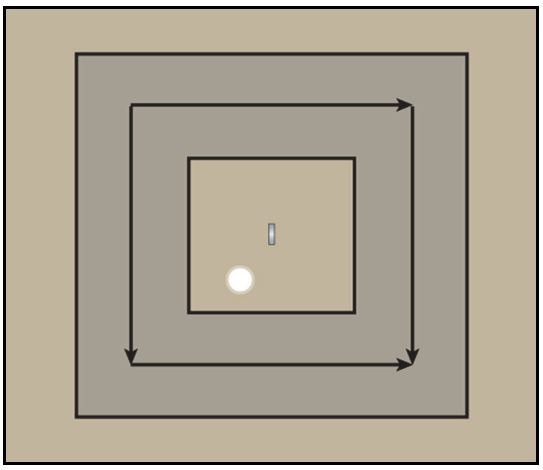

Figure 4.8: Step Cut, Step 6

   – By making angled cuts on two sides, the cutout will not fall through the hole onto a possible victim (refer to Figure 4.9).

Figure 4.9: Step Cut, Step 6a

   – Making the vertical cuts last keeps the saw from binding when gravity takes over and the cutout tries to close the kerf (refer to Figure 4.10).

Figure 4.10: Step Cut, Step 6b

7. Place a piece of webbing in the eye nut and make a lever across the cutout using a spud bar. The cutout may be loosened using a sledge on one corner (refer to Figure 4.11).

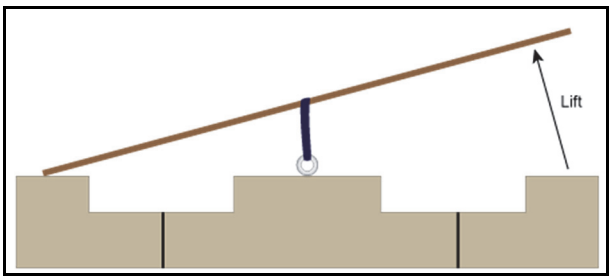

Figure 4.11: Step Cut, Step 7

Lift up and wedge to ensure it does not fall through the hole (refer to Figure 4.12).

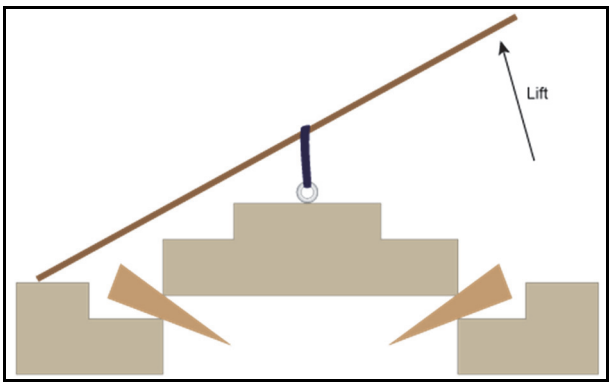

Figure 4.12: Step Cut, Step 7a

Activity 4.5: Vertical Breach (Clean and Dirty)

Purpose

Slide 9

The purpose of this activity is for participants to perform vertical breaches through concrete to gain access to a victim or create an access/egress point.

Participant Directions

Note: Be sure to use proper body mechanics and PPE during this exercise.

1. Complete a pre-use inspection of the equipment.
2. In the area of concrete designated by the instructor, select the appropriate tools and configurations to create a triangular-shaped (20–24 inch base width, high enough for entrance/egress by responders) clean breach using a stitch cut (refer to Application 4.2: Performing a Stitch Cut). Rig and capture the concrete section to remove it from the slab.
3. In the area of concrete designated by the instructor, select the appropriate tools and configurations to create a triangular-shaped (20–24 inch base width, high enough for entrance/egress by responders) dirty breach.


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Application 4.2: Performing a Stitch Cut

1. Cut an inspection hole to observe the hidden side prior to cutting. Make holes in three corners with a core drill or hammer drill (refer to Figure 4.13).

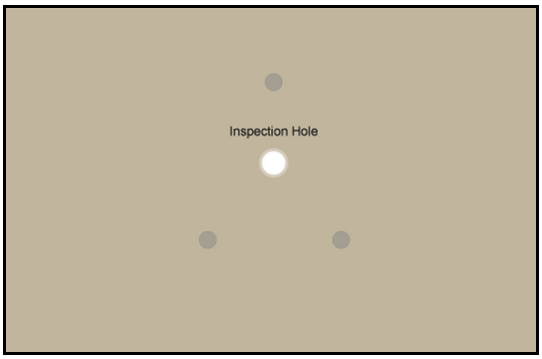

Figure 4.13: Stitch Cut, Step 1

2. Stitch drill the corners together (refer to Figure 4.14).

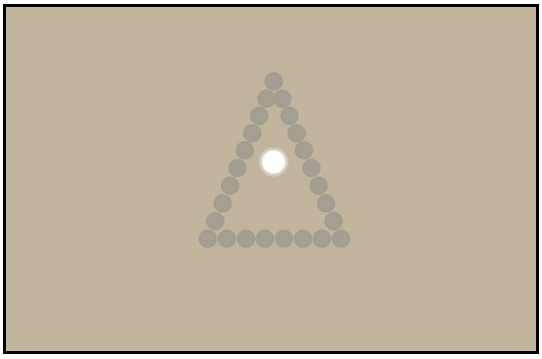

Figure 4.14: Stitch Cut, Step 2

3. Connect the stitch drill with a breaker (refer to Figure 4.15).

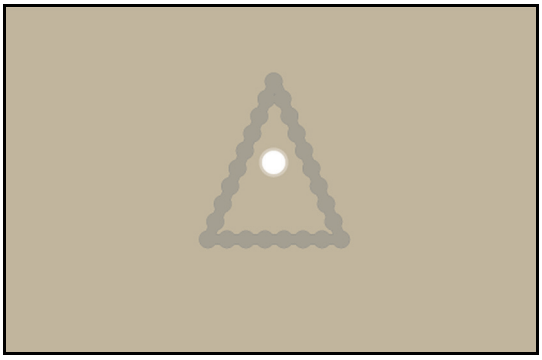

Figure 4.15: Stitch Cut, Step 3

4. Cut the reinforcing bar (rebar) and remove the piece (refer to Figure 4.16).

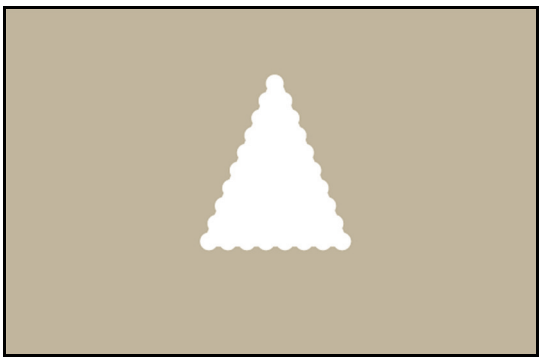

Figure 4.16: Stitch Cut, Step 4

Activity 4.6: Torch Application Workshop

Purpose

The purpose of this activity is for participants to perform torch operations commonly required during US&R breaking and breaching operations.

Participant Directions

Note: Be sure to use proper body mechanics and PPE during this exercise.

1. Complete a pre-use inspection of the equipment.
2. At each prop, complete the following cuts:
   - Steel plate: shackle, plunge, and line cuts
   - I-beam: shackle and beam cuts
   - Rebar: straight cuts

Activity 4.7: Confined Space Breach

Purpose

The purpose of this activity is for participants to perform breaches while working in a confined space.

Participant Directions

Note: Use your full-face Air-Purifying Respirator (APR) with P-100 cartridge during this exercise. Be sure to use proper body mechanics and PPE during this exercise.

1. Complete a pre-use inspection of the equipment.
2. In the area of concrete designated by your instructor, select the appropriate tools and configurations to create an 18 inch × 18 inch dirty breach.

Activity 4.8: The Funhouse

Purpose

The purpose of this activity is for participants to use the breaking and breaching skills learned to access trapped victims.

Participant Directions

Note: Be sure to use proper body mechanics and PPE during this exercise.

1. As a squad, use the breaking and breaching methods learned to access the trapped victims assigned to your squad.
2. If manikins are used as victims, use appropriate patient packaging methods to remove the victim.


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Module

5

Lifting and Moving

Lifting and Moving—Introduction

Slides 1–2

Rescuers need to understand the relationship of gravity to basic tactical evolutions such as lifting, lowering, moving, and stabilizing loads. Even with the availability of powerful cranes, strong hydraulic winches, and high pressure air bags, there is a need for a knowledge of the basic concepts of leverage and gravity. It is the ability of the rescuer to make effective size ups in confined areas of collapsed buildings that often means the difference between life and death.

The rescuer also has a critical role to play when using the heavy lifting equipment such as cranes. All loads to be lifted or moved must be assessed for weight, stability, and rigging points. The rescuer's knowledge of rigging equipment and its basic application will enhance the ability of the heavy equipment to perform.

This module will allow you to practice lifting and moving objects using the following methods:

- levers;
- rollers;
- cribbing/bridging;
- airbags;
- rigging;
- cranes;
- anchors; and
- Mechanical Advantage (MA) systems.

Lifting and Moving—Administration

Duration

20 hours:

- Classroom: 1 hour
- Field exercises: 19 hours:
  - Activity 5.1: Levers (Type I–III), Rollers, and Bridging (3 hours)
  - Activity 5.2: Airbags and Cribbing (3 hours)
  - Activity 5.3: Rigging (3 hours)
  - Activity 5.4: Heavy Equipment (2 hours and 30 minutes)
  - Activity 5.5: Anchors and Bolting (2 hours and 30 minutes)
  - Activity 5.6: Mechanical Advantage (MA) Systems (2 hours and 30 minutes)
  - Activity 5.7: Obstacle Course (2 hours and 30 minutes)

Terminal Learning Objective (TLO)

Upon the successful completion of this module, participants will be able to perform lifting and moving operations to gain entrance into a collapsed structure and/or to free trapped victims.

Enabling Learning Objectives (ELO)

1. Complete moving a load through an obstacle course using a variety of tools and techniques.
2. Use a variety of levers to lift objects.
3. Practice basic rigging including anchors and calculating the weights of objects.
4. Perform the lifting and moving of an object using a crane or other piece of heavy equipment while using appropriate hand signals.
5. Perform the lifting of objects using air bags.
6. Perform the moving of objects using rollers.
7. Use cribbing to stabilize a load.

Resources

- LCD projector with remote
- PowerPoint presentation for module 5

Note: The following lists the materials and quantities needed for the entire module. Refer to individual activities for materials and quantities needed for each station.

