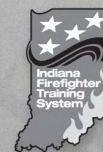


# Technical Rescue

AWARENESS LEVEL TRAINING

STUDENT MANUAL



# STUDENT MANUAL TECHNICAL RESCUE AWARENESS GENERAL

## Introduction

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The material in this program was originally developed by members of the Illinois Fire Service. A team of experienced Technical Rescue Instructors from Indiana took the original program and updated it to bring it into compliance with the 2004 edition of NFPA 1670.



# STUDENT MANUAL TECHNICAL RESCUE AWARENESS GENERAL

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### Administrative Support

**Joe Wainscott, Jr.**  
Executive Director  
Indiana Department of  
Homeland Security

**John Buckman, III**  
IDHS Branch Chief  
Indiana Firefighter  
Training Section

**Gerald George**  
Chairman,  
Indiana Fire Chief Association's  
Technical Rescue Committee

**Karen Wells**  
Administrative Assistant  
Putnam County Emergency Mgt.

**Rick Pohlman**  
Technical Rescue  
Training Coordinator

### Course Development

**Rick Pohlman**  
Coordinator, Introduction

**Gerald George**  
General, Structural Collapse

**Russ Shoaf**  
Rope, Confined Space

**Eddie King**  
Vehicle, Machinery

**Todd Heier**  
Water

**Mike Pruitt**  
Wilderness Search

**Steve White**  
Trench



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### GENERAL

#### Definitions

**Aluminum Hydraulic Shoring.** Pre-engineered shoring system comprised of aluminum hydraulic cylinders (crossbraces) used in conjunction with vertical rails (uprights) or horizontal rails (walers) and designed specifically to support the sidewalls of an excavation and prevent cave-ins.

**Angle of Repose.** The greatest angle above the horizontal plane at which loose material (such as soil) will lie without sliding.

**Attendant.** A term used to describe U.S. federally regulated industrial workers who are qualified to be stationed outside one or more confined spaces, who monitor authorized entrants, and who perform all of the following duties:

- (a) Remain outside the confined space during entry operations until relieved by another attendant
- (b) Summon rescue and other needed resources as soon as the attendant determines that authorized entrants might need assistance to escape from confined space hazards
- (c) Perform non-entry rescues as specified by the rescue procedure listed on the permit (see Entry Permit)

**Auger.** A screw-like shaft that is turned to move grain or other commodities.

**Authority Having Jurisdiction.** (AHJ) The organization, office, or individual responsible for approving equipment, an installation, or a procedure.

**Authorized Entrant.** A term used to describe U.S. federally regulated industrial workers who are designated to enter confined spaces and who meet the following training requirements for each specific space they enter:

- (a) Hazard Recognition. The ability to recognize the signs and symptoms of exposure to a hazardous material or atmosphere within the space and to understand the consequences of exposure and the mode of transmission (i.e., injection, ingestion, inhalation, or absorption) for the hazard.
- (b) Communications. The ability to carry out the method by which rescue services are to be summoned in the event of an emergency, the method by which the entrant will communicate with the attendant on the outside of the space, and a backup method of communication should the primary system fail.
- (c) Personal Protective Equipment (PPE). The ability to use all PPE appropriate for the confined space.
- (d) Self-Rescue. The ability to carry out the method by which the entrant will escape from the space should an emergency occur.

**Bastard Search.** No victim exists due to the report being inaccurate or the victim/individual has left the area.

**Benching or Benching System.** A method of protecting employees from cave-ins by excavating the side of an excavation to form one or a series of horizontal levels or steps, usually with vertical or near-vertical surfaces between levels.



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**Blanking and Blinding.** A form of hydraulic energy isolation that is the absolute closure of a pipe, line, or duct by fastening a solid plate (such as a spectacle blind or skillet blind) that completely covers the bore and that is capable of withstanding the maximum pressure within the pipe, line, or duct with no leakage beyond the plate.

**Blitz or Hasty Team.** Minimum number of experienced rescuers that are sent out to locate the victim

**Boil.** The hydraulic backwash below a dam, sometimes described as a vertical whirlpool.

**Boil Line.** A point, below a dam, where the current splits, flowing upstream and downstream.

**Cave-In.** The separation of a mass of soil or rock material from the side of an excavation or trench, or the loss of soil from under a trench shield or support system, and its sudden movement into the excavation, either by falling or sliding, in sufficient quantity so that it could entrap, bury, or otherwise injure and immobilize a person.

**Collapse Zone.** See Rescue Area.

**Compact Soil.** Means clay (fine grained soil), or soil with a high clay content, which has cohesive strength. Compact soil does not crumble, can be excavated with vertical side slopes, and is plastic when moist. Compact soil is hard to break up when dry, and exhibits significant cohesion when submerged. Compact soils include clayey silt, sandy clay, silty clay, clay and organic clay.

**Competent Person.** One who is capable of identifying existing and predictable conditions in the surroundings or in the working area that are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate such conditions.

**Confined Space.** A space that has the following characteristics:

- (a) Is large enough and so configured that a person can enter and perform assigned work
- (b) Has limited or restricted means for entry or exit (e.g., tanks, vessels, silos, storage bins, hoppers, vaults, and pits)
- (c) Is not designed for continuous human occupancy

**Conveyor belt.** A system to transfer goods, products or stock along a continual moving track.

**Cribbing.** Various lengths and dimensions of sturdy material, usually wood or plastic, used in rescue operations to stabilize or support vehicles, machinery or parts of structures.

**Cross Braces (or Struts).** The individual horizontal members of a shoring system installed perpendicular to the sides of the excavation, the ends of which bear against either uprights or wales. (See also Shoring.)

**Disturbed Soil.** Soil that has been previously excavated. Within the last 25 years.



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**Eddy.** Is the swirling of a fluid and the reverse current created when the fluid flows past an obstacle. The moving fluid creates a space devoid of downstream-flowing water on the downstream side of the object. Fluid behind the obstacle flows into the void creating a swirl of fluid on each edge of the obstacle, followed by a short reverse flow of fluid behind the obstacle flowing upstream, toward the back of the obstacle. This phenomenon is most visible behind large emergent rocks in swift-flowing rivers.

**Electrical Drain Time.** The time frame in which the electrical potential is completely lost in the electrical circuit.

**Engulfment.** The surrounding and effective capture of a person by a fluid (e.g., liquid, finely divided particulate) substance that can be aspirated to cause death by filling or plugging the respiratory system or that can exert enough force on the body to cause death by strangulation, constriction, or crushing.

**Entrant.** Means an employee who is authorized by the employer to enter a permit space.

**Entry Permit.** A written or printed document, established by an employer, for non-rescue entry into confined spaces.

**Excavation.** Any man-made cut, cavity, trench, or depression in an earth surface, formed by the removal of earth.

**Extrication.** The removal of trapped victims from a vehicle or machinery.

**FEMA Task Force Search and Rescue Marking System.** Distinct markings made with international orange spray paint near a collapsed structure's most accessible point of entry.

**Full-Cycle Machines.** Machinery that is thought to be isolated (electrically or mechanically) may continue to move to complete its cycle.

**Groundpads.** Plywood or similar material used to distribute weight around a trench operation.

**Hasty or Blitz Team.** Minimum number of experienced rescuers that are sent out to locate the victim

**Hazard Analysis.** The process of identifying situations or conditions that have the potential to cause injury to people, damage to property, or damage to the environment.

**Hazardous Atmosphere.** Any atmosphere that is oxygen deficient, contains a toxic or disease-producing contaminant, or is potentially explosive. A hazardous atmosphere could be immediately dangerous to life and health, but not necessarily.



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**Hazardous Atmosphere for Confined Space.** Any atmosphere that could expose personnel to the risk of death, incapacitation, injury, acute illness, or impairment of the ability to self-rescue, due to one or more of the following causes:

- (a) Flammable gas, vapor, or mist in excess of 10 percent of its lower flammable limit (LFL)
- (b) Airborne combustible dust at a concentration that meets or exceeds its LFL
- (c) Atmospheric oxygen concentration below 19.5 percent or above 23.5 percent
- (d) Atmospheric concentration of any hazardous substance that could result in exposure to personnel in excess of its dose or permissible exposure limit (PEL)
- (e) Any other atmospheric condition that is immediately dangerous to life or health (IDLH)

**Helical flow.** Is found in steep sloped channels. Water quickly rises from the deep middle to the shallow bank.

**High Angle.** Refers to an environment in which the load is predominately supported by the rope rescue system.

**Hydraulics.** Is a topic of science and engineering dealing with the mechanical properties of liquids.

**IDOL.** Indiana Department of Labor

**Immediately Dangerous to Life or Health (IDLH).** Any condition that would do one of the following:

- (a) Pose an immediate or delayed threat to life
- (b) Cause irreversible adverse health effects
- (c) Interfere with an individual's ability to escape unaided from a hazardous environment

**Incident Command System (ICS).** The combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure with responsibility for the management of assigned resources to effectively accomplish stated objectives pertaining to an incident (as described in the document *Incident Command System*) or training exercise.

**Incident Management System.** The management system or command structure used during emergency operations to identify clearly who is in command of the incident and what roles and responsibilities are assigned to various members.

**Laminar flow.** The water close to the river bottom moves at a slower rate than the water at the surface.

**Last-Seen-Point.** The most likely location to find a victim or object under the water obtained by witness interviews, use of reference points or objects, and/or physical evidence.

**Life Safety Harness.** A system component that is an arrangement of materials secured about the body and used to support a person during rescue.



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**Life Safety Rope.** A compact but flexible, torsionally balanced, continuous structure of fibers produced from strands that are twisted, plaited, or braided together and that serve primarily to support a load or transmit a force from the point of origin to the point of application.

**Litter.** A transfer device designed to support and protect a victim during movement.

**Litter Attendant.** A person who both accompanies and physically manages the litter.

**Load.** That which is being lowered or raised by rope in a high angle system. Some examples include a rescue subject, a rescuer, and subjects in a litter with a litter attendant.

**Lockout.** A method for keeping equipment from being set in motion and endangering workers.

**Low Angle.** Refers to an environment in which the load is predominately supported by itself and not the rope rescue system (e.g., flat land or mild sloping surface).

**Low head dam.** Is a uniform barrier across a body of moving water

**Machinery.** The moving parts of a particular machine.

**Magnitude.** Size or extent of the incident.

**NFPA.** *National Fire Protection Association.* This organization develops safety standards for the fire service. The proposed standards can then be adopted by the individual departments or local governments.

**National Search and Rescue Plan.** A document that identifies responsibilities of U.S. federal agencies and serves as the basis for the National Search and Rescue Manual, which discusses search and rescue organizations, resources, methods, and techniques utilized by the federal government.

**OSHA.** *Occupational Safety and Health Administration.* A part of the Department of Labor entrusted with enforcing safety in the workplace.

**Oxygen-Deficient Atmosphere.** Air atmospheres containing less than 19.5 percent oxygen by volume at one standard atmosphere pressure.

**Oxygen-Enriched Atmosphere.** Air atmospheres containing more than 23.5 percent oxygen by volume at one standard atmosphere pressure.





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## TECHNICAL RESCUE AWARENESS

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**Permit Required Confined Space.** A Confined Space that has one or more of the following characteristics:

1. Contains or has a potential to contain a hazardous atmosphere
2. Contains a material that has the potential for engulfing an entrant
3. Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor that slopes downward and tapers to a smaller cross section
4. Contains any other recognized serious safety or health hazards (including fall, environmental, and equipment hazards)

**Personal Flotation Device.** (also named PFD, lifejacket, life preserver, Mae West, life vest, life saver, cork jacket, life belt) is a device designed to keep a wearer afloat and their head above water.

**Personal Protective Equipment (PPE).** The equipment provided to shield or isolate personnel from infectious, chemical, physical, and thermal hazards.

**Public Safety Diving.** Underwater diving, related to team operations and training, performed by any member, group, or agency of a community or government-recognized public safety diving or water rescue team.

**Rapid Intervention Crew.** At least two members available for rescue of a member or a team if the need arises.

**“Reach, Throw, Row, Go.”** The four sequential steps in water rescue with progressively more risk to the rescuer. Specifically, a “go” rescue involves physically entering the medium (e.g., in the water or on the ice).

**Recovery Mode.** Level of operational urgency where there is no chance of rescuing a victim alive.

**Reference Object.** An object, (like a person or a boat), that is the same size as the object that sank below the surface of the water. This reference object is used to assist a witness in describing the last seen point.

**Registered Professional Engineer.** A person who is registered as a professional engineer in the state where the work is to be performed.

**Rescue.** Those activities directed at locating endangered persons at an emergency incident, removing those persons from danger, treating the injured, and providing for transport to an appropriate health care facility.

**Rescue Area. (or Hot, Danger, or Collapse Zone).** An area surrounding the incident site (e.g., collapsed structure or trench) whose size is proportional to the hazards that exist.

**Rescue Mode.** A level of operational urgency where there is a chance that a victim will be rescued alive.



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## TECHNICAL RESCUE AWARENESS

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**Risk.** A measure of the probability and severity of adverse effects that result from an exposure to a hazard.

**Risk Assessment.** An assessment of the likelihood, vulnerability, and magnitude of incidents that could result from exposure to hazards.

**Risk/Benefit Analysis.** A decision made by a responder based on a hazard and situation assessment that weighs the risks likely to be taken against the benefits to be gained for taking those risks.

**Running Soil.** Means soil which is underwater or is free seeping.

**Safety Officer.** An individual qualified by the authority having jurisdiction to maintain a safe working environment.

**Safing.** This term is used to explain removing hazards, placing ground pads, establishing ventilation, monitoring, etc. to assure the site is safe to work around the trench.

**SAR.** Search and rescue.

**Saturated Soil.** Means a soil in which the voids are filled with water. Saturation does not require flow. Saturation, or near saturation, is necessary for the proper use of instruments such as a pocket penetrometer or shear vane.

**Scope.** Extent of activity or range of operations

**Sheeting.** The members of a shoring system that support the sides of an excavation and are in turn supported by other members of the shoring system.