- 1 crane or other piece of heavy equipment (like a rotator wrecker) capable of lifting anticipated loads with operator (**Note:** Depending on the number of participants, multiple pieces of heavy equipment may be needed.)
- Materials to lift and move:
  - 1 large piece of concrete (minimum 1,000 pounds)
  - 5 large pieces of concrete and/or steel (minimum 500 pounds)
  - 2 large pieces of concrete (6 inches thick)
  - Materials to create a 24 inch high obstacle (i.e., stacked slabs) that can support weight of concrete being moved
  - Rubble pile of previously used concrete slabs with reinforcing bar (rebar)
  - Assortment of items for lifting (flat slab, pipes, car, concrete blocks, etc.) (minimum of 5 items)
  - 1 high profile object to lift using Paratech HydraFusion
  - 36 inch diameter (minimum) pipe or other vault-type object as a confined space (1 piece)
- Lumber:
  - 4 inch × 4 inch × 24 inch cribbing (120 pieces)
  - 4 inch × 4 inch × 16 foot lumber (8 pieces)
  - 4 inch × 4 inch wedges (48 sets)
- Airbags with regulator, controller, airbag relief/shutoff valve, and hoses:
  - 1, 3-ton
  - 1, 5-ton
  - 2, 8–15-ton
  - 2, 16–20-ton
- Tools:
  - 15, 1½ inch steel pipe rollers, 4 feet long
  - 4 rotary hammers with ½ inch bit
  - 4, ½-inch drive 10–250 pound adjustable torque wrenches
  - 4, ¾-inch deep well sockets for torque wrench (½-inch drive)
  - 8, 3-pound maul hammers
  - 2 come-alongs (minimum capacity 1¼ ton)

  - 2 griphoists
  - 2 chain falls (3-ton capacity)
  - 2 Paratech HydraFusions with pump and hose
  - 6 hydraulic low profile jacks
- Equipment:
  - Self-Contained Breathing Apparatus (SCBA) cylinders (2 cylinders and the ability to refill on site or 8 cylinders)
  - Synthetic sling edge protection (at 2 stations)
  - 22 synthetic slings of various sizes and lengths capable of lifting expected loads
  - 8 wire rope slings of various lengths capable of lifting expected loads
  - 1, ⅜ inch × 50 foot tag line
  - 6, 60 inch pinch bars
  - 16 round screw-pin shackles
  - 16 flat screw-pin shackles
  - ½ inch wedge anchors (1 per participant + 10)
  - 90 concrete screws with appropriate sized drill bit
  - 8, ½ inch steel eye nuts, Crosby or other U.S. equivalent
  - 8, ½ inch × 2½ inch steel swivel hoist rings, Crosby or other U.S. equivalent
  - 1 handheld metal detector
  - 12 bulb syringes
  - 12 tape measures
- Figure 5.5–Figure 5.8

Instructor-to-Participant Ratio

1 instructor to 8 participants:

- Minimum: 16 participants
- Maximum: 72 participants (more participants acceptable if hosting site can accommodate)

Reference List

None

Practical Exercise Statement

Participants will work as individuals and as squads to use a variety of tools and methods for lifting and moving operations.

Assessment Strategy

Instructors will assess participants through observation of proper techniques, questioning, and discussion.

Practice Weight Calculations

Slides 3–6

What is the weight of the wood object in Figure 5.1?

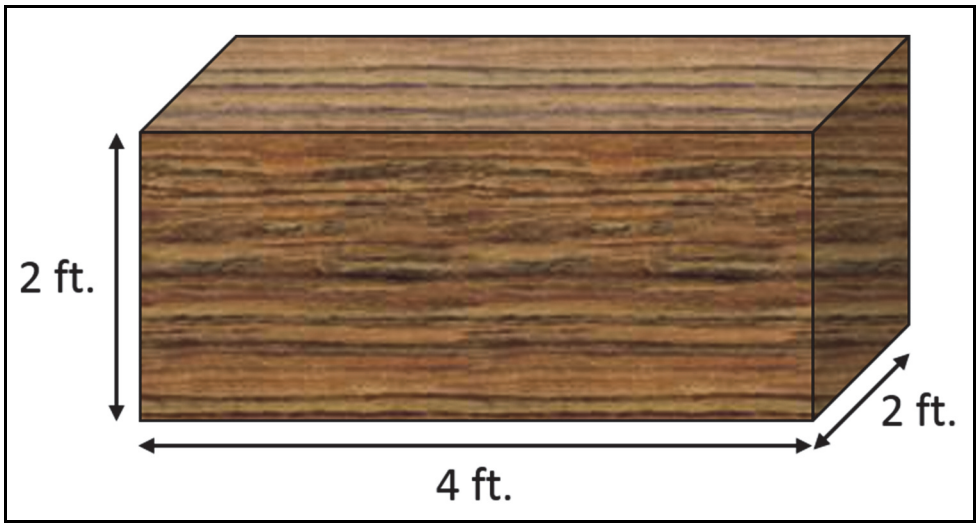

Figure 5.1: Practice Weight Calculations Question 1

Note: Wood = 40 pounds per cubic foot

What is the weight of the steel object in Figure 5.2?

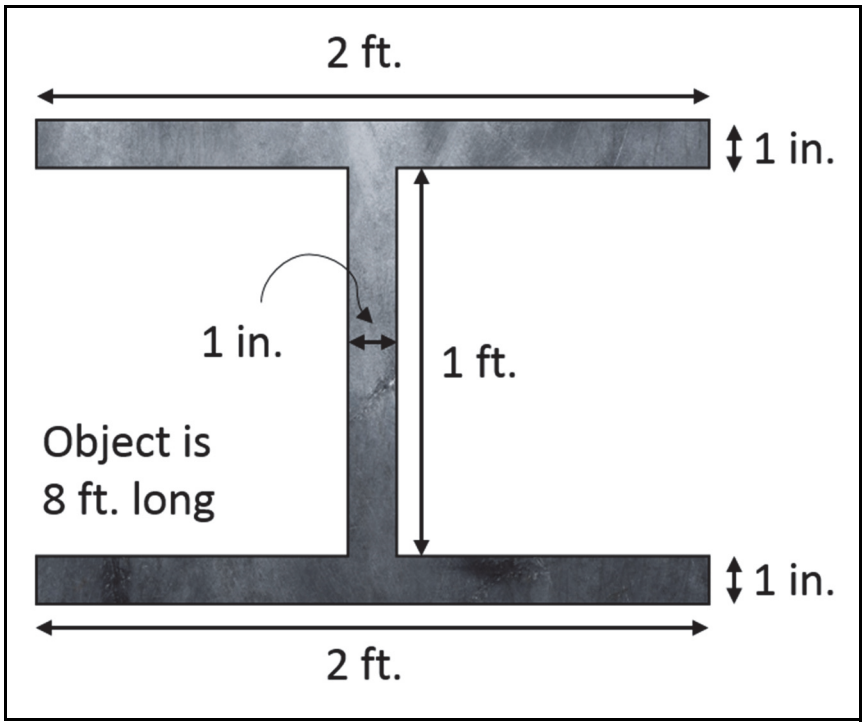

Figure 5.2: Practice Weight Calculations Question 2

Note:

- Steel = 10 pounds/square foot per ¼ inch

  or

- Steel = 490 pounds/cubic foot

What is the weight of the solid reinforced concrete object in Figure 5.3?

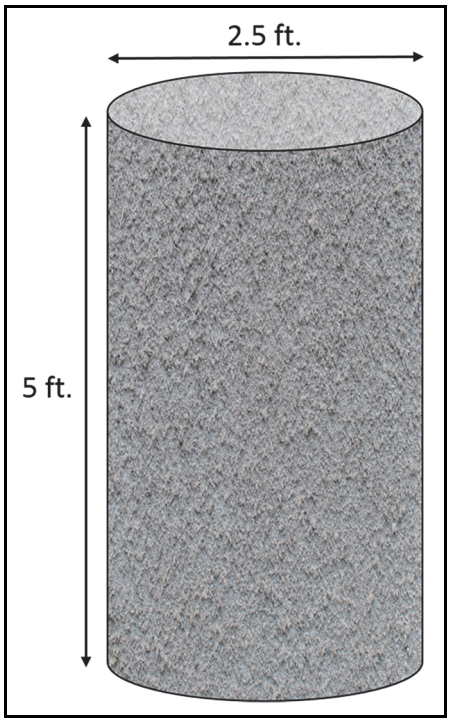

Figure 5.3: Practice Weight Calculations Question 3

Note: Reinforced concrete = 150 pounds/cubic foot

Hint:

- Hint: $\pi r^2 h$

  or

- $0.8 \times d \times d \times L \times 150$

What is the weight of the brick object in Figure 5.4?

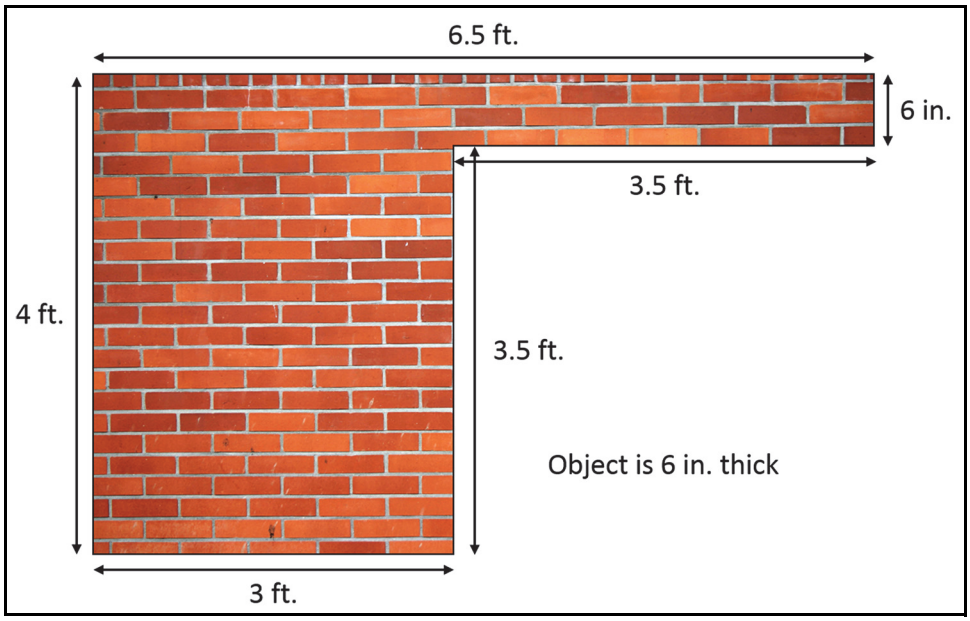

Figure 5.4: Practice Weight Calculations Question 4

Note: Brick = 120 pounds/cubic foot

Lifting and Moving Sequence

Slides 7–11

To ensure the safety of rescuers and victims during lifting and moving operations, Structural Collapse Specialists should use the Lookouts, Communications, Escape routes, and Safety zones (LCES) strategy. To ensure that operations are conducted in a safe manner, there is a sequence of operations to be followed:

1. Identify the material.
2. Perform load calculations and determine the Center of Gravity (CG) of the object.
3. Determine the type of stabilization needed (e.g., cribbing or tiebacks).
4. Determine appropriate rigging.
5. Develop and share a lifting and moving plan.
6. Lift and move the object.

Activity 5.1: Levers (Type I–III), Rollers, and Bridging

Purpose

Slide 12

The purpose of this activity is for participants to practice lifting and moving objects using levers, rollers, and bridging methods.

Participant Directions

Note: Be sure to use proper body mechanics and Personal Protective Equipment (PPE) during this exercise.

1. Calculate the weight of the concrete object and roughly locate the CG.
2. Lift the concrete block at least 24 inches off the ground using levers and cribbing. Then lower the load back to the ground in a controlled manner.
3. Move the concrete block to and over the obstacle using levers (refer to Figure 5.5–Figure 5.7), rollers, and rails in a controlled manner.

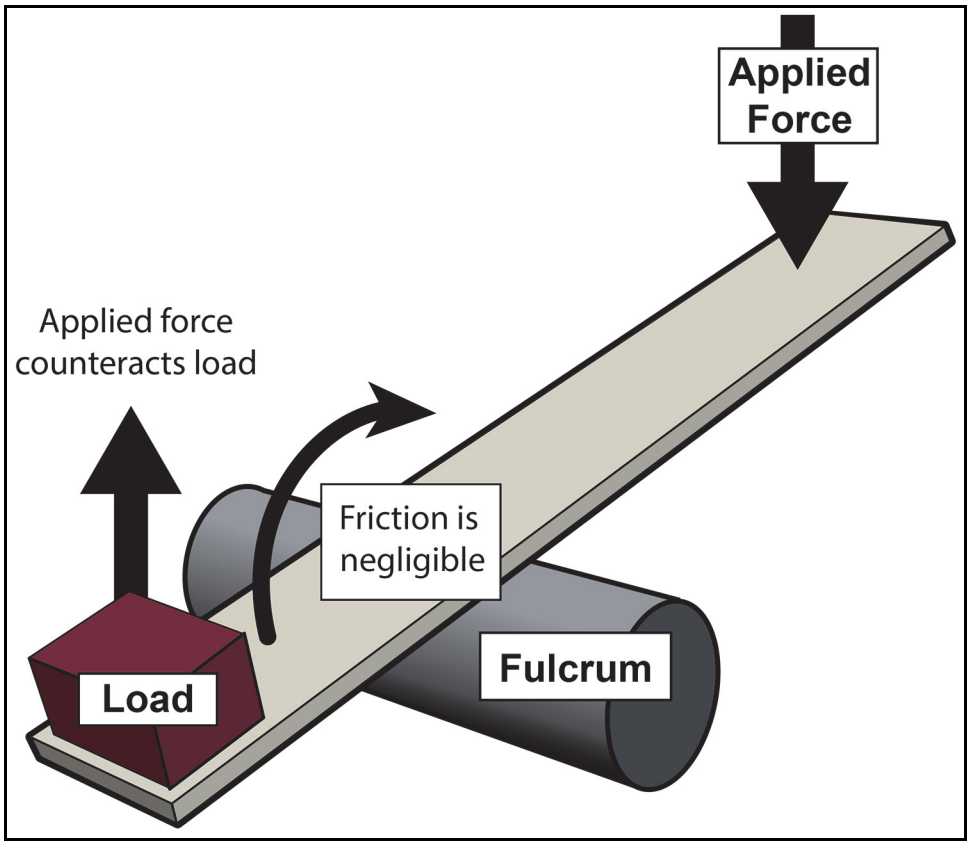

Figure 5.5: Class I Lever

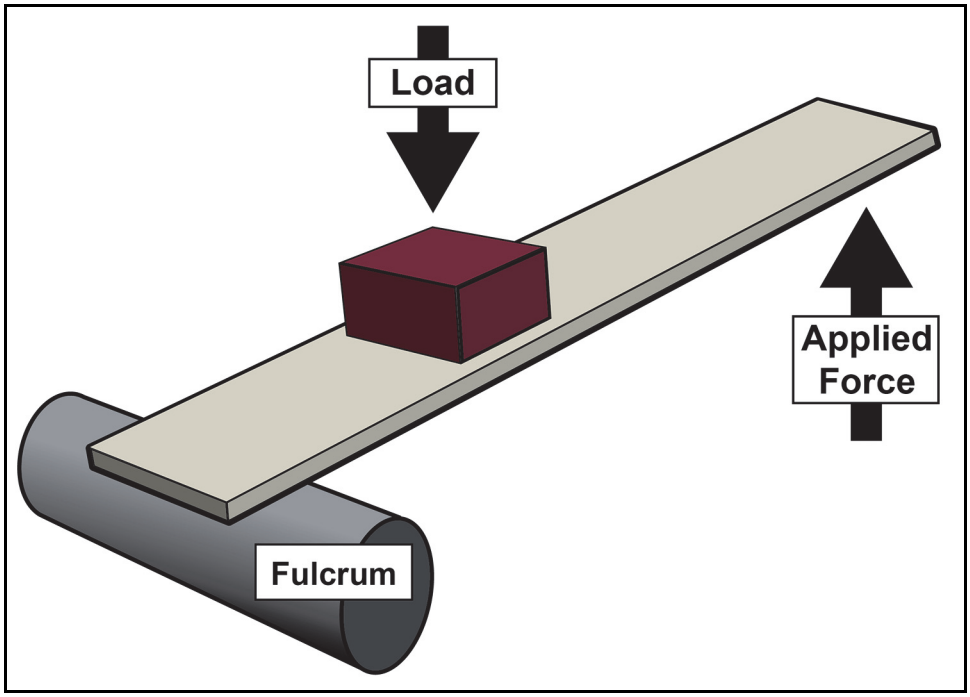

Figure 5.6: Class II Lever

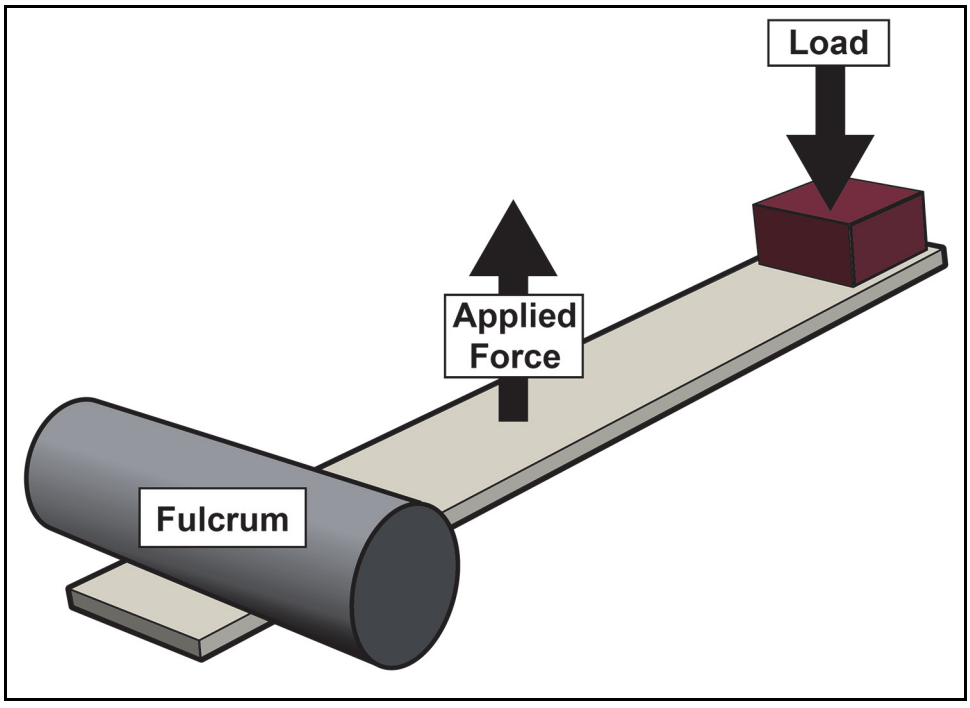

Figure 5.7: Class III Lever

4. Move an object over an obstruction by building a bridge using available lumber.

Activity 5.2: Airbags and Cribbing

Purpose

The purpose of this activity is for participants to practice lifting and moving objects in an unstable environment using airbags and cribbing.

Participant Directions

Note: Be sure to use proper body mechanics and PPE during this exercise.

1. Calculate the weight of the objects and roughly locate the CG.
2. Lift several objects on the rubble pile at least 12 inches using airbags to lift and cribbing to stabilize. Then lower the load in a controlled manner. Perform the following types of lifts:
   - Single airbag lift
   - Dual airbag lift
   - Side-by-side airbag lift
3. Lift the objects in the confined space at least 12 inches using airbags (in the most appropriate configuration) to lift and cribbing to stabilize (refer to Figure 5.8). Then lower the load in a controlled manner.

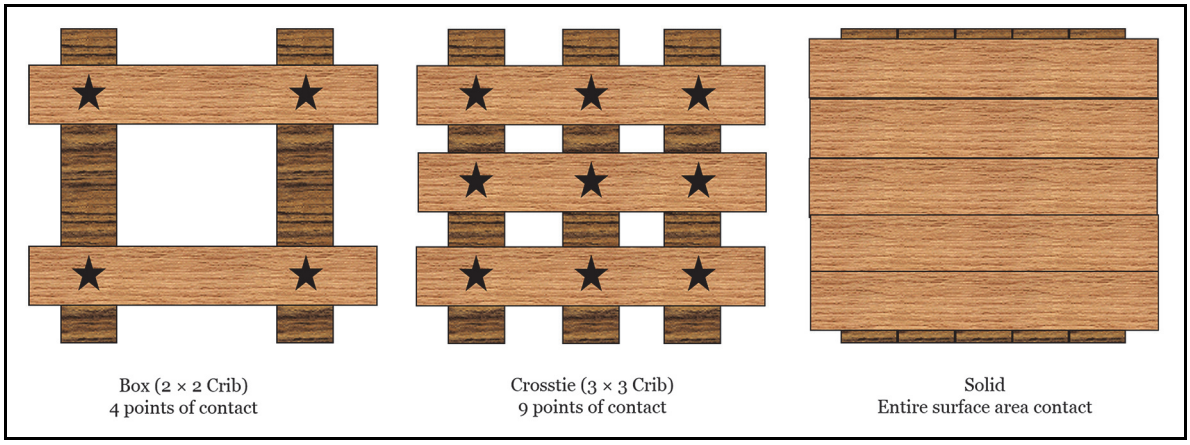

Figure 5.8: Three Common Cribbing Configurations

Activity 5.3: Rigging

Purpose

The purpose of this activity is for participants to practice rigging objects for lifting operations in the Urban Search and Rescue (US&R) environment.

Participant Directions

Note: Be sure to use proper body mechanics and PPE during this exercise.

1. Calculate the weight of the objects and roughly locate the CG.
2. Inspect the rigging prior to use.
3. Attach rigging to an object and lift it at least 12 inches. During the lift, check for the accuracy of the CG estimation. Then lower the load in a controlled manner. Use the following types of rigging configurations:
   - Basket hitch
   - Double basket hitch
   - Choker hitch

Activity 5.4: Heavy Equipment

Purpose

Slide 13

The purpose of this activity is for participants to practice rigging and lifting operations using heavy equipment in the US&R environment.

Participant Directions

Note: Be sure to use proper body mechanics, crane hand signals, and PPE during this exercise.

1. Calculate the weight of the objects and roughly locate the CG.
2. Confirm with the crane operator that the object's weight is within the crane's lifting capacity.
3. Inspect the rigging prior to use.
4. Attach the rigging to an object and direct the crane operator to lift and move the object to the indicated location. During the lift, check for the accuracy of the CG estimation. Use the following types of rigging configurations:
   - Basket hitch
   - Double basket hitch
   - Choker hitch
   - Vertical hitch

Activity 5.5: Anchors and Bolting

Purpose

The purpose of this activity is for participants to practice the installation of wedge anchors and bolts for lifting applications.

Participant Directions

Note: Be sure to use proper body mechanics, crane hand signals, and PPE during this exercise.