**Shield (or Shield System).** A structure that is able to withstand the forces imposed on it by a cave-in and thereby protect employees within the structures.

**Shoring (or Shoring System).** A structure such as a metal hydraulic, pneumatic/mechanical, or timber shoring system that supports the sides of an excavation and is designed to prevent cave-ins.

**Size-Up.** A mental process of evaluating the influencing factors at an incident prior to committing resources to a course of action.

**Slough-in.** This type of collapse results in an undercut area of the trench wall and creates a large unsupported overhang of soil.

**Spoil Pile.** The material that is excavated from the trench. The spoil pile should be a minimum of two feet (2') from the lip of the trench.



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**Strainer.** An obstruction in a flowing body of water that allows the current to pass through it but does not allow the clear passage of larger objects such as people or boats.

**Superimposed loads.** Loads that place stress on trench walls. Examples include backhoes, pipes, cable, trench shields, rescuers, students, spoil pile, etc.

**Surcharge Loads.** Any weight near the lip of the trench that increases the likelihood of instability or secondary cave-in.

**Surface encumbrances** Structures that were designed to be supported by the dirt which was in the trench. Examples include utility poles, roadways, foundations, etc.

**Swift Water.** Water moving at a rate greater than one knot (1.15 mph).

**Tabulated Data.** Any set of site-specific design data used by a professional engineer to design a protective system at a particular location.

**Tag-out.** A method of tagging, labeling, or otherwise marking an isolation device during hazard abatement operations to prevent accidental removal of the device. (See also Lockout.)

**Technical Rescue.** The application of special knowledge, skills, and equipment to safely resolve unique and/or complex rescue situations.

**Tension Crack.** Crack like openings that indicate soil under tension.

**Terrain.** Specific natural and topographical features within an environment.

**Thermocline.** Dividing line between sun-warmed, upper layers of still water and markedly cooler lower layers.

**Topographical Map.** A graphical representation of the earth's surface, drawn to scale and reproduced in two dimensions, that reflects the topographical features of the area depicted.

**Trench (or Trench Excavation).** A narrow (in relation to its length) excavation made below the surface of the earth. (OSHA definition of Trench – An excavation that is deeper than it is wide and less than 15 feet wide.

**Trench Box (or Trench Shield).** A manufactured protection system unit made from steel, fiberglass, or aluminum that is placed in a trench to protect workers from cave-in and that can be moved as a unit. (See also Shield.)

**Uprights (or Strongback).** The vertical members of a trench shoring system placed in contact with the earth, usually held in place against sections of sheeting with shores and positioned so that individual members do not contact each other.



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### GENERAL

**Utilities.** Gas/electrical/water/pneumatic sources of energy or power.

**Vehicle.** A device or structure for transporting persons or things; a conveyance.

**Vehicle Posts.** Starting at the front of the vehicle, alphabetically with A, the areas of the vehicle where the roof support is connected to the body.

**Virgin Soil.** Soil that has never been excavated. Soil that has never been dug in.

**Watermanship Skills.** Capabilities that include swimming, surface diving, treading water, and staying afloat with a reasonable degree of comfort appropriate to the required task.

**Wilderness.** An uncultivated, uninhabited, and natural area usually, but not necessarily, far from human civilization and trappings.



# STUDENT MANUAL TECHNICAL RESCUE AWARENESS GENERAL

*This Technical Rescue Awareness course has been developed by fellow firefighters within the State of Indiana. The members of the technical rescue committee of the Indiana Fire Chief Association followed the guidelines of IOSHA and NFPA 1670. This course is meant to provide you a means to identify and properly react to uncommon, dangerous and difficult rescue situations. Further training in each discipline is required before any actual rescue operations are undertaken.*

## Certification:

The Indiana Board of Firefighter Personnel Standards has established the following requirements for this course. Each individual is required to attend 100% of the twelve-hour class, be Hazardous Materials Awareness certified and successfully pass the state written exam by 70%.

## Purpose Statement:

The Purpose of the Course is to enhance the students understanding of the following capabilities:

1. Assessing Technical Search and Rescue Hazards within their response area
2. Identifying the appropriate level of Operational Capability (organizational) as established by the AHJ
3. Implementing the appropriate Functional Capabilities (individual) when engaging in technical rescue events as established by the AHJ
4. Identifying appropriate Awareness Level Operational / Functional capabilities for INITIAL COMPANY OPERATIONS at technical rescue events.

## Overview

This program is brought to you  
by the  
Indiana Department of Homeland Security  
and the  
Indiana Fire Chief Association's  
Technical Rescue Committee

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## Certification

- Requirements for certification
  - Certified in Hazardous Materials Awareness
  - 100% attendance of the 12 hour awareness course
  - Passing the state written exam by 70%

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## Purpose Statement

- Purpose of the Course is to enhance the students understanding of the following capabilities:
  - Assessing Technical Search and Rescue Hazards within their response area. (Community Risk Analysis)
  - Identifying the appropriate level of Operational Capability (organizational) as established by the AHJ. (Guidelines)
  - Implementing the appropriate Functional Capabilities (individual) when engaging in technical rescue events as established by the AHJ. (Procedures)
  - Identifying appropriate Awareness Level Operational / Functional capabilities for INITIAL COMPANY OPERATIONS at technical rescue events.

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## TECHNICAL RESCUE AWARENESS

### GENERAL

#### Scope:

This course will cover basic and general knowledge on the following topic areas: Structural Collapse Rescue, Rope Rescue, Confined Space Rescue, Vehicle and Machinery Rescue, Water Rescue, Wilderness Rescue, and Trench / Excavation Rescue. These seven areas are identified in NFPA 1670. The information you will be provided will be at an awareness level. In most cases, you will not be the rescuer.

#### AHJ Requirements:

**This course does not contain hands on training. The department or agency (AHJ) is responsible for compliance of administrative responsibilities as outlined in NFPA 1670, Operations and Training for Technical Rescue Incidents. These responsibilities include development of policies and procedures that stipulate the level of response offered by the organization and the level of training offered to address the level of response. Each agency should acquire a copy of NFPA 1670 as a reference document in meeting these responsibilities.**

#### Incident Response Plan:

Each department or agency needs to have an action plan and policies in place to handle these types of rescue incidents. Proper planning includes knowing where your agency is in terms of technical rescue training, level of operation, and when to call additional resources. Mutual aid agreements can provide you with additional external resources, some of which may be at a higher level of training. They must have total control over all resources requested. If conditions warrant the operation may be halted by the Authority Having Jurisdiction (AHJ).



#### General Scope

- Course Requirements & Standards
  - Follows guidelines of NFPA Standards and OSHA Regulations.
  - Refresher training should be conducted annually.
  - Further training is required for actual rescue operations and practices.

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#### AHJ Requirements

- NOTE
  - This course DOES NOT contain hands on training
  - The AHJ is responsible for training per NFPA 1670
    - Operations and Training at Technical Rescue Incidents
  - The AHJ must assure members have
    - Hazardous Materials Awareness certification

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#### General

- Each AHJ needs to establish an Incident Response Plan to include policies and procedures for technical rescue operations in accordance with NFPA 1670 (Establish SOG's and SOP's)
- AHJ has complete control over all resources requested
- AHJ has authority to stop all rescue attempts

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# STUDENT MANUAL TECHNICAL RESCUE AWARENESS GENERAL

## Hazard / Risk Analysis:

A hazard analysis and risk assessment will provide the department or agency with the information needed to make an informed decision on the likelihood of an incident, where it might occur, and the effects on the community. It will also provide the department or agency with information as to the feasibility of conducting a technical rescue.

Indiana is an OSHA state and as such, all employers are obligated to comply with the OSHA general duty clause to provide employees with a safe work environment.

**Awareness** – The basic first in company operations occur at the Awareness Level. This will be mostly non-hands on training. It will provide you the information needed to identify the specific hazards and rescue situations.

Awareness level personnel are those who may be first on the scene through the course of regular job duties of a technical rescue incident. Generally, they are not considered as “rescuers” as such. The AHJ should ensure these people know the hazards that are in their jurisdiction.

**Operations** – Operations is a hands-on response. In the operations level, personnel will perform rescues based on their training. It is intended to provide individuals with the required training to perform the operation safely and effectively.

**Technician** – Individuals at this level are taught to deal with the most complex and advanced rescue procedures/guidelines. This level is the expert level of training. FEMA USAR teams are trained at this level.

Departments or agencies are required to establish written standard operating procedures/guidelines consistent with one of the following NFPA 1670 functional capabilities: Awareness, Operations, or Technician.



## General

- AHJ must conduct hazard and risk analysis to determine feasibility of conducting Technical Rescue Operations
  - Information to make informed decision
  - Likelihood of incident
  - Where it might occur
  - Effects on the community

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## Hazard / Risk Analysis Matrix

Hazards	Risks	Equipment	Capability
Earthquake, Tornado	Structural Collapse, Confined Space, Ejection	SAK team, Structural Collapse team, etc.	
Flood, river, lake	Swift Water, Hazmat, Marine		
Old Structures			
Highrise			
Fire, explosion			
Industrial			
Agriculture Machinery			
Wild, caves, mines, tunnels			
Traffic, compound, excavations			

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## General

- AHJ should adhere to OSHA General Duty Clause (Provide a safe workplace for employees)
- NFPA 1670 Levels of functional capability
  - Awareness Level
    - Basic initial company response
      - First on the scene in course of duty
      - Identify type of incident
      - Start initial company operations
      - Generally NOT considered rescuers

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## General

- NFPA 1670 Levels of functional capability (con't)
  - Operations Level
    - Basic technical response
      - Deal with most non-complex situations
  - Technician Level
    - Considered expert in the field
      - Deal with complex and difficult situations

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# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### GENERAL

#### Hazards associated with technical rescue incidents.

Most people who have entered the fire service possess the type of personality that likes to jump in and get the job done. They are action oriented. They want to take action and help now. This trait is often a great asset, but it can also make them the biggest hazard on the scene. When emotions take over, dangerous attempts at a rescue are executed without the proper training or equipment. This is where strong, competent, levelheaded leadership must gain control of the scene to prevent the loss of one of our own.

**Protecting rescuers is the highest priority during technical rescue incidents.**

#### Elements of Safety at a Technical Rescue

##### Personnel Accountability Safety System (PASS).

The department or agency must be accountable for EVERYONE operating at an incident. There are various forms of PAS available, but the Authority Having Jurisdiction must insure that whatever system is utilized, it must account for EVERYONE operating at the incident at all times.

##### Evacuation Procedures/Guidelines.

EVERYONE operating at the incident must know these procedures/guidelines. Each sector must know what its' actions will be in the event an evacuation order is given. These procedures/guidelines should be identified in the risk/benefit analysis and the operational procedures/guidelines established by the department or agency. This information should be shared at the incident briefing prior to initiating the Incident Action Plan.

- Evacuation Signals
  - Evacuate 3 short blasts (1 second each)
  - Cease Operations 1 long blast (3 seconds long)
  - Resume Operations 1 long and 1 short blast

#### General

- Safety at a technical rescue
  - Personnel accountability system (PAS)
    - Account for all members at incident
- Evacuation procedures / guideline
  - **Everyone** operating at the incident must know correct actions if evacuation order is given
- Evacuation Signals (example from FEMA US&R)
  - Evacuate – 3 short blasts (1 second each)
  - Cease Operations – 1 long blast (3 seconds long)
  - Resume Operations – 1 long and 1 short blast





# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### GENERAL

#### Personnel Protective Equipment.

Each department or agency is responsible for determining personnel protective equipment. The decision as to what must be worn is based on the incident and what hazards are present or could become present during the incident.

#### Size-Up (Hazard and Risk Assessment)

The need for continuous six-sided approach to size up must never be overlooked. Every technical rescue, no matter what magnitude, can change very rapidly. The initial size up will set the groundwork for the entire incident.

#### Scope, Magnitude, Nature of the Incident.

The incident may affect local areas only, or encompass a multi county area. Is it only a building collapse, or it a building collapse because of a tornado? In some areas the magnitude of the incident may not have been realized or planned for.

#### Location and number of victims.

Size up determines an approximate number of victims and possible locations. Time of day, area affected and nature of the incident will assist in this determination.

#### Risk / Benefit Analysis.

Will the end result justify the means? What is an acceptable level of risk you are willing to accept? How long has the victim been incapacitated? Are you utilizing your resources for the greatest amount of good for the most people? These questions not only pose a moral issue but an ethical one as well. Greater risk for more success, little risk for little success. There will come a time when no matter what efforts you put forth, the end result will be the same.

#### Pre-Planning.

This will address more than one way to get to the area. Roads may be closed because of debris, structural damage, unstable roadways and bridges. Knowing the buildings and hazard locations in your response district, will help you with an emergency response. The department or agency is required by NFPA 1670 to identify all possible technical rescue hazards.



#### General

- PPE
  - Each AHJ is responsible for determining appropriate level of PPE
    - In most cases, will not be structural firefighting gear



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#### General

- Hazard & risk assessment (scene size-up)
  - Continuous (Six sided approach)
  - Every technical rescue, no matter what magnitude, can change in a second
  - Initial size-up will set ground work for entire incident

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#### General

- Size-up (con't)
  - Scope, magnitude, nature of incident
  - Location and number of victims
    - Time of day, Area affected, complexity of incident
  - Risk / benefit analysis
    - Will the end result justify the means
  - Pre-plans
    - May provide structure information
  - Environmental factors
    - Extreme heat and cold

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# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### GENERAL

Pre-planning will minimize the risk of rescuers, maximize resources and mitigate consequences of the incident.

Community resources that maybe required for technical rescue incidents must be identified before the need arises.

#### Environmental Factors.

Loss of life can be expected to rise in time of extreme heat and cold. The victim's chances for survival are, in part, dependent on the conditions of the environment. How will rain, sleet and snow effect your operation? Do you have a contingency plan for these types of conditions?

#### Patient Contact/Condition.

Safety is paramount before any actions are taken. Can you see or hear the victim? Does the victim know you are there? Some methods that can be utilized are, hailing, tag lines, hard line communication systems, and radios.

#### Availability / Necessary Resources.

What resources do you have available? Remember both internal and external. Utilize local resources by explaining to them what you need and send them a letter of intent prior to your need. Private Contractors, Registered Professional Engineers, equipment rental shops, and Public Works agencies can all assist in the event of an emergency.

#### Incident Management System / Incident Command System.

In order to manage any incident, command and control must be established. The incident command system should be in place before an operations is implemented.

The incident command system includes management of all emergency and non-emergency personnel.

The recommended span of control when using the incident command system is 5 to 1.

#### Command.

The incident commander is responsible for the entire incident. Command need not be trained to the level of the incident, but must have the resources available in order to make an informed decision. Command may halt any and all operations at any technical rescue incident.



#### General

- Size-up (con't)
  - Patient contact/condition
    - Your safety is paramount
    - Can you see or hear patients?
    - Hailing, tag lines, radios, con-space systems
    - Does the patient know where they are?
- Availability / needed resources
  - What resources do you need?
  - What resources do you have available?

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#### General

- IMS / ICS
  - In order to manage the incident, command and control must be established.
  - Positions Filled (*minimum*)
    - Command
      - Responsible for entire incident
    - Safety
      - Should be trained to level of incident



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# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### GENERAL

#### Safety.

The Safety Officer should be trained to the level of the incident. There are certain established methods of rescue that the normal fire ground safety officer may not be aware of and deem them unsafe, when in fact they are standard to the specific type of incident.

**Safety is the responsibility of everyone.**

#### ADDITIONAL POSITIONS TO CONSIDER BASED ON INCIDENT COMPLEXITY

##### Operations Section Chief

The operations section is responsible for establishing a rescue plan, informing all division/groups of the plan, and insuring the plan is carried out. This individual must be trained to the type of incident. In the rescue division, working outside of your level of training is not acceptable.

##### Optional positions

Logistics Section, Public Information Officer, Staging Area Manager, Rehab Unit, Fire Branch, EMS Branch, and others as outline in NFPA1561, Standard in Fire Department Incident Management.

##### Scene Control.

Control Zones – These zones will replicate the zones established during a hazardous materials incident. Hot, warm and cold. Establishing these zones early will afford the incident commander control over the incident vs. the incident controlling the commander. These zones should be established for all technical rescue incidents when the first fire department or police department representative arrives on scene.


##### Witness Interviews.

Who, what, where, why, and when must be extracted from all individuals in the area. Where were they standing when the incident took place? What did they see or hear? The department or agency should establish forms to assist in this information gathering for the various types of possible incidents identified in their jurisdiction.



### General

- Additional IMS / ICS Positions to consider
  - Operations Section Chief
    - Rescue Branch Director
      - » Establish rescue plan
      - » Inform all personnel of the plan
      - » Insure the plan is carried out
  - Optional Positions
    - Finance, Logistics, Planning, PIO
    - Others outlined in NFPA 1561 *Standard for FD Incident Management*



Rescue

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### General

- Scene control
  - Control zones
    - Hot, warm, cold
  - Witness interviews
    - Who, what, where, when, why from all people in area
    - Patient contact
      - Control who talks to victim and what victim hears
    - Bystander interaction
      - Control zones will keep non-essential people out of harms way

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# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### GENERAL

#### **Patient Contact.**

Control who talks to the victim and what the victim hears. It does no one any good to say things that will only upset the victim. Lying is not acceptable, but limiting the information is. Prudence in this matter will be of benefit to your agency and the victim.

#### **Bystander Interaction.**

This includes family that has been told of the incident and they are there to see their loved ones. Establishing control zones will keep all non-essential personnel out of harms way. The department or agency personnel interacting with the public can also pose problems. If numerous people tell “their” version of what’s going on, the real story may become overlooked. This is the importance of a Public Information officer.

#### **Police Assistance.**

The Police departments are an extremely valuable resource at your disposal. From the local to state level, most are willing to cooperate with you. Like all other members working on the scene, they must be kept apprised of the situation and any and all potential problems.

#### **Machinery/Vehicles.**

All too often, notices are sent out because a rescuer was killed at the scene of an incident. Whether it is traffic on a back-road or a 6-lane highway, a conscious effort must be made to protect all personnel operating at the incident. Do not utilize personnel to block traffic. With machinery, find someone with expertise. What are the actions of a “full cycle machine”? Call for assistance.

#### **Utilities.**

Notify the proper authorities. Unless you are “qualified, certified, or properly trained” do not attempt to manipulate their equipment. Have their emergency contact numbers available ahead of time.

#### General

- Scene control
  - Police assistance
    - PD is a valuable resource
  - Machinery / vehicles
    - Find someone with expertise (machines)
    - What are the actions of a full cycles machine?
    - Use apparatus to block traffic, not personnel
  - Utilities
    - Have emergency contact information ahead of time. Know capabilities and resources.

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# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### GENERAL

## Course Objectives

This course has been designed to meet the 2004 edition of NFPA 1670. Students should reference the standard for specific objectives for the awareness level in each subject addressed.

At the completion of each subject, the student should be able to implement the relevant initial company operations below.

## Initial Company Operations

- 1.) **Upon Arrival - Establish Strong visible command**
  - a. Provide initial report
  - b. Implement ICS / NIMS
  - c. Establish minimum positions
    - i. Command
    - ii. Safety
  - d. Establish additional Command Staff and General Staff positions as needed
  - e. Consider Unified Command for Complex Incidents
  
- 2.) **Identify the need for Technical Rescue**
  - a. Conduct Rapid Size-up Considering the following:
    - i. Scope, Magnitude and Nature of the incident
    - ii. Location / complexity of the incident
    - iii. Risk vs. Benefit (rescue or recovery)
    - iv. Scene Access
    - v. Functional Capabilities of Available Resources
    - vi. Location of Additional, Trained Resources.
    - vii. Environmental Conditions
  
- 3.) **Recognize the General Hazards involved in the incident.**
  - a. Make area safe for all responders
    - i. Identify all Hazards
    - ii. Control / Limit Traffic
    - iii. Control / Limit Access
    - iv. Mitigate hazards within your capabilities



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### GENERAL

- 4.) **Identify the appropriate resources for the incident**
  - a. Consider Functional Capability
    - i. Awareness
    - ii. Operations
    - iii. Technician
  
- 5.) **Initiate the appropriate emergency response system**
  - a. Consider all Available response systems as identified by the AHJ
    - i. Local
    - ii. County
    - iii. State
    - iv. National
  
- 6.) **Initiate Site Control Measures**
  - a. Establish personnel accountability system (control access points)
  - b. Develop Incident Action Plan and Communicate the plan to EVERYONE
  - c. Establish and Communicate an Evacuation Plan for EVERYONE
  - d. Secure the General Area
  - e. Secure Witnesses and Conduct Interviews for Intelligence
  - f. Establish Control Zones (Rule of Thumb)
    - i. Hot Zone            100' critical functions
    - ii. Warm Zone        200' support functions
    - iii. Cold Zone        300' Command and Control functions

Outside Cold Zone    Liaison to Rest Of World
  
- 7.) **Establish Patient Contact without endangering Personnel**
  - a. Establish Location of All Patients
  - b. Establish verbal contact with the patient
  - c. Determine Patient Condition (from a safe distance)
  - d. Assist with NON-ENTRY RESCUE  
(without endangering personnel)



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

Emergency providers have become an organized faction that responds to a large number of diverse types of emergency and non-emergency incidents. These incidents range from responses to automobile fires to collapses of multistory buildings. Our emergency response personnel continue to provide life saving action in all incidents whether they are formally trained or not. Due to that type of culture it is important for responding companies to have the needed knowledge to safely evaluate, and establish a method to start mitigation of each type of incident without exposing our personnel. The safety of our personnel continues to be the highest priority of each incident. Personnel that respond to these incidents need to be aware of hazards associated with each type of incident. In this section you will be able to identify general principles for a structural collapse.

Earthquakes, wind storms, floods, heavy snow, inadequate construction techniques, explosions, rain, fire, transportation accidents, and decay due to age affect buildings no matter where they are located across the globe.

The following program will cover what you the responder should expect to find at these incidents; including the initial response by the local residents, selecting strategies during initial size-up, destructive forces expected due to the type of disaster, and the initial information that is needed to direct incoming rescue forces. Along with discussions of the different building designs, their weaknesses, and how the different damaging forces will cause adverse structural loading and the resultant collapse patterns. Emergency responders from each community have a different method for addressing the same problems as found elsewhere in the nation. Communities must evaluate the probability of each type of damaging forces that affect their location. This will help us effectively plan for these special emergencies, and their special hazards. Protecting our personnel and the occupants that remain in those damaged structures will be the result of these efforts.

### Structural Collapse



### Overview

- Functional Capabilities of Responders
- Initial Response and Size-up
- Causes of Collapse
- Potential Secondary Collapse Indicators
- Phases of Response
- Categories of Building Construction
- Collapse Patterns
- FEMA US&R Marking Systems
- Structural Triage Criteria
- Initial Company Operations



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

It is the intent of this program to train fire department personnel to be competent at surface rescues. Surface rescues involve minimal removal of debris and building contents to extricate easily accessible victims.

**Awareness Level Personnel can perform the following functions:** Size-up, Site control, Scene Management, Hazard Identification, Basic Search and Removal of Readily Accessible Victims. (surface rescue)

**Operations Level Personnel can do all of Awareness Level Plus:** Conduct rescues from Light Frame, Ordinary, Un-reinforced and Reinforced Masonry Construction.

**Technician Level Personnel can do all of Awareness and Operations Levels Plus:** Conduct rescues from Concrete Tilt-Up, Reinforced Concrete and Steel Construction.

#### Functional Capabilities

##### **Awareness Level Personnel can:**

- Perform Size-up, Site control, Scene Management, Hazard Identification, Basic Search and Removal of Readily Accessible Victims. (surface rescue)

#### Functional Capabilities

##### **Operations Level Personnel can do all of Awareness Level Plus:**

- Conduct rescues from Light Frame, Ordinary, Unreinforced and Reinforced Masonry Construction.

#### Functional Capabilities

##### **Technician Level Personnel can do all of Awareness and Operations Levels Plus:**

- Conduct rescues from Concrete Tilt-Up, Reinforced Concrete and Steel Construction.





# STUDENT MANUAL TECHNICAL RESCUE AWARENESS STRUCTURAL COLLAPSE

**Size-up Defined:** The conscious process involving very rapid but deliberate consideration of the critical factors and development of a rational plan of attack.

**Size-up is a SIX SIDED APPROACH: TOP, BOTTOM,  
And ALL FOUR SIDES  
INITIAL INFORMATION GATHERING**

Information gathering techniques will be crucial to the efficient transition of the Technical Rescue Specialist into the incident. It is important for these incoming forces to carefully verify information obtained from the first responders and other individuals at the disaster site. By the time the information exchange takes place, the first responders will probably be subjected to the following:

Long periods of physically and emotionally draining work. Feelings that it's not possible that other victims have survived within a badly collapsed structure.

A need to experience closure that the incident is over.

Feelings by relatives/friends of the missing that they have surely survived and are entrapped.

The information gathering must therefore, proceed as swiftly and unemotionally as possible, while testing all current assumptions. Information from others on structural safety issues should be recorded, but the Search Specialist should perform his own assessment, independently, as in any good check.



## Size-up Defined

The conscious process involving very rapid but deliberate consideration of the critical factors and development of a rational plan of attack

**Size up is**  
**A**  
**Six Sided Approach**  
**THE TOP**  
**THE BOTTOM**  
**ALL FOUR SIDES**



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

#### Initial Size-up

After assuming command of the incident, a size-up of the structural collapse incident should be completed and the following factors should be taken into consideration:

#### Survey Incident Area:

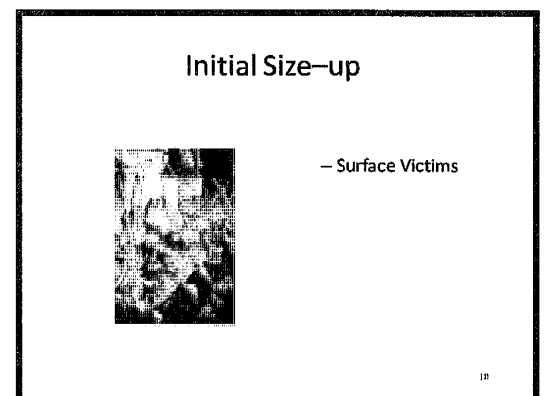
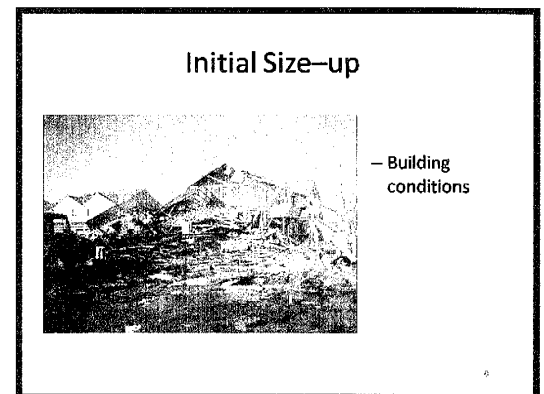
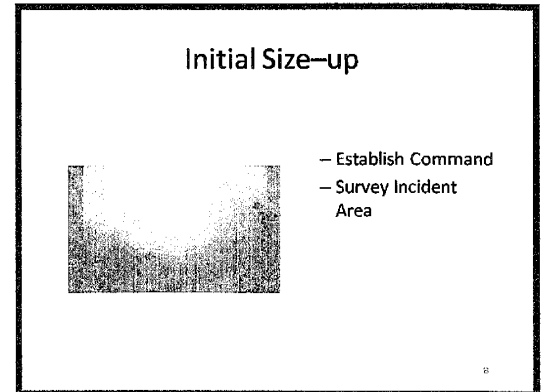
- Scope, nature and magnitude of the incident
- Complete a 360 of the structure, from a distance
- Assess the extent of the collapse
- Check for hazards adjacent to the structure
- Accessibility to the scene
- Environmental factors