1. Calculate the weight of the objects and roughly locate the CG.
2. Install a minimum of two wedge anchors with eye bolts or swivel hoist rings into the assigned concrete object.
3. Attach the rigging to the installed anchors and lift and move the object to a new location. During the lift, check for the accuracy of the CG estimation. Then lower the load in a controlled manner.

Activity 5.6: Mechanical Advantage (MA) Systems

Purpose

The purpose of this activity is for participants to use MA tools to move, lift, and lower objects.

Participant Directions

Note: Be sure to use proper body mechanics and PPE during this exercise.

1. Calculate the weight of the objects and roughly locate the CG.
2. Use the provided MA tools to lift and move objects around the station area in a controlled manner.
3. During the lift, check for the accuracy of the CG estimation. Then lower the load in a controlled manner.

Activity 5.7: Obstacle Course

Purpose

The purpose of this activity is for participants to use the skills they have learned to maneuver a load through an obstacle course.

Participant Directions

Note: This is a controlled exercise. Safety is paramount. All participants are expected to actively contribute to the operation.

1. As a class, select a team leader for this exercise. The team leader will be responsible for:
   - Developing a plan and backup plan
   - Sharing the plan with all members of the team
   - Ensuring all members actively participate in the exercise
   - Ensuring safety
   - Accomplishing other team leader tasks as needed
2. As a team, you will use all the skills and knowledge learned throughout this course to move the object through the obstacle course. You are required to use, **at a minimum**, the following tools/equipment to complete the task:
   - Come-along
   - Chain fall
   - Griphoist
   - Airbags
   - Pinch bars
   - Slings
   - Wedge anchor
   - Rollers

Module

6

Cumulative Exercise

Cumulative Exercise—Introduction

Slides 1–4

This exercise is designed to have you and your squad utilize all the skills and techniques you have learned in a simulated incident.

Cumulative Exercise—Administration

Duration

10 hours

- Classroom: 3 hours
- Field exercises: 7 hours

Terminal Learning Objective (TLO)

Upon the successful completion of this module, participants will apply the knowledge and techniques learned in this course to complete a simulated rescue operation.

Enabling Learning Objectives (ELO)

1. Use the various tools that may be encountered during Urban Search and Rescue (US&R) rescue operations.
2. Construct a variety of shoring systems for structure stabilization.
3. Perform breaching and breaking operations to gain entrance into a collapsed structure.
4. Perform lifting and moving operations to gain entrance into a collapsed structure and/or to free trapped victims.

Resources

- LCD projector with remote
- PowerPoint presentation for module 6

Note: The following lists the materials and quantities needed for the entire module. Refer to individual activities for materials and quantities needed for each station.

- 1 crane or other piece of heavy equipment (like a rotator wrecker) capable of lifting anticipated loads with operator
- 1 trailer-mounted 185 cubic feet/minute industrial air compressor with 30-pound, 45-pound, and 90-pound breaker/chipper with bits and hoses (non-cache item)
- Tool oilers for compressor
- Assorted debris rubble pile with entombed victims
- Collapse simulator with entombed victims
- Federal Emergency Management Agency (FEMA) Type I rescue cache

Note: The FEMA Type I cache should contain all the tools and equipment needed to complete this exercise. If the cache is missing items, supplement as necessary.

- 15, 1½ inch steel pipe rollers, 4 feet long
- Torches:
  - Oxygen/Acetylene torch setup with tips
  - Petrogen torch setup with tips
- Lumber and nails:

  Note: Lumber lengths are based on either a 10 foot ceiling height or a 12 foot insertion point. Adjust as needed for the ceiling height/window and door sizes of the training facility. Quantities are for every three squads.
  - 4 inch × 4 inch × 24 inch cribbing (60 pieces, minimum)
  - 4 inch × 4 inch × 16 foot lumber (20 pieces)
  - 4 inch × 4 inch wedges (24 sets)
  - 2 inch × 4 inch × 16 foot lumber (15 pieces)
  - 2 inch × 6 inch × 16 foot lumber (15 pieces)
  - ¾ inch or ⅝ inch plywood (6 sheets)
  - 8d nails (15 pounds)
  - 16d nails (20 pounds)
- Cutting table (if available)
- Fuels and oil:
  - Torch fuel and oxygen for oxygen/acetylene and Petrogen cutting systems
  - Fuel for generator (1, 5 gallon container)
  - Fuel for power units (1, 5 gallon container)
  - Mixed fuel (fuel and oil) for saws (1, 5 gallon container)
- Patient packaging items:
  - 1 Stokes litter
  - 1 Yates Spec Pak
  - 1 sked
  - 1 long backboard
  - 40 feet of 1 inch webbing

Instructor-to-Participant Ratio

1 instructor to 8 participants:

- Minimum: 16 participants
- Maximum: 72 participants (more participants acceptable if hosting site can accommodate)

Reference List

None

Practical Exercise Statement

Participants will work as individuals and as squads to complete a simulated rescue operation that involves application of the knowledge and skills learned throughout the course.

Assessment Strategy

Instructors will assess participants through observation of proper techniques, questioning, and discussion.


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Activity 6.1: Cumulative Exercise Scenario

Purpose

Slides 5–7

The purpose of this cumulative exercise is for participants to respond to a simulated collapse and utilize all the skills learned throughout the course to rescue victims.

Participant Directions

1. Your instructor will brief your squad on the event, type of structures, approximate number of trapped victims, operational period (time frame), safety briefing, and objectives.
2. Each squad leader will report to the Rescue Team Manager (RTM) (designated staff member/instructor) who will assign each squad a mission.
3. As a squad, develop appropriate strategies and tactics to meet the objectives of the assigned mission. The squad leader will provide progress reports to the RTM as needed.
4. With your squad, rotate through the different stations. At the time of rotation, the outgoing squad leader should brief the incoming squad leader of the mission, strategy, tactics, and progress.
5. At the end of the allotted time for the evolution, take a short rehabilitation period and then carry out the demobilization plan.
6. Once the demobilization plan has been fully executed, assemble in the classroom for the debrief and course conclusion (evaluations and certificates).


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Appendix A

Glossary

For an extensive resource for Federal Emergency Management Agency (FEMA) definitions, go to https://www.responsesystem.org/definitions.


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A

Aftershock

Smaller earthquakes that occur after all large earthquakes

Aggregates

Materials (usually rock) that are mixed with cement to make concrete; may be fine or coarse and the type of rock can affect the strength of concrete

Anchor System

System used to attach objects or structures to concrete and to attach concrete to a crane or another lifting system

B

Bending

Combination of compression, tension, and shear forces through an object

Bevel Cut

An angled cut that is made during a lift-out operation; critical when cutting over the top of a victim(s)

Bolt Shear

The tendency of a steel, pin-like connector (such as a bolt, nail, or screw) to break across its cross-section

Bolting

The placement of bolts into concrete as anchors to support either the slab portion being removed or to support a tool

Brittle

The tendency of a material to break without warning

C

Cast-in-Place Concrete

Concrete that has been poured in the location where it is expected to remain

Catenary Action

The failure of a vertical support will cause unplanned tension forces in the remainder of the structure and may cause lean-over of the remaining walls. Catenary action can prevent complete collapse, but it leaves a condition that is difficult to assess.

Class I Lever

Fulcrum is placed between the force applied and the weight (load)

Class II Lever

Weight (load) is placed between the force and the fulcrum

Class III Lever

Force is placed between the fulcrum and the load

Complex Mechanical Advantage (MA) System

A system of traveling pulleys that move in the opposite direction of the load

Compound Mechanical Advantage (MA) System

One simple system pulls on another simple system and some of the traveling pulleys move at a different speed than the load

Concrete Frame Buildings

Structures constructed with a heavy floor structure made of cast-in-place, non-ductile reinforced concrete; some have infill walls while others do not

Concrete Screw

A screw that is driven into a pre-drilled hole to fasten devices like the electronic level and other monitoring devices

Concrete Shear Wall Buildings

Structures constructed with a heavy wall structure made with reinforced concrete shear walls

Coarse Aggregates

Aggregates that include crushed stone, gravel, cinders, shale, lava, pumice, and vermiculite with particles between 0.2 in. (5 mm) and 1½ in. (38.1 mm) in diameter

Critical Angle

The angle formed between a horizontal line and a sling leg

D

Diagonal Bracing

The component of a shore used as lateral bracing as an X or V between shores

Diagonally Braced Framing Systems

Constructed similarly to moment frame structures; lateral load resistance provided by adding diagonal members between columns to prevent lateral racking

Diagonally Braced Steel Frame Buildings

These buildings are constructed from heavy structural steel. This type of building is normally well engineered where members are very ductile. The overall performance is dependent on the connections and proper proportioning of column strength.

Diagonal Tension Crack

Cracks that occur in the high-shear stress zones of beams and girders in a typical pattern under normal vertical load conditions

Door/Window Shore

A door/window shore is a shore used in Unreinforced Masonry (URM) buildings to support loose masonry over openings. This shore may be used in other building types where door or window headers have been damaged and in badly racked wood buildings to provide additional shear wall strength.

Double Basket Hitch

A hitch that uses two single slings wrapped as basket hitches at separate locations on the load

Double Choker Hitch

A hitch that uses two single slings wrapped as choker hitches at separate locations on the load

Double-T Shore

A stable initial stabilization shore and much preferred to the marginally stable T-shore

Ductile

The ability of a material to stretch and/or bend without suddenly breaking

E

Earthquake Magnitude

A method of measuring the total energy released by an earthquake, which could also relate to the total damage done

Equilibrium

A state in which opposing forces or influences are balanced and the object is at rest

Explosion

A rapid increase in volume and a release of energy generating high temperatures and the release of gases

Explosive Spalling

The violent projection of concrete that may be caused by heat or a portion of concrete being sheared by a tool

Eye Nut

A drop forged and galvanized device that can be attached to the exposed threads of an installed expansion bolt to produce a lifting device

F

Fine Aggregates

Aggregates that usually include natural sand or crushed stone with a particle diameter less than 0.2 in. (5 mm)

Fixed Pulley

A stationary pulley that is attached to the anchor system and is used to change the direction of effort

Framed Vertical Load System

Consist of a uniform grid of columns and beams; tend to have longer spans between columns and the collapse of one column may involve an area twice the column spacing in each direction

Friction

The force found in the location of contact between two surfaces; depends on the type and roughness of the contact surfaces as well as the force of gravity that is acting upon it

G

Gravity

The force that attracts a body toward the center of the earth, or toward any other physical body having mass; imposes vertical loads on a structure

Grout

A mixture of Portland cement and water with sand and sometimes pea gravel

H

Header

The horizontal component of a shore that collects the load at the roof and the floor

Hollow Core Slab

A precast, pre-stressed concrete slab with continuous voids extending the length of the slab that are often used as electrical or mechanical runs

Horizontal Members

Structural members that support floor and roof planes

Hydrostatic Pressure

Lateral and lifting pressures due to water (or other fluid) that can highly load foundation and basement walls and lift structures when the water level is not equalized between exterior and interior spaces

I

Inclined Plane

A simple machine consisting of a gradual slope

Included Angle

The angle formed between sling legs at the hook

Inelastic Action

The permanent deformation of a material through force

Insertion Point

The height at which a raker shore needs to intersect a wall

L

Laced Post Shore

A high capacity four-post system constructed in a similar way to a pair of two-post vertical shores, but laced together; space inside the laced post may be used as a safe haven

Lateral Forces

Forces applied horizontally to a structure; most common lateral loads are wind and earthquakes

Lateral Loads

Forces pushing against a structure

Lateral Shoring

Shoring used to counteract horizontal loads being placed on a structure following failure of structural components due to natural or human-made events

LCES

Acronym that stands for Lookouts, Communications, Escape routes, and Safety zones

Lever

A simple machine that transfers force from one place to another and changes the force's direction

Light Metal Buildings

Light metal buildings are normally one-story, pre-engineered buildings sheathed with metal siding and roofing. They are often combined with wood or light-gauge metal interior partitions and mezzanine or have masonry, precast, tilt-up, or metal interior or exterior walls.

Live Loads

Vertical forces imposed on a structure from furniture, people, or moveable partitions

Load-Resisting Systems

The elements of a structure designed to transfer loads to the ground through interconnected structural components or members

M

Manufactured Pneumatic Shoring System

Manufactured shores comprised of variable length struts and accessories designed to configure struts into vertical or lateral shoring systems

Mechanics

The act of applying a machine to an object to make it move

Mid-Point Bracing

The component of a shore used to brace rakers or posts at mid-point

Mobile Home

A structure constructed on a portable steel base frame with very light, metal walls that are covered with sheetrock or wall board

Mortar

A mixture of Portland cement and water with sand and lime

O

One-Way Slab

A concrete slab that is supported on two opposite sides causing loads to be transferred only in one direction

P

Pan Joists

Deep concrete ribs that are usually about 6 in. wide and are spaced 24–36 in. apart

Partially Framed Vertical Load System

External walls form the unframed section and are load bearing while the framed section is comprised of posts and beams erected to replace load-bearing internal portions

Plastic Bending

A nonlinear behavior in members made of ductile materials that frequently achieve greater bending strength

Plastic Hinge

The deformation of a section of beam where plastic bending occurs

Portland Cement

A fine gray powder that is mixed with water and aggregates to form concrete

Post

The vertical component of a shore that supports the weight being collected by the header and transfers it to the sole plate where it is distributed

Precast Concrete Frame Buildings

Structures constructed with precast columns, beams, and slabs; some buildings may have cast-in-place floor fill

Prefabricated Door/Window Shore

A reusable alternate to the built-in-place door and window shore; main advantage is to allow preconstruction a safe distance from the dangerous wall or collapse zone

Pulley

A simple machine used to change the direction of effort

Punching Shear

Occurs where a flat, two-way concrete slab is connected to a column and the tendency of the slab is to drop as a unit around the column

R

Rack

The leaning of walls due to lateral forces

Raker

The component of a shore that is a post-like member that extends diagonally from the wall plate to the sole to support a leaning wall

Raker Cleat

The components of a shore that are connected to deliver shear forces from the horizontal or vertical component of the sloped raker into the wall plate and sole

Reinforced Concrete

Concrete that contains an arrangement of reinforcing bar (rebar) for additional strength

Reinforcing Bar (Rebar)

Rebar is a steel bar or mesh of steel wires used in reinforced concrete and reinforced masonry structures to strengthen and stabilize the concrete in tension. Rebar's surface is often patterned to form a better bond with the concrete.

Relief Cut

A cut into concrete to address tension and shear versus compression

Risk/Benefit

The determination of whether the risk of a task is worth the benefit

S

Shear

Two forces applied directly toward each other (offset) through an object.

Shear Wall/Box Building

Shear walls/box buildings are buildings with exterior walls that provide bearing strength as well as seismic resistance. They may or may not have interior, structural walls. Floors and flat or sloped roof planes form the horizontal surfaces to complete the boxes with the walls forming the sides.

Shim

Any piece of lumber, wedge-shaped or flat, that is used to fill in voids between a shore and the structure

Shrinkage Crack

Cracks that occur in concrete slabs, beams, walls, and columns within 60 days of the pour, after the concrete is allowed to dry out

Simple Machine

Rigid or resistant bodies that have pre-defined motions and are capable of performing work; consist of inclined planes, levers, pulley wheels, gears, ropes, belts, and/or cams

Simple Mechanical Advantage (MA) System

One rope is routed between pulleys on the anchor and load, and all of the pulleys that move (i.e., the "traveling pulleys") do so at the same speed and in the same direction as the load

Sleeve Anchor

A torque controlled anchor that has an undercut shaft that is inserted into the hole and a sleeve device that expands as a cone at the bottom of the shaft is pulled through it when the fastener is tightened

Sling Angle

The angle formed between a horizontal line and a sling leg

Sloped Floor Shores

A shore that is built in pairs and is similar to a laced post shore; used to support damaged and sloped concrete floors

Sole Plate

The horizontal component of a shore that transmits the load to the floor or ground

Solid Sole Raker

A shore used in incidents where access to the base of the wall is unencumbered

Split Sole Raker

A shore used in incidents where access to the base of the wall is obstructed

Step Cut

A step cut is used during a lift-out operation when the slab is thicker than what can be cut with one pass of a circular saw. Two cuts are made parallel to one another the width of the saw blade guard. The concrete is then chipped out between the two cuts forming a trench. This allows the saw to complete the cut through the full depth of concrete.

Steel Angle

An L-shaped piece of metal used with wedge anchors, screws, and/or through bolts to create a lifting point

Steel, Moment Frame Building

A steel, moment frame building is a structure constructed with heavy structural steel. All steel-framed buildings get their basic structural support for the building weight from a skeleton (or frame) composed of horizontal steel beams and vertical steel columns.

Steel T

A T-shaped piece of metal used to create a lifting point

Stitch Drill

Bore holes that are partially or completely drilled thorough the concrete in a close stitch pattern within a predetermined area to place the concrete in shear or tension

Structural Durability

The ability to repeatedly sustain reversible stresses in the inelastic range without significant degradation; essential for a moment frame structure

Supplied Air Breathing Apparatus (SABA)

SABA supplies air to the wearer for virtually unlimited amounts of time via an air source (e.g., large bottles or compressor) outside the area of use. It can be used in toxic environments as well as oxygen-deficient atmospheres.

Suspension/Tension Systems

Not commonly used in building structures but are most commonly seen as bridges

T

T-Spot Shore

A temporary shore used to initially stabilize damaged floors, ceilings, or roofs, so that the more substantial shoring can be constructed at less risk

Temperature Crack

Cracks that are caused by changes in temperature and occur in roughly the same pattern as shrinkage cracks

Tension

Two forces being applied through an object at 180 degrees to each other, usually along the long axis

Tension Crack

Cracks that occur in concrete slabs and beams when bending-caused tension forces stretch the reinforcing steel

Tilt-Up Concrete Wall Buildings

Structures constructed with long span roofs of 50 or more feet and floors of 25 or more feet; buildings may have wood floors, concrete floors, steel framing with concrete-filled metal deck floors, or up to 1½ in. concrete fill on wood floor

Torsion

The action of twisting or the state of being twisted, especially of one end of an object relative to the other; common in concrete frame structures when URM infill

is placed within the concrete frames on the exterior property line walls for fire resistance

Traveling Pulley

A pulley that is attached to the resistance that moves and changes direction

Two-Post Vertical Shore

A vertical shore that can be partly prefabricated then assembled in the danger area

Two-Way Flat Slab

A solid concrete slab that is supported on four sides only by columns and the load is carried in two directions

U

Unframed Vertical Load Systems

Consist of bearing walls for vertical supports; normally have shorter spans and more redundancy and tend to perform better under extreme loading

Unreinforced Masonry (URM) Buildings

Structures constructed with URM-bearing walls, wood floors, and wood interior, bearing and non-bearing partitions; tend to lack strap anchors and ties; tends to be brittle with little capacity to resist unanticipated loads

V

Vertical Load-Resisting Systems

Systems that transfer a load from the source to the ground; vertical loads include gravity, dead loads, live loads, and impact loads

Vertical Shoring

Shoring used to counteract the forces of gravity on the structure following failure of structural components due to natural or human-made events

Vertical Support Members

Structural members that provide lateral stability that allow compression without buckling.

W

Waffle Slab

A waffle slab is a two-way slab where the slab is poured over square, steel voids so that rips are formed in the concrete. The voids are omitted at and near the columns, in order to allow the full thickness of the concrete to resist punching shear stresses.

Wall Plate

The component of a shore that collects the load from the wall or other vertical surface

Wedge

Two wooden incline planes married together and placed under the bottom of the post or at the end of a raker

Wedge Anchor

A torque controlled anchor that has an undercut shaft that is inserted into the hole and a wedge device that expands as a cone at the bottom of the shaft is pulled through it when the fastener is tightened

Weight

The force of the Earth's gravity on a mass sitting on its surface

Wetting

The application of water from tool attachments or from manual spray devices to keep blades and chains cool and lubricated and to keep down dust

Window/Door Cleat

The component of a window or door shore that is used to support or strengthen the window/door opening

Wood Frame Building

A structure constructed with a light frame of 2 in. × 4 in. or 2 in. × 6 in. wood framing or light-gauge steel framing; some may be unframed

Appendix B

Power Tool Systems


NATIONAL US&R RESPONSE SYSTEM
U.S. DEPARTMENT OF HOMELAND SECURITY
FEMA

Introduction

As a Structural Collapse Specialist, it is imperative that you to be able to assemble, operate, and maintain tool systems in order to efficiently and safely extricate or force entry to protect a life. Inability to do this will result in further pain and suffering for the trapped victim. As your knowledge of these tools/systems increases, so will your proficiency as an operator in quickly determining the proper application and safe operation of the tool systems found in the Federal Emergency Management Agency (FEMA) Urban Search and Rescue (US&R) cache.

Remember, we work in a harsh environment. The tools in the cache are the only tools you may have for the length of the deployment. You need to treat these tools with the utmost of care because they need to work until the deployment is complete.

This appendix details general considerations for the use of the tools and operating principles of each type power source (pneumatic, electric, and gas-powered).

Note: Always consult the manufacturer's recommendations before operating or troubleshooting hydraulic or pneumatic tools. No recommendation in this course should supersede those of a specific manufacturer. Do not work beyond your capability, know when to get help.

General Power Tool and Tool System Guidelines

Most often, it is operator competence that affects the performance of a tool. By acquiring a depth of knowledge and experience on the capability and limitations of the tool, the operator will perform as needed by selecting the right tool for the right job and using it properly. When Structural Collapse Specialists have questions or problems, they should refer to their supervisors and the operating manuals.

Operation Guidelines

When deployed, Structural Collapse Specialists should anticipate long-term operations. To ensure the best and longest operation of the tools, they should be sure to adhere to the following guidelines:

- Plan for the replacement of consumables and the need for field repairs (i.e., changing chain saw chains, spark plugs, and filters).
- Keep conductors of energy as short as possible (i.e., air hoses, electric extension cords, and hydraulic lines):
  - This will reduce the loss of energy being delivered to a tool.
  - Just as bends, kinks, and friction loss in fire hose results in less water, energy conductors can suffer the same loss of energy through their hoses/cords.