#### Check Building Conditions:

- Are corners straight
- Are openings racked
- Age of building
- Construction type and occupancy
- Collapse extent – localized or extensive
- Potential for secondary collapse
- Number of structures involved

#### Surface Victims:

- Remove readily accessible victims
- Interview them about other victims
- Survey entire area for other victims and damage
- Total number of victims – needs to be identified early



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

#### Mutual Aid / Outside Assistance:

- When in doubt, call them out
- Pre-plan response needs
- Include closet technical rescue teams

#### Hazards

General hazards associated with search and rescue operations at structural collapses can present the organization with uniquely challenging situations. The organization should consider the following potential hazards when responding to structural collapse incidents:

#### Utilities:

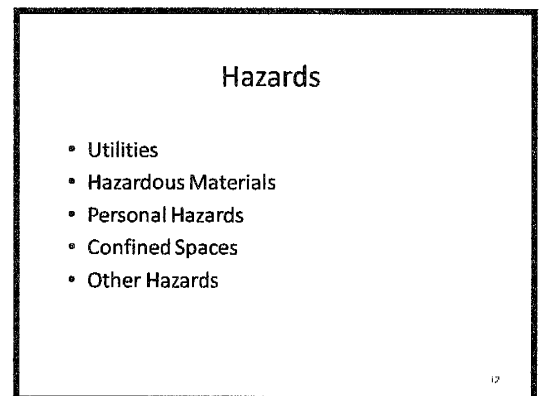
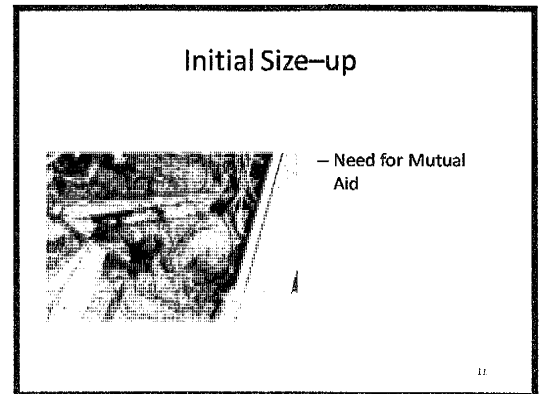
- Electrical services (primary and secondary)
- Gas, propane, fuel, oil or other alternative energy sources (primary systems)
- Water
- Sanitary systems
- Communications
- Secondary service systems (i.e., compressed, medical or industrial gases)

#### Hazardous Materials:

- Recognize the potential for the structure to have hazardous materials
- Determine what the hazards will be to victims and responders
- How can you contain, confine or divert the materials

#### Personal Hazards:

- Trip hazards
- Fall hazards
- Blows
- Punctures
- Impalement, etc.



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

#### Confined Space:

- A collapse could cause a confined space
- Recognize the need for a confined space team
- Know how to approach a confined space as an awareness trained person

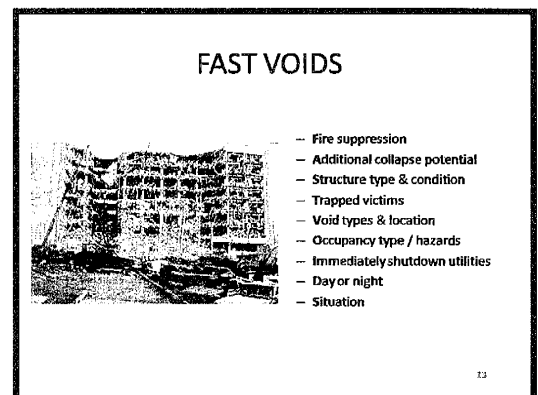
#### Other Hazards:

- Recognition of building materials and structural components of light-frame ordinary construction
- Recognition of unstable collapse and failure zones of light-frame ordinary construction
- Recognition of collapse patterns and probable victim locations in light-frame ordinary construction

#### “FAST VOIDS”

Fast Voids is an acronym for items that should be addressed as part of the size-up process.

- Fire Suppression – Is there a fire or a potential?
- Additional collapse potential – Is building still moving? Loose / hanging debris.
- Structure type & condition – Old, new, under construction, vacant, etc.
- Trapped victim rescue – Confirmed / unconfirmed / dead / alive?
- Void types – location & number (or potential)
- Occupancy type / hazards – residential, commercial, nursing home, etc.
- Immediate utility shut down – Can you do or do you need utility company?
- Day or night – Might dictate number of potential victims.
- Situation – Cause of collapse? (explosion, collision, etc.)



# STUDENT MANUAL TECHNICAL RESCUE AWARENESS STRUCTURAL COLLAPSE

## Causes of Collapse

### Natural Disasters:

- **Earthquakes** –both the initial tremor and aftershocks may cause shaking that has its greatest effect on weak, heavy structures that are rigidly coupled with their sites.
- **Wind** – hurricanes and tornadoes cause damage due to wind velocity, airborne missiles and difference in atmospheric pressure. Wind affects mostly light, un-engineered buildings and structures that are penetrated, thereby causing high uplift/blowout forces.
- **Floods** –Two Major Categories: Coastal Flooding and Inland Flooding. Coastal flooding occurs when the step up surges of hurricanes combined with their high winds produce combined forces from wind and flooding. The damage from flooding is caused by hydrostatic lateral pressure/lifting, hydrodynamic forces due to velocity and wave height, and debris impact from waterborne objects. More deaths occur from flooding than any other weather related event. As the system moves inland and stalls, rainfall amount of 20 to 40 inches can occur over several days causing widespread flash flooding.


### Overloading of Structural Components:

- **Snow and Heavy Rain** – cause roof collapse due to overload. Most often occurs in long span construction with relatively flat roof, where roof beam or truss fails, leading to partial collapse. Snow build-up causes more complete collapse due to failure of vertical supporting elements. Clogged drains and pooled water on flat roofs.



Causes of Collapse


- Natural Disasters
  - Earthquakes
  - Hurricanes/Tornados



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Causes of Collapse


- Natural Disasters
  - Floods
    - Coastal
    - Inland



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Causes of Collapse

- Overloading of Structural Components
  - Water
  - Snow
  - Stacked building materials
  - HVAC equipment
  - Water tanks
  - Anything added after construction



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# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

- **Construction Problems** – most often caused by lack of temporary lateral bracing or inadequate vertical shoring. Failures have occurred during concrete pours, while placing large roof beams and trusses, and during lifting of large concrete slabs. In addition, collapse has been caused by overloads due to stockpiling materials and non-engineered alterations.

#### Structural Aging/Deterioration:

- Age of structure
- Quality of materials and workmanship
- Maintenance of structure
- Occupied or vacant
- Weather exposure (water, wind, hot & cold)
- Breakdown of mortar


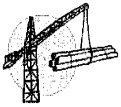
**Structural Decay** – has lead to collapse of older buildings and bridges. Collapse can be most devastating when vertical support member's fail leading to multi-floor collapse. In older buildings, the exterior un-reinforced masonry walls can be left standing full height without any bracing by pancaked floors. Walls could later fall in on floor debris pile, or out into the street, or adjacent buildings – very significant hazard.

- Expansion/contraction
- Undermining foundations
- Insect infestation
- Improper alteration
- Removal of structural components



#### Causes of Collapse

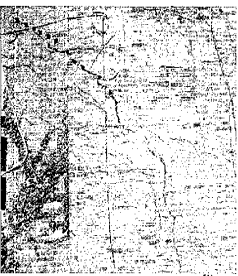
- Structural Aging/Deterioration
  - Age of structure
  - Quality of materials & workmanship
  - Maintenance of structure
  - Occupied or vacant



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#### Causes of Collapse


- Structural Aging/Deterioration (con't)
  - Weather exposure
  - Breakdown of mortar
  - Rotting of structural members
  - Expansion/contraction



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#### Causes of Collapse

- Structural Aging/Deterioration (con't)
  - Undermining foundations
  - Insect infestation
  - Improper alteration
  - Removal of structural components



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# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

#### Explosions:

- **Accidental** – caused by natural gas build-up, industrial dust, drug labs, explosive storage, flammable liquids/gasoline tankers, malfunctioning utilities.
- **Intentional** – demolition (controlled), mining (below grade), road construction (blasting).
- Light weight wood and steel structures often have the weakest part blown out to reduce pressure (i.e., roof or wall skins, windows) entire roof or the wall may be blown out. Reinforced concrete structures contain blast better, often causing greater loss of life, and if columns or walls are badly damaged, collapse of floors can result. Precast structures are especially vulnerable since large concrete parts can become disconnected or blown out leading to progressive collapse.


#### Fire:

- Wood or metal roof/floors often collapse due to burn through and can pull exterior masonry or concrete walls in or leave them standing in an unbraced condition.
- A steel structure left standing after a fire can have significantly reduced strength due to loss of original heat treatment.
- A remaining concrete structure can be damaged due to spalling and shearwalls and can be cracked due to expansion of floors.



### Causes of Collapse

- Explosions
  - Accidental
    - Natural Gas
    - Industrial Dust
    - Drug Labs
  - Intentional
    - Demolition
    - Mining
    - Road construction




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### Causes of Collapse

- Fire
  - Wood/metal roof collapse
  - Steel left standing after a fire
  - Concrete



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# STUDENT MANUAL TECHNICAL RESCUE AWARENESS STRUCTURAL COLLAPSE

## Collision Impact:

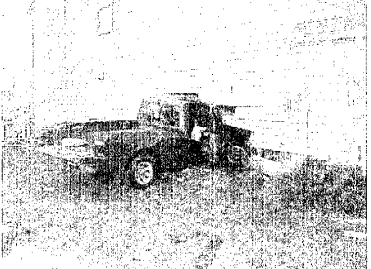
- Vehicles
- Aircraft
- Train
- Debris/materials (storm/explosion)
- Construction equipment

## Terrorism:

- Difficult to plan for
- Watch for secondary devices or attacks that are used to injure or kill responders

### Causes of Collapse

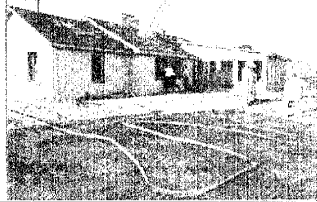
- Collision Impact



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### Causes of Collapse

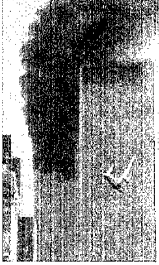
- Collision Impact (cont)
  - Vehicle, trains, ships, and aircraft may crash into structures.
  - Structural collapse during these incidents adds to the danger.



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### Causes of Collapse

- Terrorism
  - Difficult to plan
  - Watch for secondary device or attack.



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# STUDENT MANUAL TECHNICAL RESCUE AWARENESS STRUCTURAL COLLAPSE

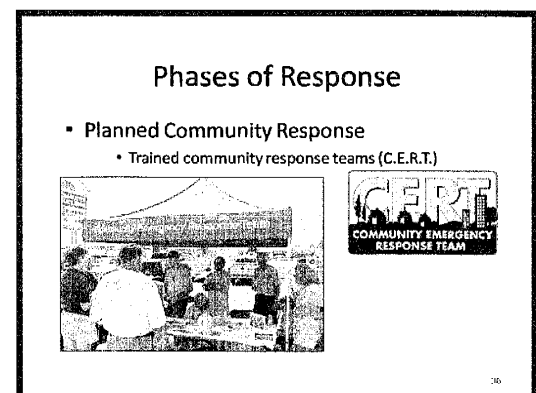
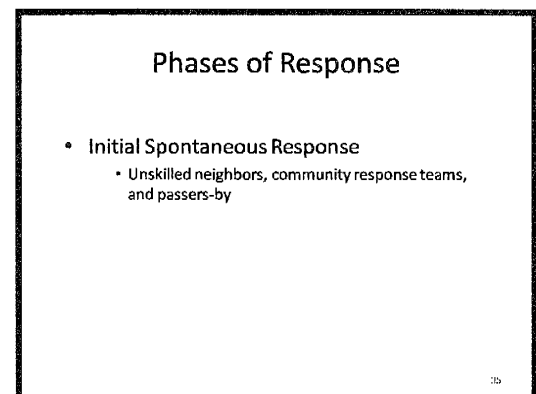
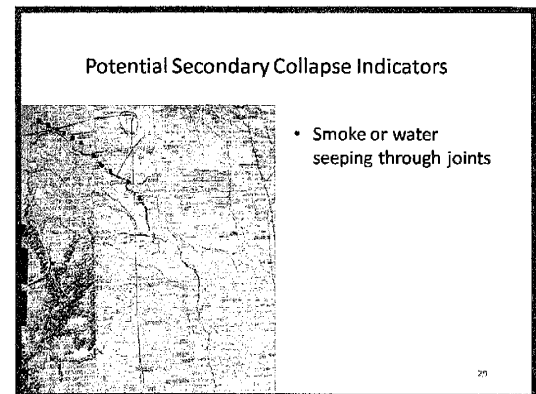
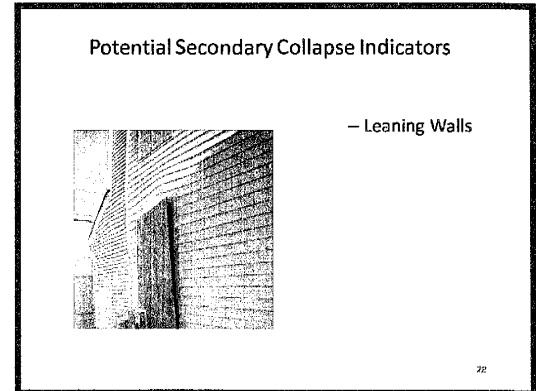
## Potential Secondary Collapse Indicators

- Leaning Walls
- Smoke or water seeping through joints
- Unusual sounds
- Sliding plaster
- Dust
- Aftershocks
- Sagging Floor or roof assemblies
- Separating walls
- Racked or twisted structure
- Missing, strained, or damaged points of connection of structural elements

## Phases of Response

It is important for all to understand the typical chronology of a Technical Rescue incident. The emergency response normally occurs in the following phases:

- **Spontaneous Rescuers** - unskilled, neighbors, community response teams, and passers-by will heroically help remove lightly trapped and/or injured victims. These rescuers have often acted far beyond their normal skill level and often save three-fourths or more of the total. Survival rates are relatively high, since victims are not normally entrapped. Professional firefighters, law enforcement officers, and emergency medical personnel may participate and better organize the response. This phase will often end after the first few hours.
- **Planned Community Response** – by trained community response teams. Call-out and visual searches would be used to locate and rescue the non-structurally trapped. Some lifting of objects (furniture, bookcases, etc.) would be done as well as mitigation of hazards (extinguish small fires, turn off gas, observe/refer hazardous materials).