- Plan for the action/reaction of the tool and the barrier. Be prepared to deal with rubble, weight of the cut out, and the speed of the release.
- Continuously assess the working end of a tool:
  - Keep the blades/bits dressed and sharp.
  - Inspect carbide segments and diamonds for any deformation and loss of integrity.
  - Ensure bits/blades are compatible with the barrier and the desired result. For example:
    - The bull point of a jack hammer will create circular lines of force (general demolition).
    - A chisel bit will create linear lines of force for a more precise/predictable break.
- Listen for pressure relief valves (hydraulic or pneumatic) venting:
  - Pressure release may indicate that the tool system is overloaded.
  - Stay within the operating envelope of the tool package available.
- When operating power tools, always wear the appropriate Personal Protective Equipment (PPE), including:
  - gloves;
  - ear protection;
  - safety glasses;
  - a helmet;
  - respiratory protection; and
  - work uniform.
- Do not wear loose fitting clothing or other items that could get entangled in the power tool.
- Prepare to mitigate any hazard tool operation may produce (i.e., dust, dirty water runoff, and exhaust fumes).
- When operating gasoline engines:
  - Plan for and predict the accumulation of carbon monoxide and always monitor the atmosphere.
  - Re-fuel tools away from the work area.
- Remember that all tools require a general inspection prior to use. Check for:
  - Loose, cracked, or broken components
  - Loose fasteners
  - Proper lubrication

  - Blocked vents
  - Cord damage
  - Proper operation
- Never operate power tools when the operator is too tired or under the influence of drugs. A moment of inattention could result in a permanent serious injury.
- When operating tools, try to maintain a firm and balanced body position and try not to over reach.
- Keep the work area as well-lighted and ventilated as possible.
- Do not set a running (blade/chain) tool on the ground until it is stopped.
- If a tool is not operating properly, place an *out of service* tag on it and turn it in for repair.
- Take care of tool power cords:
  - Never carry a tool by its cord.
  - Never yank the cord out of a receptacle.
  - Never carry the tool with the cord dragging on the ground.
  - Inspect power cords/lines, keep them out of dirt/grease, and protect them from sharp edges.
- Do not carry tools that are still running/operating.
- When not using a tool, keep fingers away from the on/off switch.

Troubleshooting Guidelines

When a tool system is malfunctioning, typically there will only be one thing wrong. Most troubleshooting techniques operate from this premise. The most efficient way to find the problem will be to start at one end (usually the power source) and work toward the tool, inspecting, isolating, and testing each component. The problem is usually something simple. This way, even if there are multiple problems, the operator is likely to find them.

Operators should resist starting in the middle of the system to troubleshoot. This will often result in them going back and forth looking for the problem, and if there are multiple problems they will quickly become frustrated. Additionally, time will be lost that otherwise could be used to rescuing someone.

As stated, operators should:

- Begin at the power source or at the tool itself.
- Isolate and test components of the system in a logical order
- Do not make assumptions.
- Trace out the flow of energy, find where it stops, and determine why.

Operators should be prepared to change their minds when looking for the problem. Unless they are very familiar with the history of the system, any preconceived notions they may have are likely wrong. They should be logical and methodical when troubleshooting.

Application Guidelines

Another major factor affecting tool performance is one of application, specifically not using the right tool for the right job. The material must be matched to the tool. Additional guidelines on tool application include the following:

- Sometimes tool selection is dictated by environment or proximity to the victim. For example:
  - When cutting metal, excessive heat produced by a torch or vibrations from a reciprocating saw may agitate the patient.
  - Hydraulic powered shears may produce more reaction when they snap through the workpiece than can be reasonably controlled, potentially causing additional injury to the victim.
- Working in confined spaces often limits what kind of tools responders can use. Gasoline-powered tools produce carbon monoxide and will require atmospheric monitoring and ventilation.
- Cutting and grinding tools create sparks and will need additional considerations if used around spilled fuels.
- Cutting through multiple barriers of plastic, insulation, rubber, and steel may all require a different tool.
- Some tools are capable of being operated around or even partially submerged in water.
- Extremes in environmental temperature or altitude can change the operating envelope of tool systems.

Operators must consider these limits when selecting their tools and techniques for an operation.

Cache Guidelines

Operators should make sure the tool system is in service as if someone's life depends on it, because it does. Additional guidelines regarding the cache include the following:

- Take time to look up and read the operator's manuals; most are available online.
- Study the cache list and know the available power sources and fuels.
- Know what support tools may be needed, such as special wrenches to change blades, torch tips, requirements for tool adjustments, and adapters for electric or pneumatic tools.

- Maintain fresh fuel and a field repair kit to sustain operations.
- Figure out how far away operators can stage their power source so the power transmission lines (hydraulic, electric, and pneumatic) will reach the job without excessive friction loss or voltage drops.
- Group tools in kits; this grouping will minimize the time needed to assemble a tool system.

Every step saved is a step closer to the trauma center for the patient.

Tool Speed and Feed Rate Guidelines

A good rule of thumb when running a saw, drill, or jack, either electric, hydraulic, or gas-powered, is to not load or apply so much pressure on the tool that it slows the Revolutions per Minute (RPM) down to an inefficient rate. The operator should start slowly to establish a kerf/divot (space created by the saw blade); this will make it easier to hold the tool/blade in place.

Once fully engaged in the piece, the operator should keep the saw cutting at full speed. An exception to this is a reciprocating saw cutting high strength steel alloys found in modern cars; the best performance is usually found running the saw at ¾ of full speed.

If the operator of the tool is pressing too hard and slowing the tool down too much, typically the motor, pumps, and saw blades will overheat, which softens its steel and results in a duller blade. This makes the operator press harder, which further compromises performance. If the tool cannot cut fast enough, determine whether the right tool/bit/blade is being used or get multiple tools in operation.

By maintaining around 85–90 percent of full speed RPM, the tool/bit will cut/grind as efficiently as possible. To know this feed rate, or loading pressure, it is beneficial for the operator to train with the tools and develop a touch. With practice, an operator can listen for the pitch of a properly tuned engine and know from the vibration of the tool that it is running correctly.

The operator must control heat, one of the byproducts of tool systems. Overheating a tool can cause the following problems:

- The teeth on saw blades will soften and round off.
- Curved pneumatic chisel bits that keep the workpiece centered also concentrate heat in one spot and can fatigue the bit prematurely.
- Carbide tips will overheat and break off. They can also get knocked off from vibration and impact loads.
- Diamond segments on grinding tools will mushroom and the cutting edges will round off.
- Electric motor insulation can break down if the tool itself becomes too hot.
- Mechanical bearings can be damaged.

Some techniques to keep tool and blades/bits cool include:

- Ensure adequate lubrication, water or oil, if appropriate.
- If dry cutting through thick material (especially concrete), pull the tool blade/bit out of the cut every 10 to 20 seconds to run in ambient air to cool.
- Make sure a properly dressed/sharp bit/blade is in the power tool.
- If the motor is too hot to touch, consider switching it out or changing techniques or tool systems.
- Keep air vent passages (electric motor) on the tool unobstructed, this means not only dust/debris but also gloved hands.

Power Source Operating Principles

Hydraulic, electric, and pneumatic tools are essential to almost any rescue incident. But these tools are also complex and dangerous and can easily pose problems to the operator. The best way to mitigate safety hazards and ensure smooth operation of power tools is to know how they operate, how to use them, and what to do when something goes wrong.

Hydraulic Operating Principles

Hydraulic rescue systems feature five basic components:

- Power unit with a gasoline engine or electric motor
- Hydraulic fluid pump/reservoir
- Associated valves to control direction and pressure
- Hoses
- The tool itself

Hydraulic systems are closed systems featuring a pressure port (output of the pump) and a return port to allow hydraulic fluid to flow back into the reservoir. Hoses transmit the pressurized fluid to the tool. Downstream of the fluid reservoir, pressure is applied in all directions within the hoses, valves, and tool actuators. The hydraulic fluid is mostly incompressible but may contain up to 10 percent air.

Note: For best operations, hydraulic fluid temperature should remain between 60°F and 140°F.

The action that creates the Mechanical Advantage (MA) is described by Pascal's Law, which explains that a force or pressure on a small surface can be transferred to a larger surface, amplifying the force. Think of the small piston attached to the pump handle of a hydraulic bottle jack. The small force created by pumping the small piston with the lever (handle) transmits the force (the pressure in pounds per square inch [psi]) to a larger area (the square inches in psi). This is why by simply pumping the jack by hand, one can lift several tons.

Hydraulic tools feature positive displacement pumps, which means that if they pump against a closed head for very long, the pressure will build until something relieves the strain. System operating pressure is directly related to the load applied. It is ultimately relieved automatically by internal overpressure valves or by decreasing the load on the working end of the tool. Think of a vehicle rescue system ram pushing against a vehicle component. The tool system will load up and build pressure until the object is displaced, the operator releases the tool, or the relief valve kicks in.

Consider the following safety issues when using hydraulic tools:

- Always assume the hydraulic systems are under pressure. Pressures in hydraulic systems can be 2,000–40,000 psi.
- Treat as hot work and keep a fire extinguisher or charged hoseline nearby.
- Always wear proper PPE, including bunker gear and hearing/eye protection.
- Relieve pressure back through the system after being left in the hot sun; the fluid will expand and prevent uncoupling.
- Inspect hoses for leaks and excessive wear, ensuring all fasteners are tight. Do not use hands to check for pinhole leaks, because the pressurized fluid can penetrate skin.
- Make sure fluid levels are full; do not use any fluid other than manufacturer-recommended fluids.

Note: if Structural Collapse Specialists receive a pressurized hydraulic fluid penetration of their skin, this is a serious injury. They should seek medical attention immediately.

Most hydraulic units are powered by a small, four-cycle gasoline engine. Specific starting instructions can be found in the owner's manual of a particular tool; however, the following steps work for most units:

- Pull the choke out full, pull the recoil starter cord, gently allow it to return once the engine is running and return the choke to the open position.
- Move the hydraulic dump valve to the run position and cycle the tool to purge air.
- Start the engine/pump with the dump valve open so the gas engine has no load on it during startup.
- Keep the dump valve open when changing out tools or if possible stop the engine.

Pneumatic Operating Principles

The pneumatic systems in the US&R cache are considered open systems; they vent and consume the pressurized air. Pneumatic tools are lightweight and very portable and have many excellent applications. They create an MA just like hydraulic systems.

Air tools, with the exception of airbags, are often measured not only in operating pressure but also in Cubic Feet per Minute (CFM). This is the amount of air the tool uses to work. The speed of the air is expressed as Feet Per Second (FPS), similar to the number of amperage (amp) or the current an electrical tool uses. CFM and FPS can be negatively affected by friction loss in the hoses. To compensate for these friction losses, operators should jog the tool, engaging it with a second or two between; this will allow the pressure to build back up.

Note: The air in these containers, when static, represents potential energy and must be relieved carefully.

Cracking valves or couplings may blow O-rings and launch projectiles. Operators should drain and charge the pneumatic system by shutting off the source (typically a Self-Contained Breathing Apparatus [SCBA] cylinder) and opening the control valve or running the tool. They should watch pressure gauges to ensure the gauges bleed into a zero-energy state.

To charge the system, operators should assemble it completely, making sure all fittings and connections are tight. They should slowly turn off the air source, then adjust the air regulator output to the pressure recommended for the tool.

Class D breathing air (SCBA air) will dry out the system's O-rings and cause premature failure. To prevent this, operators should oil the O-rings regularly by adding a couple of drops of pneumatic oil into the tool. They can extend their usable air supply by jogging their tool to counteract the friction losses in the system. The air consumption of the tool can exceed the regulator and hoses' ability to deliver the needed CFM, especially when the SCBA bottle is getting low on pressure. It is not uncommon to find the metal couplings close to the SCBA bottle covered with frost due to the speed of the air moving through the system.

The pressure regulator has two gauges: one indicating cylinder pressure (closest to the source), the other indicating output pressure. Operators should not assume that an input pressure gauge with a 6,000 psi scale will operate a 4,500 psi source. Every regulator will have its operating pressure rating stamped on its body. The adjustment of the output pressure is done with an adjusting knob or T-handle. There are two types of air regulators used for rescue tools: a diaphragm style and a piston style. The diaphragm style features a larger regulator with a T-handle; it typically delivers more air (CFM) than the piston-style regulator. Some regulators have a fixed output pressure.

The typical operating pressure for high-pressure airbags is 118–150 psi. Tools such as air chisels can go as high as 300 psi, while others operate at 90–100 psi. For safety, operators should check the owner's manual to determine the proper maximum air pressure ratings of tools.

Operators must control the bleeding-off of pressure. They should use a pressure relief valve with airbags and check the pressure rating of all components. They should ensure the system is bled off prior to connecting or disconnecting the hoses. Operators should never use oxygen or another compressed gas other than tool/compressor air (Class D, SCBA) in pneumatic tools.

Small Gasoline Engine Operating Principles

Typically, two-cycle engines are in use on chain saws, rotary saws, and some outboard boat engines. The two-cycle engine has no oil crankcase; lubrication for the internal parts is applied through the fuel, mixed gas and oil. Because they have no oil crankcase or sump, two-cycle engines can be operated in almost any position. If there is too much oil, the motor will smoke excessively and foul the spark plug quicker. If there is not enough oil, the internal engine parts will be damaged. Operators should check the owner's manual for the proper oil to fuel ratio.

Most saw manufacturers recommend 89 octane without additives, such as alcohol. Operators should use quality two-cycle oil for their motors. They should rotate two-cycle fuel at least quarterly to ensure fresh fuel. Because these motors run hotter and faster than their four-cycle brothers, they need their spark plugs changed more often and are more sensitive to old gas.

Two-cycle motors tend to flood (too much fuel in the carburetor) easily. This is because with every down stroke of the piston fuel, air is being drawn into the cylinder. The easiest way to solve this issue is to start the tool correctly the first time.

To start a cold two-cycle engine, pull the choke (butterfly valve that control air into the carburetor) to full, set the throttle lock on full speed, and briskly pull the starter cord. If the two-cycle gas mix fuel container has been sitting for some time (gas and oil will separate) it will benefit from agitation to ensure a uniform mix.

Some engines have a cylinder decompression valve. This valve looks like a button and by pushing it in operators allow some of the air in the cylinder to escape during the start up. The valve resets itself. This makes it easier to pull the starter cord as well as protecting the plastic parts, starter cord, and handle from breakage.

Drop starting techniques are fool-hardy and are a sign of an inexperienced power tool operator. Operators should place the chain/rotary saw securely on the ground or hold it with their body to help ensure a safe start up. Once the engine chugs as if was going to start but stalls out, they should push the choke in (half way or all the way depending on the particular saw), push in the decompression valve, and pull start it again. If the saw has fresh fuel, a clean spark plug, and a clean filter, it should take off and run.

Operators should begin to develop a feel for the motor and the chug in a high noise environment and know the sound so they can do it in the dark. If the tool is flooded, operators can turn the saw off, turn the saw so the exhaust is down, pull the start cord several times (decompression button), turn the saw upright, or try to start with normal warm saw starting procedures.

Operators should make sure the air filter is clean. When changing the air filter, they should close the butterfly valve to prevent debris from falling into the carburetor during the filter change. Some fuel tanks have a vented cap to allow air in as fuel is pumped out. If the systems have this feature, operators should make

sure the vent is working. If operators remove the cap and hear air sucking in, they should check to see if the vent is clear.

When performing equipment checks, operators should start the saw and ensure it is running properly and everything is in order. They should only run the saw long enough (1–2 minutes) to know it is working. Allowing the saw to sit at idle only allows unburned fuel to collect in the cylinder, speeding up the fouling process inherent with two-cycle motors. The motors are tuned to run at working loads/speeds and not to sit at idle. Also, many two-cycle motors today have self-compensating carburetors that re-tune the carburetor as the air filter loads with debris.

Another typical problem is a fouled spark arrestor located on the exhaust muffler; a small screen that suppresses any sparks produced by the engine. This will build up with sludge, hampering performance and will require periodic cleaning.

Chain saws have a chain oiler. While running the saw, operators should hold the chain/bar close to the ground and in a couple of seconds they should see a small strip of oil. If they do not, they should check the bar oil reservoir. If the reservoir is full, the bar oil outlet that is built into the bar and mates up to an outlet in the body of the saw under the sprocket cover could be blocked by saw dust. Operators should keep this oil dispensing outlet clean. This bar oil has special viscosity characteristics that helps keep it adhering to the chain and groove in the bar. Regular motor oil will spin off too quickly, under oiling the chain and bar.

The chain must be adjusted properly. Operators should ensure that the chain is on in the proper direction and seated in the groove of the bar. Pull up on the nose of the bar; adjust the droop out of the chain with the adjusting screw. Tighten until the chain is in full contact on the bar and give it an additional quarter turn. Adjust the bar nuts snuggly. Some chain saw bars have a nose sprocket and some are solid. The sprocket nose bar will typically hold the chain on the bar better, but the solid nose has no moving parts. Maintenance on the bars include keeping the bar oil port clean and occasionally filing off any mushrooming along the length of the bar caused by the chain. Operators should reverse the bar every time they service the chain to ensure even wear on the bar.

Electric Operating Principles

Electric generators are a vital part of almost any assignment. Generators are sized by how much wattage they can generate, usually expressed as kilowatt (kW), or thousands of watts. In other words, a 2.5 kW generator is rated to make 2,500 watts of electrical energy. The tools in the cache operate at 120 Volts Alternating Current (VAC). They will draw or consume approximately 1,000 watts for every 8 amps delivered from the power source. For example, if a 120 VAC reciprocating saw is rated to operate at 4 amps, the saw will burn 500 watts of the total capacity of the generator.

Appliances such as lights (resistive loads) draw the same amount of current regardless of how they are used. Electric motors (reactive loads) are different; when the motor is not spinning and the voltage is turned on, for only an instant,

the motor is essentially a short circuit. This creates a momentary increase in the current draw till the motor starts to run. Structural Collapse Specialists may experience brown outs or circuit breakers may trip, turning off the circuit. Also when the tool operator bears down on the tool forcing it to slow down, the electric motor draws more current from the generator to make up for the drop in voltage.

If the generator is not powerful enough to supply the tools plugged into it, electric circuit breakers will likely trip, and the generator may shut down. These are engineered protective measures, because if responders put too much electrical load on a generator its voltage output will drop below what the tool is made to run at. This will ultimately ruin the tool and generator. This voltage drop is why one sees lights dim and tools slow down.

Maximum versus Rated Power

Generators are advertised at the maximum wattage they can produce. But one will also see the rated power listed. Maximum power is the maximum output that a generator can produce. Maximum power is usually available for up to 30 minutes. Rated power is the power that a generator can produce for long periods of time. It is typically 90 percent of the maximum power.

Operators should use rated power to determine if a generator will be able to adequately power their applications continuously.

Tools list their power requirements in amps. Most generators list their output in watts. Fortunately, it is easy to convert from one to the other:

- Watts = Volts × Amps
- Amps = Watts ÷ Volts

If operators have two of the numbers (e.g., volts and amps), then they can find out the other (watts). This can help to determine the rated power they will need from their generator. A good rule of thumb is 8 amps at 120 VAC is about 1,000 watts or 1 kW.

To calculate power needs correctly, operators need to know which kind of load they are dealing with. (A load is defined as the device that one is powering.) There are two kinds of loads: resistive loads and reactive loads.

Resistive Loads

Resistive loads are pretty simple: They require the same amount of power to both start and run the equipment. Many resistive loads are involved in heating or making heat of some kind. Examples of resistive loads include:

- light bulbs and
- coffee makers.

Reactive Loads

Reactive loads contain an electric motor, which requires additional power to start, but significantly less power to run once it gets going. Typical starting power is

three times the amount of power to run the application. Examples of reactive loads include:

- air compressors and
- power tools.

Voltage Drop

Five percent is considered the most voltage drop (by the National Electric Code) responders can tolerate without damaging equipment. For a 120 VAC circuit, 6 volts is 5 percent (120 VAC × 0.05 = 6 volts). So the minimum operating voltage operators can allow is 114 VAC.

Extension cord size, both length and gauge (wire diameter), are a part of this and affect tool performance. A twelve-gauge, three-wire extension cord, powering an appliance 100 feet away from the generator, drawing 20 amps, will lose over 6 volts in friction loss, or electrical resistance. If operators increase the length of the extension cord, they also increase the resistance to the amperage flow and increase voltage drop. The same can happen if they use a smaller diameter wire.

Within these parameters is how operators build portable electrical systems.

Use of a Ground Fault Circuit Interrupter (GFCI)

A GFCI is a device that shuts off an electric power circuit when it detects that current is flowing along an unintended path, such as through water or a person. It is used to reduce the risk of electric shock, which can cause the heart to stop or cause burns. They can also prevent some fires, like when a live wire touches a metal conduit preventing the conduit from heating up. It is to be used when operating electrical devices around water or in a damp places.

A GFCI works by measuring the current leaving one side of a power source (the live or hot wire), and comparing it to current returning on the other (the neutral side). If they are not equal, then some of the current must be leaking in an unwanted way, and the GFCI shuts the power off. After the problem is fixed, the device must be reset manually by pushing the reset button. If the problem is not fixed, the GFCI will keep shutting off. There is also a test button next to the reset button, which shows that the GFCI works properly.

It takes a small current of only 5 milliamps (mA) (0.005 amps) of current leakage from the hot wire to the ground or neutral to cause a GFCI to trip. A small amount of leakage current may be difficult to avoid in some normal circuits. Handheld power tools do not cause a tripping problem if the tool is maintained in good condition. Some stationary motors, or fluorescent lighting fixtures, may produce enough leakage to cause nuisance tripping. Another issue could be multiple extension cords connected together and the connections are damp. A damaged outer sheath of the extension cord could allow water in to cause enough current

leakage. If possible, operators should keep GFCI circuits less than 100 feet long. To avoid nuisance tripping, a GFCI should not supply:

- Circuits longer than 100 feet
- Fluorescent or other types of electric-discharge lighting fixtures
- Permanently installed electric motors

Operators should not automatically dismiss these trips as a nuisance; they may very well be a clue that there is a malfunction. Operators should take time to troubleshoot the issue. They should check the electrical connections (someone may have put a tool away wet). There are de-watering aerosols in the cache that can be used on electrical tools.