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

- **Void Space Rescue** – by emergency services rescue forces. Search elements would help prioritize site to make better risk vs. benefit judgments. Rescue would proceed using existing cavities, duct/plumbing shafts, basements, and/or small cut openings in easily breachable floors and walls. Some shoring might be done to protect safe haven areas and otherwise protect emergency responders and/or victims. This phase may start the first day, but often, not until after some organizing efforts have taken place, requiring at least one hour. Only trained personnel should attempt entry into void spaces.
  
- **Technical, Urban Search & Rescue Teams** - by trained Technical Rescue Specialists, aided by equipment. Site or sites would be re-evaluated, re-searched, and prioritized for the ten-day long effort. Extensive cutting, shoring, etc., may be done to penetrate the structure. Cranes may be used to remove layers of structural debris or parts of the structure that are hazardous.

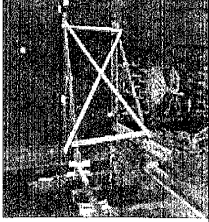
### Categories of Building Construction

- **Light-Frame** – Mostly wood frame
  
- **Heavy Wall** – URM, Tilt-up, low-rise buildings with concrete and masonry walls.
  
- **Heavy Floor** – Concrete frame buildings and highway bridges.
  
- **Pre-cast Concrete** – fairly heavy floors and some heavy walls.



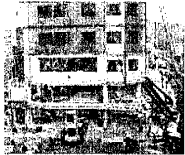
#### Phases of Response

- Void Space Rescue



#### Phases of Response

- Technical Rescue Teams
  - Trained technical rescue specialists



#### Categories of Building Construction

- **Light-Frame** – Mostly wood frame
- **Heavy Wall** – URM, tilt-up, low-rise buildings with concrete and masonry walls
- **Heavy Floor** – Concrete frame buildings and highway bridges
- **Pre-cast Concrete** – fairly heavy floors and some heavy walls.

#### Construction Code Classifications by Building Type

Construction Code Classifications	Fire-resistive	Noncombustible	Gird/Fray	Heavy timber	Wood
NFPA 220 Classifications	I	II	III	IV	V
Construction type					
Light frame					
Heavy wall					
Heavy floor					
Pre-cast concrete					



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

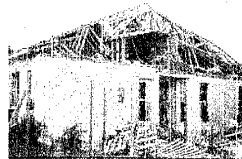
#### Light Frame Construction

- These structures can vary from 1 to 4 stories and contain from 1 to over 100 living units.
- Their principal weakness may be in lateral strength of walls or interconnection of the structure, especially at the foundation.
- They are unique in that the vertical load resisting systems (joist, beams, studs and posts) are covered with a “skin” to form the lateral load resisting system. This is different than other bearing wall systems.
- Relatively modern apartment buildings have walls that are braced using only plaster/gypsum or inadequately designed plywood.
- Homes with crawl spaces can shift or slide off their foundations.
- Masonry chimneys can crack and fall off or into the structure.
- Masonry veneer (bricks) can fall off walls and shower adjacent areas with potentially lethal objects.
- Structures can separate at offsets in floor/roof levels (such as porches and split level houses).
- A great danger of fire exists for these structures due to the presence of so much fuel.



#### Light-Frame

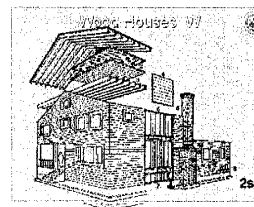
- Materials are generally lightweight
- High degree of structural flexibility
- Principle weakness is in lateral strength



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#### Light-Frame

- Constructed with skeletal structural frame
- Wood or light-gauge steel components
- Provide support to the floor and roof assemblies.



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#### Examples of Light-Frame Construction

- Residential
- Multiple low-rise
- Light commercial up to four stories.
- Light-gauge steel
- Commercial, business, and light manufacturing.



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# STUDENT MANUAL TECHNICAL RESCUE AWARENESS STRUCTURAL COLLAPSE

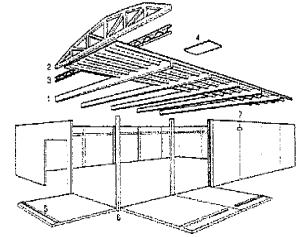
## Heavy Wall Construction

- Materials are generally heavy and utilize an interdependent structural or monolithic system, which makes the structure inherently rigid.
- Usually built without a skeletal structural frame and utilizes a heavy wall support and assembly system that provides support for the floors and roof areas.
- Some heavy wall construction occupancies use tilt-up concrete construction of one to three stories in height and consist of multiple, monolithic concrete wall panel assemblies.
- They also can use interdependent girder, column and beam systems for providing lateral support of floor and roof assemblies. These occupancies can include commercial, mercantile and industrial usage.
- Other materials are now being used in tilt-up construction, such as, reinforced and un-reinforced masonry buildings typically of low-rise construction, one to six stories in height and of any occupancy.



## Heavy Wall

- Materials are generally heavy and utilize an interdependent structural system.



## Heavy Wall

- Interdependent girder, column, and beam system
- Provides lateral wall support of floors and roofs.
- Commercial, mercantile, and industrial occupancies



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

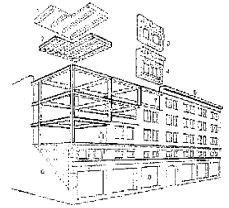
#### Heavy Floor Construction

- Built utilizing cast-in-place concrete construction consisting of flat slab panel, waffle or two-way concrete slab assemblies.
- Pre-tensioned or post-tensioned reinforcing steel rebar or cable systems are common components used for structural integrity.
- Vertical structural supports include integrated concrete columns, concrete-enclosed steel frame or steel frame, which carry the load of all floor and roof assemblies. This also includes heavy timber construction.
- The reinforcing steel, along with the varying thicknesses of concrete structural slab and girder supports utilized in this construction assembly, pose significant concerns with respect to breaching and void penetration.
- The loss of reinforcement capability and the integrity of structural loading capacity of the floor and wall assemblies create significant safety and operational considerations during collapse operations.
- Structural steel frame construction utilizes a skeletal framing system consisting of large-load-carrying girders, beams, and columns for structural support. These components represent a substantial weight factor for individual and assembly components. Floor systems consist of cast-in-place concrete slabs of varying thicknesses poured onto metal pan or structural metal floor decks and also might include pre-cast and post-tensioned concrete plank systems. These concrete/metal pan floor assemblies are supported by the structural steel framing system.



#### Heavy Floor

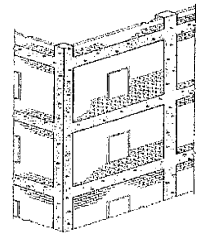
- Cast-in-place concrete construction
- Flat slab panel, waffle, or two-way concrete slab assemblies.



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#### Heavy Floor

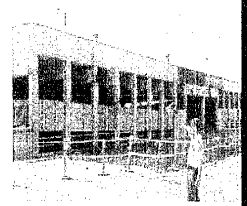
- Vertical structural supports include
  - Integrated concrete columns
  - Concrete enclosed steel frame
  - Steel frame



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#### Heavy Floor

- Exterior construction
  - Metal
  - Masonry veneer
  - Curtain wall
  - Composite material panels.
- Offices, schools, apartments, hospitals, parking structures.



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# STUDENT MANUAL

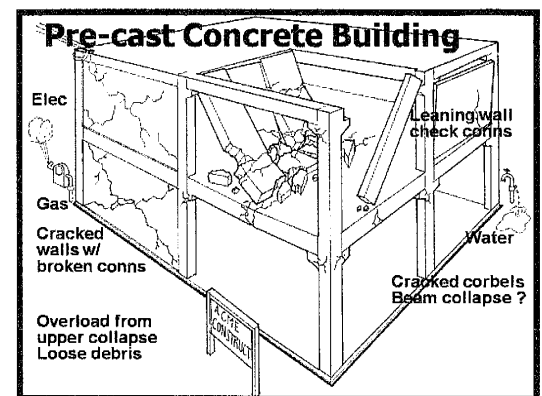
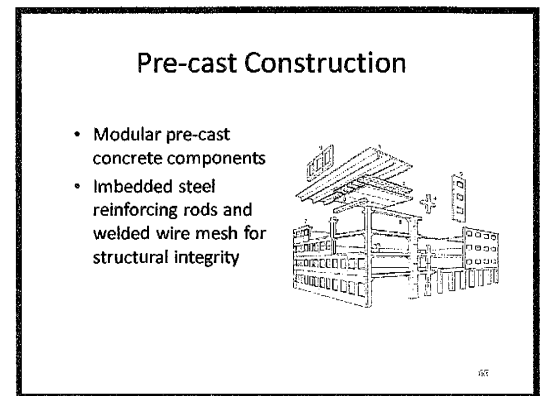
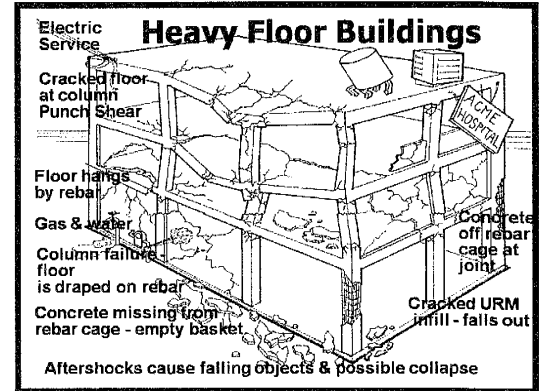
## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

- The exterior construction might consist of metal or masonry veneer, curtain wall, or composite material panel systems. Additionally, pre-cast concrete or stone clad panel systems might be present.
- Multiple assembly or component failures might be present in a collapse situation where isolated or multiple collapse conditions or collapse configurations exist.
- Examples of this type of construction include offices, schools, apartments, hospitals, parking structures, and multipurpose facilities. Heights vary from single-story to high-rise structures.

#### Pre-cast Construction

- Structures of pre-cast construction are built utilizing modular precast concrete components that include floors, walls, columns, and other subcomponents that are field-connected at the site.
- Individual concrete components utilize imbedded steel reinforcing rods and welded wire mesh for structural integrity and might utilize either steel beam and column or concrete framing systems for the overall structural assembly and building enclosure.
- These structures rely on single or multipoint connections for floor and wall enclosure assembly and are a safety and operational concern during collapse operations.
- Examples of this type of construction include commercial, mercantile, office, and multiuse or multifunction structures, including parking structures and large occupancy facilities.



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

#### Collapse Patterns

##### Light Frame Collapse Patterns

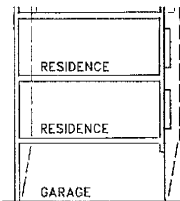
- These structures are unique in that they may be described as **Skin and Bones** structures. The lateral load resisting Skin is separate from the vertical load resisting studs, posts and columns.
- Collapse usually occurs when the sheathing on the lower walls have insufficient strength to resist the lateral forces and the walls rack (become parallelograms). This is called an **Offset Collapse Pattern**.
- If there is a sufficiently heavy load on these walls, they can completely collapse as the wall top moves sideways a distance equal to its height, as shown in the slides.
- This movement causes the structural collapse to be in the form of part or all of the building being projected away from its original foundation by the height of the story walls that fail.
- This can happen in a split level house as well as a three or four story building.
- When the bottom story of multi-story, light frame structure fails in this way, additional stories can collapse due to the impact of the first story hitting the ground.
- This type of collapse usually leaves many voids that are relatively accessible from above.
- In wood structures, when the lower floor rests directly on the foundation, but is not well connected to that foundation, the entire structure can slide over or off the foundation.

### Collapse Patterns

- **Light Frame** - wood frame buildings  
1 to 4 stories, residential & other
- **Heavy Wall** - URM, TU, & other low rise  
w/concrete or masonry walls
- **Heavy Floor** - Concrete frame bldgs
- **Precast Concrete** - fairly heavy floors &  
some w/heavy walls

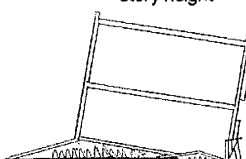
### Light Frame Collapse Patterns

1st Story Walls are Racked by Quake



Initial Condition

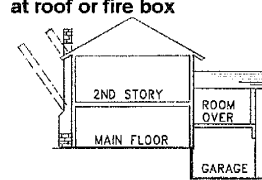
Since 1st story walls can still support vertical load, they keep their original length & project upper stories away by length of story height



Collapse Projects Structure Beyond it's Boundary


### Light Frame Collapse Patterns

chimney breaks at roof or fire box



initial condition

roof & floor over weak garage are projected away



collapse projects weak story away

### Split Level House



# STUDENT MANUAL

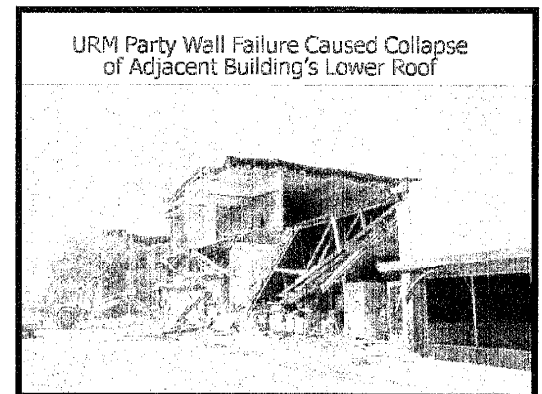
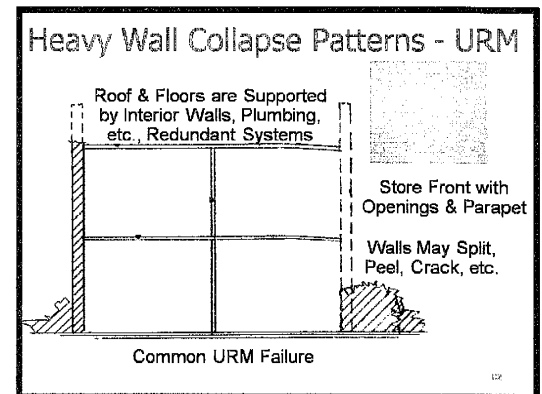
## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

- In all cases, a great danger of fire exists as a result of the combination of broken gas (or other fuel) lines and combustible debris.

#### Heavy Wall Collapse Patterns

- Collapse is usually partial and is strongly related to the heavy, weak bearing walls falling away from the floors. This is the **Wall Fall Collapse Pattern**.
- In URM buildings the walls normally fall away from their original position, but most often don't project out as far as their height.
- The combination of the weak interconnection of the masonry pieces and gravity tend to cause the debris to stay within ten to fifteen feet of the building face.
- When property line walls fall on an adjacent, lower buildings, these structures will usually have some sort of roof/floor collapse.
- However, in collapse due to failure of interior columns or due to fire, it is possible to have the very precarious situation of multi-story heavy walls that are left standing without any laterally supporting floors/roof. Under such conditions, it is probable that the walls could fall such that they extend their full height along the ground.
- When the wood roof and/or floors collapse, many easily accessible voids can be created.
- Areas adjacent to the walls where the heavy debris falls often contain badly injured or dead victims.
- The combination of broken gas lines and debris can lead to fire.



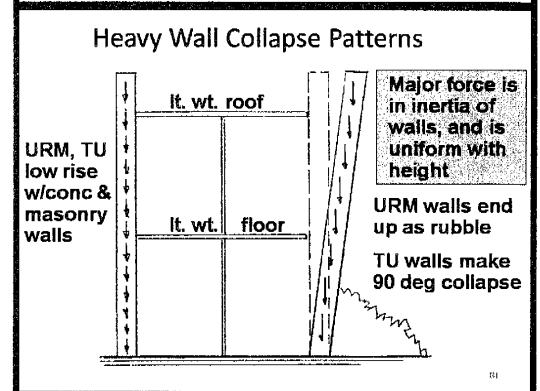
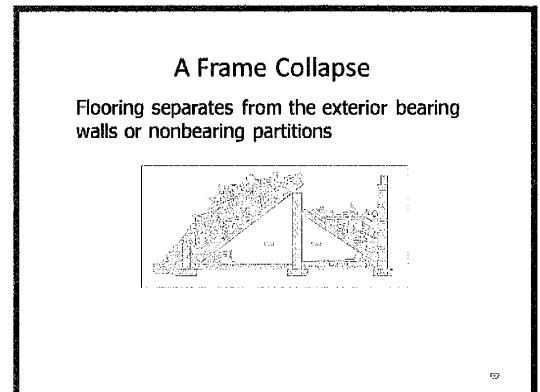
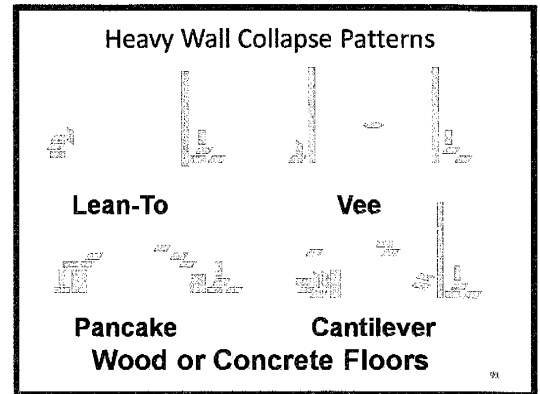


# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

- As mentioned previously, the experience with this type of building lead to the development of the five NFPA collapse patterns which follow:
  - **Lean-to:** Formed when one wall collapses, leaving the other end with questionable support (URM, TU, Heavy Floor & PC Concrete).
  - **Vee:** Occurs when interior support fails. More common in decay/overload column (URM, Heavy Floor & PC Concrete).
  - **Pancake:** Occurs when all vertical support fails (URM, Heavy Floor & PC Concrete).
  - **Cantilever:** A pancake collapse with extended floors (URM, Heavy Floor & PC Concrete).
  - **A-Frame:** Occurs with Lean-to collapse in adjacent structures.
- **Walls in tilt-up buildings** normally fall away from the roof or floor edge, but since they are very strong panels, the top of the wall will fall as far away from the building as its height. This **Wall Fall Collapse** is somewhat different from the one that involves URM construction.
- Since tile-ups have longer roof/floor spans, the adjacent section of roof will then collapse, although it may still be supported at its far end.
- Tension forces will be imposed on the roof system, therefore, all beam-to-beam and beam-to-column connections may be damaged and/or pulled-out.



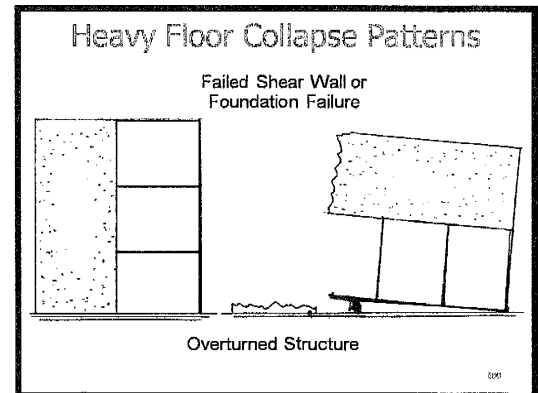
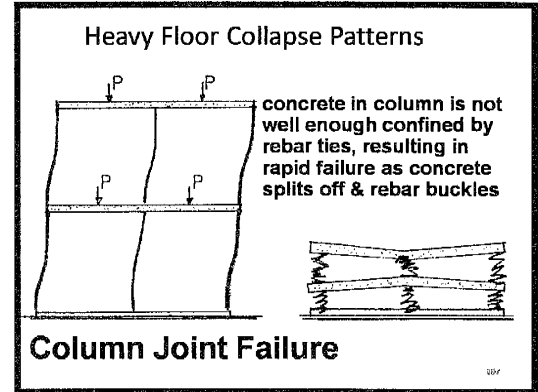
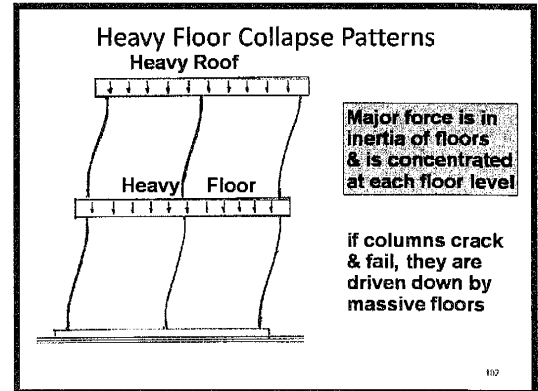
# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

#### Heavy Floor Collapse Patterns

- A heavy floor collapse can be only partial to complete. It is usually caused when columns or walls, weakened by motion, are unable to support the heavy floors.
- The collapse patterns all share the pattern of thin void spaces forming within the original plan area of the building.
- These heavy floor structures usually fall on themselves, but they can project laterally as they fall, if the columns and/or walls are strong enough to not fracture. In other words, the columns can fail due to hinging at the top and bottom, and then the collapse becomes an **Offset Pancake**.
- The voids can be very difficult to access, since even though the heavy floors can have dropped tens of feet, they are still usually well interconnected with reinforcing steel.
- The height of remaining voids between floors in **Pancake Collapse** buildings, will depend on what projections the slabs originally had (for example; beam stems, flat slab drops) and partly crushed contents.
- Tall, moment-resistant frame structures, in which tension to compression reversal causes an almost explosive failure of exterior columns, may **overturn**, but more often they will collapse within their plan boundaries because of high gravity forces.
- Many partially collapsed concrete frame structures will contain parts of slabs and/or walls that are hanging off an un-collapsed area.

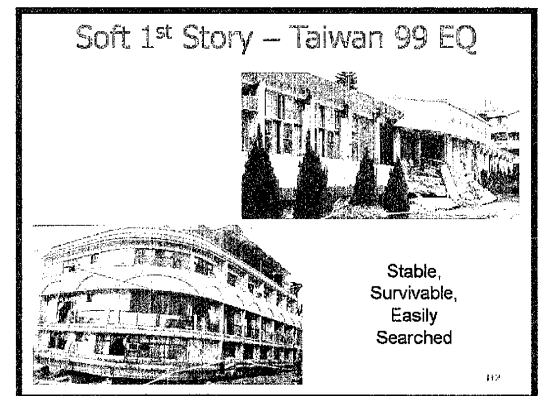


# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

- This has been observed in corner buildings in which only the street-front bays collapse due to torsion effects and in long buildings or those with several wings, where some bays do not collapse.
- **Torsion Effects** occur in concrete frame structures when URM infill is placed in exterior property line walls for fire resistance. These walls become stiffer than all other parts of the building, and cause a temporary, eccentric condition, which can lead to a collapse of the columns on the opposite side of the building.
- **Overtured**, normally taller structures with shear walls will often fail due to tension/shear failure at the base.
  - Under these conditions, the structure can project sideways by it's full height.
  - Survivability should be high.
- **Soft First Story Collapse** occurs in buildings that are configured such that they have significantly less stiffness (many fewer walls or no walls) in the first story than in the stories above.
  - This configuration often occurs in buildings where the first story occupancy is commercial (where openness is desirable) and the upper stories are residential.
  - The damage becomes focused on the "Soft Story", as what lateral resistance that is present becomes overwhelmed.
  - This configuration is not viable in concrete construction, and has been prohibited in some modern building codes.
  - The collapse is often limited to the one "Soft Story", as the building becomes on story shorter.
  - Survival rate is very high above the second floor.



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

- The first story should be accessed by cutting through the second floor.
- **Mid Story Collapse** can occur when a middle story is configured with much different stiffness than the stories above and below. **Can occur at any abrupt change in stiffness.**
  - It can occur when a story has no walls and the ones above and below have significant walls.
  - It can occur when a story has stiff, short columns and the ones above and below have longer, more limber columns.
  - Survival should be high above and below the collapsed story; however access to stories above may be blocked.
- **Pounding** can cause a mid-story collapse, leaving a difficult problem to assess, due to remaining floors being overloaded.
  - A pounding collapse normally occurs when two adjacent buildings have floors that are at different elevations.
  - The very stiff /strong edge of a floor in one building will cause the collapse of the adjacent building's column when they collide.
- Fire is usually not a problem for heavy floor buildings, unless the contents are particularly combustible.



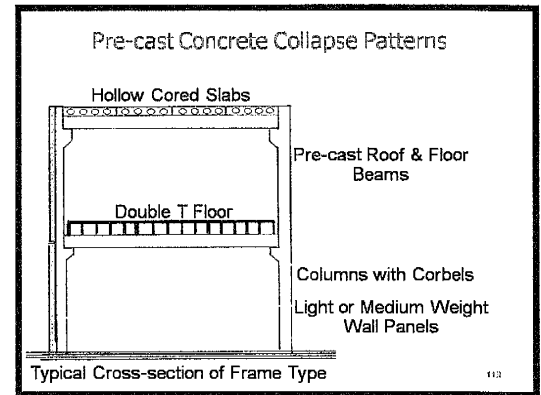
# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

#### Pre-Cast Concrete Collapse Patterns

- A pre-cast collapse is usually caused when the pre-cast parts become disconnected from one another and the structure very rapidly loses stability.
- The collapse normally contains numerous layers of broken and unbroken pieces of slabs, walls, beams and columns. The best description of this is **Random Parts Collapse**.
- It is difficult to predict how far the parts can be projected away from the original structure's position, but gravity normally will drive them downward without projecting them, laterally, away from the building.
- The voids can be difficult to access, but the slab can be removed, layer by layer, since interconnections are normally poor to non-existent.
- Pre-cast parking garages have performed particularly badly.
  - They may be as large as 400ft X 400ft and be as many as eight stories.
  - Most do not have cast in place floor topping to help tie the structure together.
  - Most common failure is a column collapse caused by un-intended shear overstressing columns near ramps or at girder connections.



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

#### FEMA US&R Marking Systems

- In this section we will discuss the following topics that involve structure marking and location:
  - Identification of Individual Buildings
  - Structure/Hazard Evaluation Marking System
  - Search & Rescue Assessment Marking System
  - Victim Marking System
- These are important communication methods that are used to designate what operations have been preformed. It is extremely important that these standards be followed, so that critical information can be shared with all responders that may be working the same incident. Standard nomenclature is critical for efficient UR&R operations.

#### **Identification of Individual Buildings**

- The standard system for locating a building on any block involves the following considerations.
  - Using existing numbers and filling in the unknowns, or
  - If the numbers are all unknown, keep the numbers small, on odd and even sides.