NATIONAL US&R RESPONSE SYSTEM
DEPARTMENT OF HOMELAND SECURITY
FEMA

Appendix C

Heavy Equipment Hand Signals

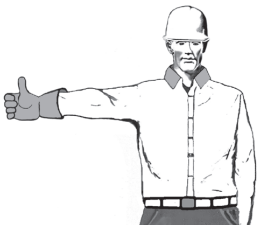
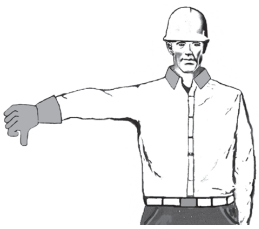
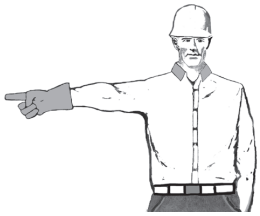
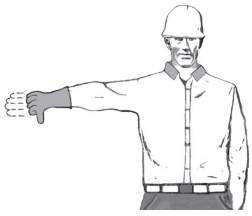
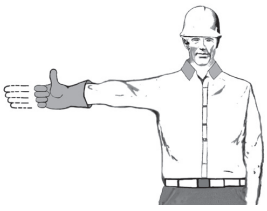
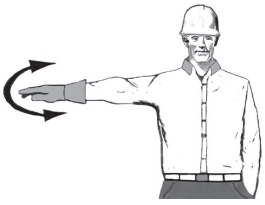
The documents in this appendix were reprinted with permission from:

- National Commission for the Certification of Crane Operators (NCCCO). (2014). Standard Hand Signals for Controlling Mobile Crane Operations. In *Signalperson Reference Manual* (Rev. 07/14). Retrieved February 2, 2023 from https://www.nccco.org/docs/default-source/reference-materials-2014/sgp_rm_051214a-web.pdf?sfvrsn=2 (page C-3)
- Construction Safety Association of Ontario/Electronic Library of Construction Occupational Safety and Health (eLCOSH). (n.d.). *Excavator Hand Signals*. Retrieved January 26, 2023 from https://elcosh.org/document/1458/d000068/Excavator%2BHand%2BSignals.html (page C-5)


NATIONAL US&R RESPONSE SYSTEM
U.S. DEPARTMENT OF HOMELAND SECURITY
FEMA

Standard Hand Signals for Controlling Mobile Crane Operations

Standard Hand Signals
FOR CONTROLLING MOBILE CRANE OPERATIONS

 HOIST With upper arm extended to the side, forearm and index finger pointing straight up, hand and finger make small circles.	 LOWER With arm and index finger pointing down, hand and finger make small circles.	 USE MAIN HOIST A hand taps on top of the head. Then regular signal is given to indicate desired action.	 USE WHIPLINE (Auxiliary Hoist) With arm bent at elbow and forearm vertical, elbow is tapped with other hand. Then regular signal is used to indicate desired action.
 BOOM UP With arm extended horizontally to the side, thumb points up with other fingers closed.	 BOOM DOWN With arm extended horizontally to the side, thumb points down with other fingers closed.	 MOVE SLOWLY A hand is placed in front of the hand that is giving the action signal. (Hoist slowly shown in example.)	 SWING With arm extended horizontally, index finger points in direction that boom is to swing.
 BOOM DOWN AND RAISE THE LOAD With arm extended horizontally to the side and thumb pointing down, fingers open and close while load movement is desired.	 BOOM UP AND LOWER THE LOAD With arm extended horizontally to the side and thumb pointing up, fingers open and close while load movement is desired.	 STOP With arm extended horizontally to the side, palm down, arm is swung back and forth.	 EMERGENCY STOP With both arms extended horizontally to the side, palms down, arms are swung back and forth.

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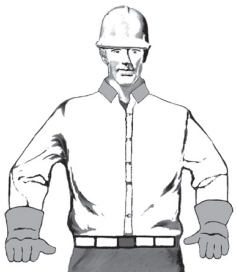
 TRAVEL With all fingers pointing up, arm is extended horizontally out and back to make a pushing motion in the direction of travel.	 DOG EVERYTHING Hands held together at waist level.	 TRAVEL (BOTH TRACKS) Rotate fists around each other in front of body; direction of rotation towards body indicates travel forward; rotation away from body indicates travel backward. (For crawler cranes only)	 TRAVEL (ONE TRACK) Indicate track to be locked by raising fist on that side. Rotate other fist in front of body in direction that other track is to travel. (For crawler cranes only)
 TELESCOPE OUT (TELESCOPING BOOMS) With hands to the front at waist level, thumbs point outward with other fingers closed.	 TELESCOPE IN (TELESCOPING BOOMS) With hands to the front at waist level, thumbs point at each other with other fingers closed.	 TELESCOPE OUT (TELESCOPING BOOMS) One hand signal. One fist in front of chest with thumb tapping chest.	 TELESCOPE IN (TELESCOPING BOOMS) One hand signal. One fist in front of chest, thumb pointing outward and heel of fist tapping chest.

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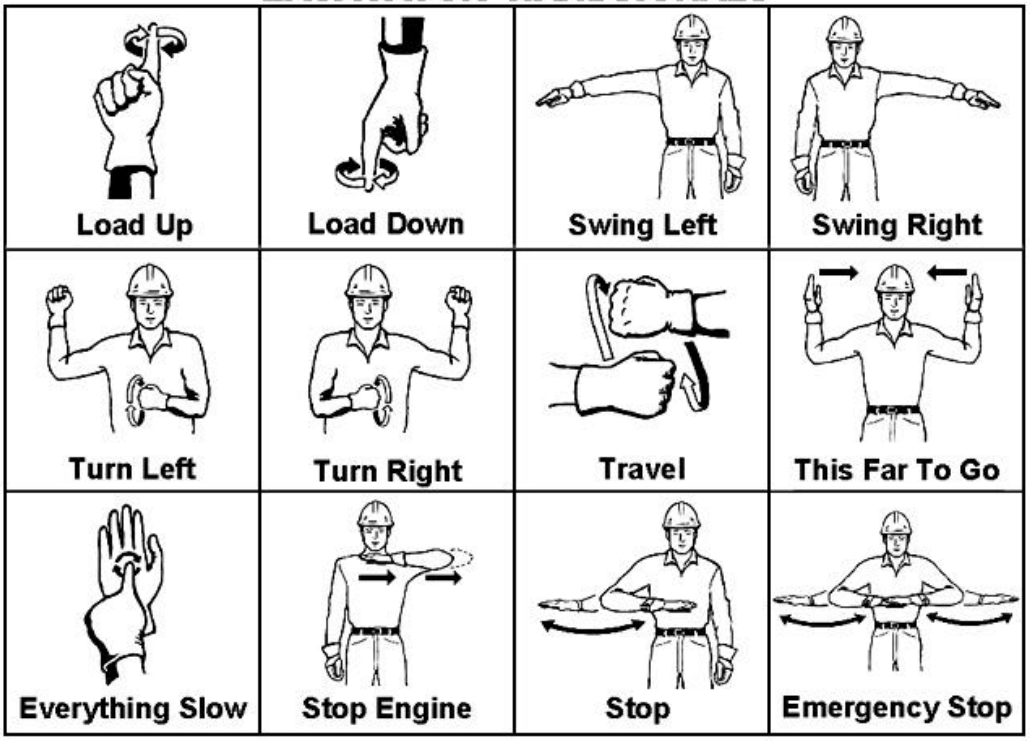
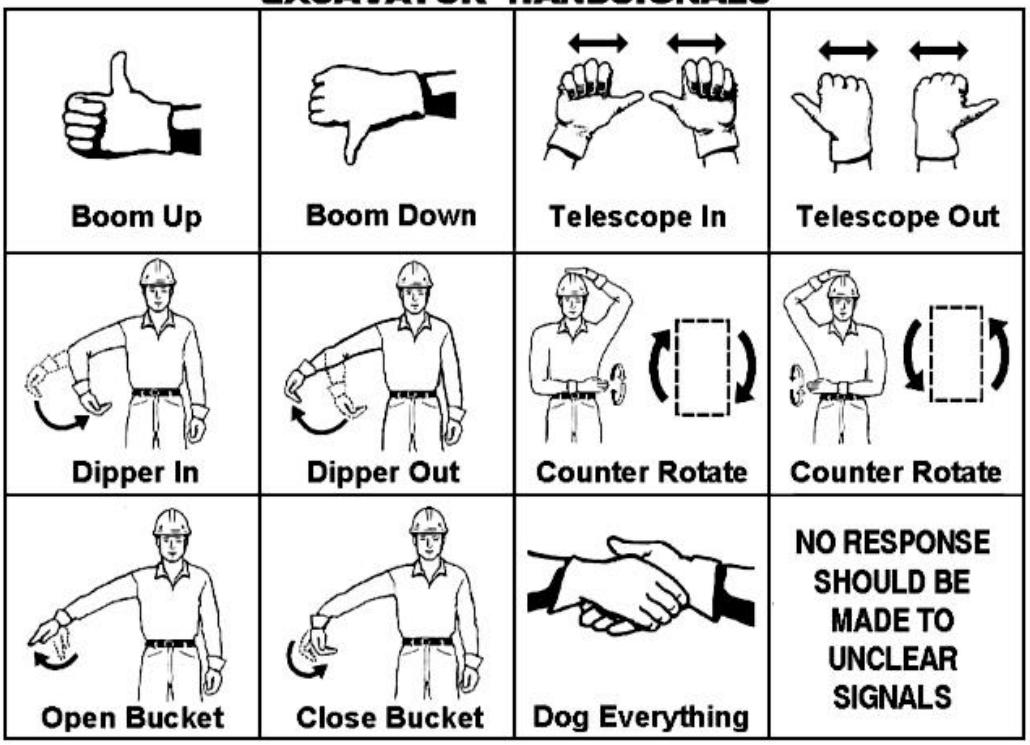
Excavator Hand Signals

EXCAVATOR HANDSIGNALS



EXCAVATOR HANDSIGNALS




NATIONAL US&R RESPONSE SYSTEM
U.S. DEPARTMENT OF HOMELAND SECURITY
FEMA

Federal Emergency Management Agency (FEMA)

Mission Statement

FEMA's mission is to support our citizens and first responders to ensure that as a nation we work together to build, sustain, and improve our capability to prepare for, protect against, respond to, recover from, and mitigate all hazards.

For 35 years, FEMA's mission remains: to lead America to prepare for, prevent, respond to, and recover from disasters with a vision of *a nation prepared*.

Statutory Authority

Robert T. Stafford Disaster Relief and Emergency Assistance Act, Public Law 100-707, signed into law November 23, 1988, amended the Disaster Relief Act of 1974, Public Law 93-288. It created the system in place today by which a presidential disaster declaration of an emergency triggers financial and physical assistance through FEMA.

The Act gives FEMA the responsibility for coordinating government-wide relief efforts.

It is designed to bring an orderly and systemic means of federal natural disaster assistance for state and local governments in carrying out their responsibilities to aid citizens.

Congress's intention was to encourage states and localities to develop comprehensive disaster preparedness plans, prepare for better intergovernmental coordination in the face of a disaster, encourage the use of insurance coverage, and provide federal assistance programs for losses due to a disaster.

This Act constitutes the statutory authority for most federal disaster response activities especially as they pertain to FEMA and FEMA programs:

- Homeland Security Act
- Post Katrina Emergency Management Reform Act (PKEMRA)
- Sandy Recovery Improvement Act of 2013 (SRIA)
- FEMA Implementation of the Sandy Recovery Improvement Act

Structural Collapse Specialist Instructor-Led Training (ILT)

Participant Guide

U.S. Department of Homeland Security

Federal Emergency Management Agency

National Urban Search and Rescue System