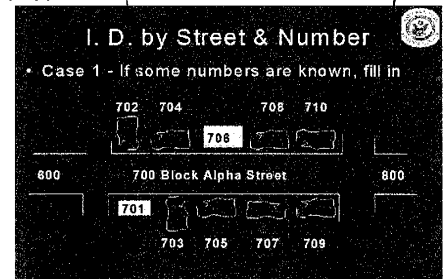
#### FEMA US&R Marking Systems

- Identification of Individual Buildings
- Structure/Hazard Evaluation Marking System
- Search & Rescue Assessment Marking System
- Victim Marking System



#### Identification of Individual Buildings

Spray paint address on street and street names at corners



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

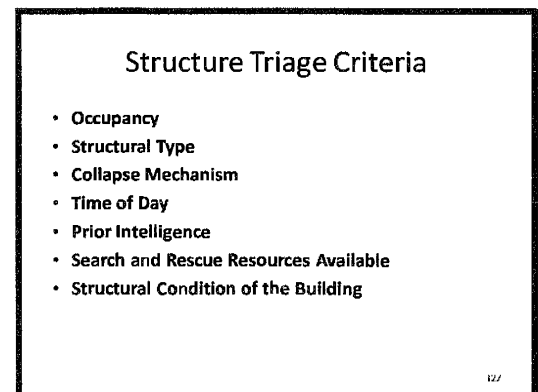
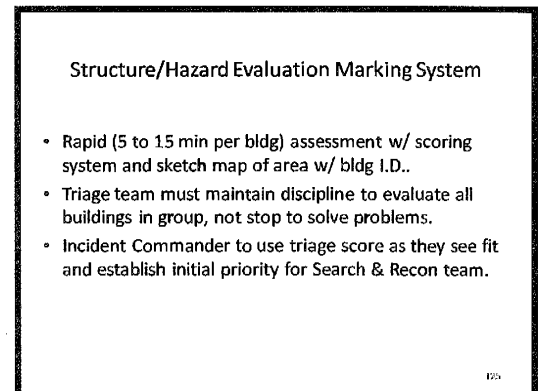
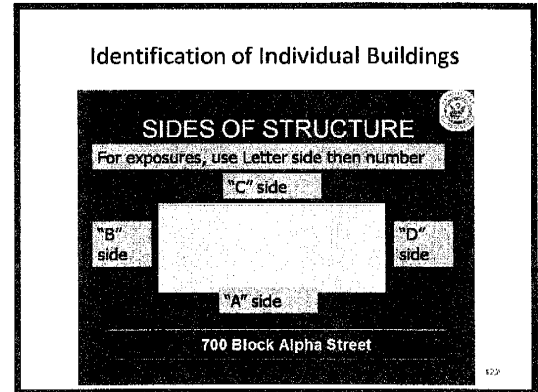
#### Identification of Individual Building

- The standard systems for building layout is as follows:
  - Sides A, B, C and D start at the street side and goes clockwise.
  - Quadrants are marked with A, B, C and D with E being the center core.
  - Stories are designated as 1 (for ground) 2, 3, 4, etc.
  - Basements are designated as B1, B2, etc.

#### Structural Triage Criteria

The following information needs to be considered in determining risk/benefit that will aid in prioritization.

- **Occupancy** – the type of activity done in the building, as well as, the potential maximum number of occupants.
- **Structural Type** – what type of materials are involved, in order to help identify difficulty of access, type of collapse, potential hazard mitigation needs, etc.
- **Collapse Mechanism** – how building failed in order to provide an indication of type of voids that might be available for victim survival.
- **Time of Day** – refers to the time of the event, which caused the collapse. This is a critical factor when combined with the occupancy type. For example, if an earthquake occurs at 2100 hours and collapses an office building and an apartment building, the apartment building would normally represent the higher potential for a success rescue than would the office building. If the event occurred at 1000 hours, the opposite would be true.



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

- **Prior Intelligence** – information from the general public, local authorities, first responders, etc., relating to known trapped victims.
- **Search and Rescue Resources Available** – does the particular building require resources beyond what is readily available to the task force (i.e., heavy equipment required to gain access.)
- **Structural Condition of the Building** – generally, can search and rescue operations proceed with a minimum of stabilization effort.

#### Triage Scoring Factors

The following factors will be used to obtain a numerical score for each structure in a group of buildings. The intent is, the higher the numerical score the better the risk/benefit ratio.

- **ZERO OCCUPANTS PROBABLE.** A notation of "ZERO" would be written in the score column if the earthquake occurred at a time of day when the type of occupancy contained in the structure was such that the building would have been normally unoccupied (school rooms on Sunday, retail shops at 6 A.M., etc.). The triage team would then proceed to the next building.
- **TOTAL NUMBER OF POTENTIALLY TRAPPED VICTIMS.** This will be assessed knowing the type of occupancy, the floor area of collapsed entrapping structure, the time of day the incident occurred, and the type of collapse. The following are the average total number occupants for various occupancies:  
**Based on units other than area:**  
Schools 25 to 35 students per classroom  
Hospitals 1.5 occupants per bed  
Residential 2.0 occupants per bedroom  
Others 1.5 occupants per parking space

#### SCORING SYSTEM

- Zero victims probable, write zero, go to next
- No. of potentially trapped victims 1 to 50 (potential no. of victims divided by 5)
- Condition of voids 1 to 20 (compact - separate layers - part collapse)
- Time req'd to access victim 1 to 20 (one day to two hours)
- Danger of additional collapse -1 to -20 (low chance to high chance)
- Special occupancy children + 25
- Each known live victim +5





# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

#### Based on area: Variation

Schools, Library 1 per 70 SQ. FT. 50-100

Hospitals 1 100 80-150

Multi Residential 1 200 100-300

Commercial 1 100 50-200

Office, Inc Govt. 1 150 100-200

Public Assembly 1 25 10-050

EOC, PD, FD 1 125 100-150

Industrial 1 200 100-300

Warehouse 1 600 400-900

- The **Time of Day** that the incident occurred may indicate that there was very little possibility of a structure being occupied. The type of collapse (auto garage only, partial collapse) may also indicate that few occupants would remain entrapped even if many occupied the structure during the incident. All these factors should be considered when calculation **Total Number of Trapped Victims**.
- The numerical value of this criterion will vary from 1 to 50 as the number of potentially trapped victims varies from 1 to more than 200. Between 5 and 250 the value is the total number of possible trapped victims divided by 5.
- **CONDITION OF VOIDS.** This criterion will attempt to assess the degree of survivability of the potentially trapped victims. Victims don't survive well in tightly compacted collapsed areas consisting of rubble masonry, badly broken cast in place concrete and pre-cast concrete. Hollow, survivable voids are often found under wooden floor panels that are collapsed into angular interlocking planes and in reinforced concrete structures, where floors have projecting beam elements, parts of columns/walls and furnishings that hold the slabs apart.



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

- Partly collapsed structures may have large triangular voids or entrapped victims in large voids due to blocked exits etc. These large voids have the best chance of having surviving entrapped victims. The value of this criteria will vary from 1 to 20.
- **TIME REQUIRED TO ACCESS VICTIMS.** This will be an estimate of the time required to get to the first victim. It should include the time required to cut through floors/roofs etc., and the time required to shore/brace the access route and appropriate adjacent structures. The numerical value will vary from 1, for more than one day, to 20 for taking only two hours.
- **DANGER OF ADDITIONAL COLLAPSE DUE TO AFTERSHOCK.** This criteria will be represented by a minus number between -1 for low probability to -20 for high probability of additional collapse, assuming the proposed shoring/bracing is installed from criteria 3.
- **SPECIAL OCCUPANCY INFORMATION.** For this criteria one will add 25 points if the occupancy is a school, day care center, hospital, or other occupancy that could involve children. In addition 5 points should be added for each potential live victim that is confirmed by previous intelligence, search, etc.
- **"NO GO" CONDITIONS.** These would include structures that are on fire, have significant haz mat spills or otherwise have conditions that would make search and rescue operations too risky. Buildings with "NO GO" conditions would be expected to be re-evaluated when those conditions were mitigated, and some comment would be made regarding this should be recorded on the form.

#### NO-GO CONDITIONS

- FIRE
- HAZMAT
- Need to add info on when No-GO is to be Re-evaluated & Revisited



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

#### Structure/Hazard Evaluation Marking System

- Structural/Hazard Evaluation should take place **AFTER** a priority list of structures has been established by the Incident Commander, using Triage or just common sense, if only a few structures are involved.
- The greatest area of concern is not with the fully collapsed structures, but with those that have partly collapsed. The Triage Team should be prepared to fill out the US&R Structure/Hazard Evaluation Form, identifying structure type, occupancy, hazards, etc. In addition the Triage Team will generate notes and diagrams regarding search operations (locations of voids, shafts, shoring, etc.). It is anticipated, however, that in some cases the assessment will only indicate that the building is too dangerous to conduct US&R operations.
- The term safe should be understood by the Triage Team in a context very different from that of "**safe for occupancy**". All the structures will be damaged, and the value judgment of "**safe enough for the risks of US&R**" will need to be measured.

#### Structure/Hazard Evaluation Marking System

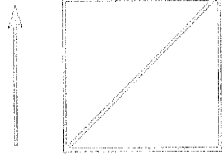
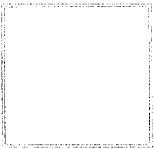
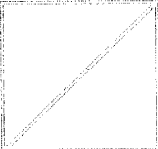
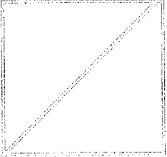
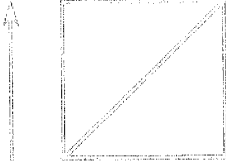
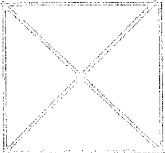
- ◆ Structural/Hazard Evaluation should take place **AFTER** a priority list of structures has been established by the Incident Commander, using Triage or just common sense, if only a few structures are involved.



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

<p><b><u>Structure/Hazard Evaluation Marking System</u></b></p> <ul style="list-style-type: none"> <li>• Triage Team makes a 2' x 2' box on building adjacent to accessible entry.</li> <li>• Done after doing Hazards Assessment and filling out Structure / Hazards Evaluation.</li> <li>• Box is spray painted with using International</li> </ul>	<div style="display: flex; align-items: center;">  <div style="margin-left: 20px;"> <ul style="list-style-type: none"> <li>• Arrow next to Marking Box indicates the direction of Safest Entry to Structure</li> </ul> </div> </div>
<div style="display: flex; align-items: center;">  <div style="margin-left: 20px;"> <ul style="list-style-type: none"> <li>• Structure relatively safe for S&amp;R ops. There is little chance of further Collapse.               <ul style="list-style-type: none"> <li>– Victims could be trapped by contents</li> <li>– or could be unconscious</li> </ul> </li> </ul> </div> </div>	<div style="display: flex; align-items: center;">  <div style="margin-left: 20px;"> <ul style="list-style-type: none"> <li>• HM indicates hazardous material condition in or adjacent to structure. S&amp;R Ops normally will not be allowed until condition is better defined or eliminated.</li> </ul> </div> </div>
<div style="display: flex; align-items: center;">  <div style="margin-left: 20px;"> <ul style="list-style-type: none"> <li>• Structure is Significantly Damaged. Some areas may be relatively safe, but others may need shoring, bracing, removal, and/or monitoring of hazards               <ul style="list-style-type: none"> <li>– Building could be completely pancaked</li> </ul> </li> </ul> </div> </div>	<h2 style="text-align: center;">STRUCTURE / HAZARDS MARK - SUMMARY</h2> <div style="display: flex; align-items: center; margin-top: 20px;">  <div style="margin-left: 20px;"> <p>15JAN07 HM NATURAL GAS ENG-1</p> </div> </div> <p style="text-align: center; font-weight: bold; margin-top: 20px;">No entry until gas is turned off. When it's mitigated, should line out the HM mark and record new date and Crew</p>
<div style="display: flex; align-items: center;">  <div style="margin-left: 20px;"> <ul style="list-style-type: none"> <li>• Structure is NOT SAFE for Rescue Ops and may be subject to Sudden Collapse. Remote search Ops may proceed at significant risk. If rescue Ops are undertaken, Safe Haven areas, &amp; rapid evacuation routes (with Structure Monitoring) Should be Created.</li> </ul> </div> </div>	



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

#### Search & Rescue Assessment Marking System

Standard SAR assessment marking is designed to perform two functions:

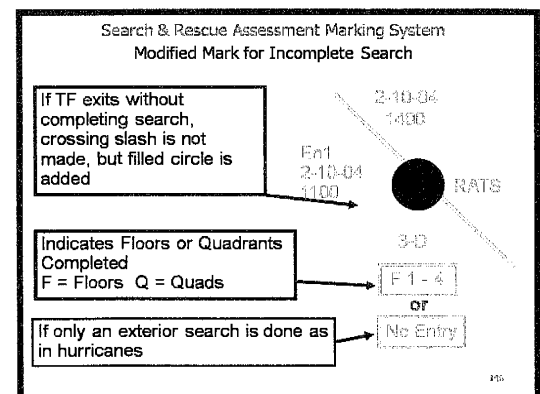
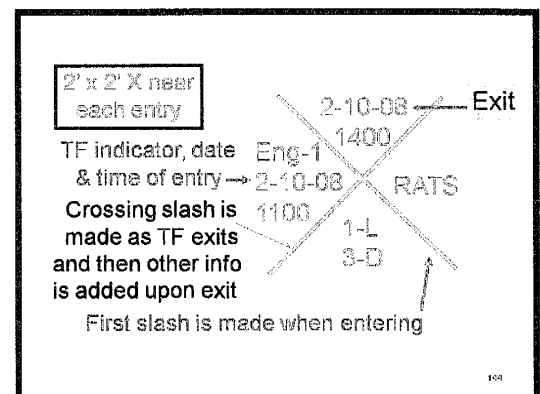
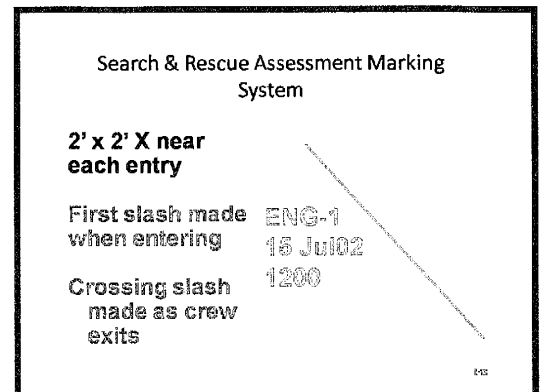
- First, when SAR personnel enter the building or parts of the building, the initial diagonal line is drawn so that others will be informed of on going operations.
- When operations are completed in the building (or parts of the building) the crossing diagonal line will be drawn and information added to indicate by whom and what was accomplished.
- The finished mark can then indicate to other SAR forces the outcome of previous operations.

#### Incomplete Search Assessment Marking

- This new system is to provide a method to indicate that a search was not completed. The team may have entered the structure and only search a portion of the structure for whatever reason.
- The extent of the search should be determined by the information placed in the new system.

#### Stick-on Search Assessment Marking

In September 2006, a stick-on search marking system was approved in order to reduce the use of paint in incidents when many structures are involved. These are to reduce the damage (of the paint) to non-totally damaged structures.



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

#### Victim Marking System

This series of markings is used to indicate the location of each victim discovered on the incident site:

- The marks are made with orange spray paint or crayon.
- Marks will normally be initiated after a search is preformed unless the victim is immediately removed.
- The V is intended to be about 2 feet high and located as near to the victim as practicable.
- It could be painted on a nearby wall surface or directly on a piece or rubble.
- As arrow may be added to indicate the exact victim location.
- The Search Team indicator should be included as shown.
- The circle is added when the victim is **confirmed**.
  - As an example, the V could be placed when only one K9 has indicated that a victim has been located. The circle could be added when the initial **find** is **confirmed** by another K9 or some other search tool.
  - However, when K9's are working in pairs, no mark should be made after the first dog indicates a victim because it may influence the second dog.
- A horizontal line is added if the victim is **confirmed to be dead**.
- An X is drawn completely through the circle after the victim has been removed.



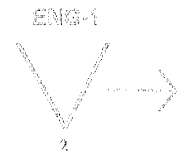
#### Victim Marking System

Potential Victims

Mark can be painted on a nearby wall or directly on a piece of rubble

Arrow may be added to indicate the exact victim location

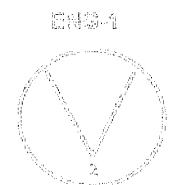
Number of victims under V



ENG

#### Victim Marking System

- Confirmed Live Victim
- Circle is added when the victim is confirmed



ENG

#### Victim Marking System

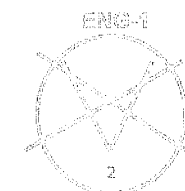
- Confirmed Dead Victims
- Horizontal line is added if the victim is confirmed to be dead.



ENG

#### Victim Marking System

- Large "X" is drawn completely thru the circle after the victim has been removed



ENG



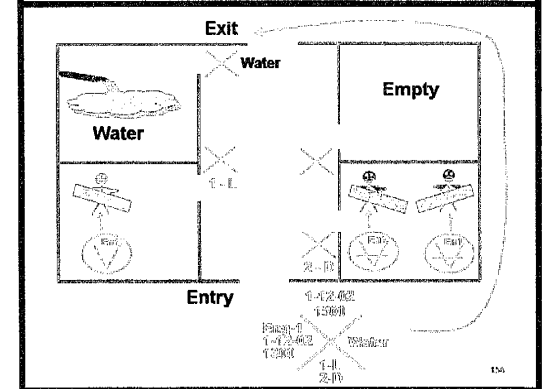
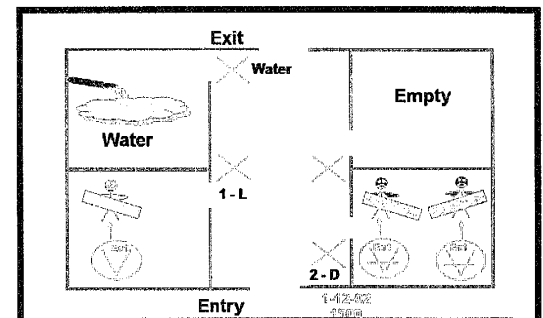
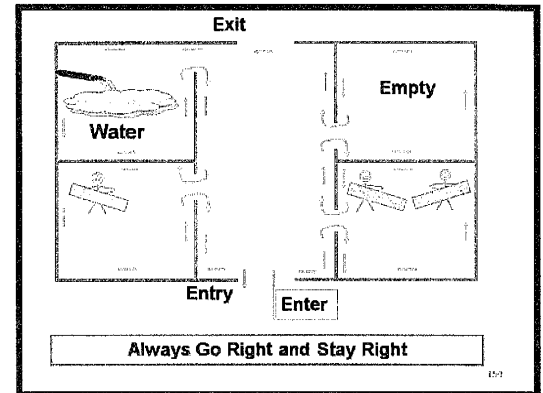
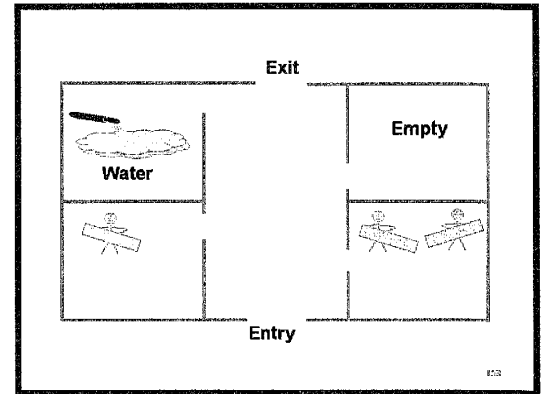
# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

#### Search Assessment & Victim Location Marking

- An example that illustrates the use of the Search Assessment & Victim Locating Marking system is illustrated as follows.
- The basic information is as follows:
  - There is a front entry and rear entry/exit.
  - There are four enclosed rooms in the building.
  - Room 1 has four deceased victims.
  - Room 2 is empty except for normal contents.
  - Room 3 has a broken water pipe and is flooded.
  - Room 4 has one live victim.
- Enter the building, mark first slash, unit ID, date and time.
- When entering rooms make first slash and then second slash when exiting each room and record findings.
- Once search is complete, draw second slash on exterior search marking, complete all data and prepare to go to the next building.



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

#### Initial Company Operations

- Establish Strong Visible Command
- Identify the need for Technical Rescue
- Conduct Rapid Size –up
  - Size of structure
  - Occupancy type
  - Structure type
  - Collapse mechanism
  - Weather
  - Exposures
  - Time of Day
  - Location of victims
- Recognize and Mitigate existing hazards
  - Gas
  - Electric
  - Water
  - Haz-mat
- Establish Scene Control
  - Isolate bystanders, family, personnel
  - Banner Tape, cones, Police
  - Set up Collapse Zones
- One of the final tasks is a complete survey of all SIX sides. During the recon stage, personnel are noting possible entry points and verify any contact with any viable victims. This stage is the most hazardous to first in companies, mainly due to the overwhelming urge to assist victims in need. The most important factor that one must remember is that Structures are unstable or unsupported and that secondary collapse is a high concern.





# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### STRUCTURAL COLLAPSE

#### Structural Collapse Summary

- Size-up of existing and potential conditions at structural collapse incidents.
- Identification of the resources necessary to conduct safe and effective structural collapse search and rescue operations.
- Development and implementation of procedures for carrying out the emergency response system.
- Development and implementation of procedures for carrying out site control and scene management.
- Recognition of general hazards associated with structural collapse incidents including the recognition of applicable construction types and categories and the expected behaviors of components of materials in a structural collapse. Identification of five types of collapse patterns and potential victim locations.
- Recognition of the potential for secondary collapse.





# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### ROPE

#### Rope Rescue Defined

Rope rescue is the providing of aid to those in danger of injury or death in an environment where the use of rope and related equipment is necessary to perform the rescue safely and successfully.

#### Types of Rope Rescue

- Rope rescue can be divided into two categories, high angle rescue (OVER 60° elevation) and slope evacuation.
- High angle rescue, also known as Vertical rescue, is defined as a rescue where the rescuer and/or victim have all their weight supported by rope.
- Slope evacuation, also called low angle evacuations, are rescue's where the weight of the rescuers is on the ground and the victims weight is on the litter tenders or rescuers.

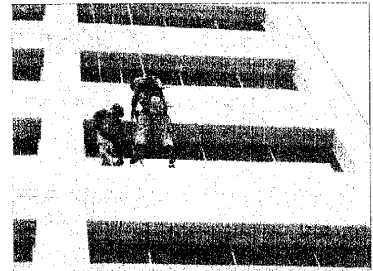
#### Uses for Rope Rescue

Rope rescue can come in to play with a wide variety of rescues. Rope rescue is the basic foundation for most disciplines of rescues. Rope rescue is used in:

- High Angle (anything greater than 60°)
- Slope Evacuations
- Confined Space Rescue
- Trench Rescue
- Water Rescue
- Wildland Search and Rescue
- Structural Collapse



## ROPE RESCUE



### Rope Rescue

– Providing aid to those in danger where the use of rope and related equipment is needed to perform safe rescue.

### Types of Rope Rescue

- High angle
  - Vertical rescue
    - Victim and rescuers have all weight supported by rope
- Slope evacuation
  - Low angle
    - Weight of rescuer on ground
    - Victims weight on litter tender or rescuer



### Uses for Rope Rescue

- Basic foundation for most rescue disciplines
  - High / Low Angle Rope Rescue
  - Confined Space Rescue
  - Trench Rescue
  - Water Rescue
  - Wildland Search & Rescue
  - Structural Collapse Rescue



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### ROPE

#### Rope Rescue Standards

- ***NFPA 1983 Fire Service Life Safety Rope and System Components***

This standard is to provide minimum performance requirements and a reasonable degree of safety for new life safety rope and new system components used to support fire service personnel and civilians during rescue, firefighting, and other emergency operations, or during training evolutions.

#### **Necessary Resources**

- NFPA 1983 Compliant Equipment
- NFPA 1670 Functional Capability for Conducting Technical Search & Rescue
- NFPA 1006 Minimum Job Performance Requirements for Technical Rescue Operations
- Personnel trained to identify level of functional capability.

#### **Obtaining Resources**

- Mutual Aid Agreements
- Agreements with Private Sector
- Memorandum of Agreement (MOA)
  - Public
  - County
  - State
  - National



#### Rope Rescue Standards

- NFPA 1983
  - Fire Service Life Safety Rope and System Components
    - Performance standard for rope & hardware
    - Life Safety Rope 15:1 Safety Factor
    - Third Party Testing for Equipment
    - Inspection and Maintenance Requirements

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#### Necessary Resources

- NFPA 1983 compliant equipment
- NFPA 1670/1006 compliant policies and procedures
- Personnel trained to identified level of functional capability

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#### Obtaining Resources

- Mutual Aid Agreements
- Agreements with Private Sector
- Memorandums of Agreement (MOA)
  - Public
  - County
  - State
  - National

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# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### ROPE

#### Hazards

- Rope rescue operations are often required in areas where elevation differentials exist.
- The possibility of someone falling, or something falling on someone, should always be considered and mitigated.
- The “general area” around a rope rescue scene is the area within 300’ ft. (Or more, as established by command).
- Making the area safe includes, but not limited to:
  - Controlling/ limiting traffic and sources of vibration in the area.
  - Controlling/limiting access to the area by unnecessary personnel.
- Identifying hazards and removing and / or reducing their impact.
- There are numerous hazards associated with rope rescue operations.
- All members operating at a rope rescue operations must know the hazards and how to avoid them.
- The most common hazard at a rope rescue operation is falling.
- Most rope rescue operations involve elevations, and with elevation, whether it is a roof, a water tower, or anything in between, there is always a chance of falling. Any responder with a chance of falling must, per AHJ policy, be secured.

#### Recognize Hazards

- Rope rescue operations are often required in areas where elevation differentials exist. The possibility of someone falling, or something falling on someone, should always be considered and mitigated.

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# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### ROPE

Other hazards associated with rope rescue include:


- Trip hazards
- Uneven or wet ground
- Entanglement or pinching hazards (i.e. hands caught in rope equipment)
- Falling objects (i.e. equipment, rocks, building components)
- Utilities
- Atmospheric hazards
- Weather
- Untrained responders (misuse and abuse of equipment)
- Hostile by-standers/victims
- Hazards specific to the location of the rescue.
- In all disciplines of “technical rescue”, if you count the numbers of deaths or serious injuries that occurred after “rescuers arrived on scene”, there are many more rescuers hurt or killed than victims.

#### Making the area safe

- Controlling / limiting traffic and sources of vibration in the area.
- Controlling / limiting access to the area by unnecessary personnel.
- Identifying hazards and removing and / or reducing their impact.
- It is the responsibility of the AHJ to pre-plan your response area to identify the location and hazards of potential rope rescue incidents and prepare for them through training and response procedures/guidelines.

#### Hazards (con't)

- Falls / elevation
- Trip hazards
- Uneven, wet ground
- Entanglement, pinching hazards
  - Hands caught
- Falling objects
- Utilities
- Weather / atmospheric hazards
- Untrained responders
- Hostile by-standers / victims
- Location



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#### Hazards (con't)

- Making the area safe includes, but not limited to:
  - Controlling / limiting traffic and sources of vibration in the area.
  - Controlling / limiting access to the area by unnecessary personnel.
  - Identifying hazards and removing and / or reducing their impact.

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#### General safety considerations

- Pre-plan
  - Potential rope rescue locations
  - Identify hazards
    - Falls
    - Overhead obstructions
- Prepare for incident
  - Training
  - SOG's / SOP's

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# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### ROPE

#### Personal Protective Equipment

- Harness – ANSI approved
- Gloves appropriate for rope rescue work
- Helmets – ANSI approved
- Eye Protection – ANSI approved

#### System Implementation

- Know and understand the procedures for implementing the emergency response system.
- Know who to call and how to activate them.
- Operation / Technician Level – fire companies with specialized equipment, technical rescue, and heavy rescue teams.
- Local – County Emergency Management, trained volunteers
- State – Resources include specialized teams, equipment, task forces, and the National Guard.
- National- Includes FEMA Task Forces, the military, and many other supporting agencies. (There are 28 FEMA Task Forces.)

#### Scene Management

- Implement site control and scene management.
- Includes achieving and maintaining control and security of the site and perimeter.
- Includes management of ALL civilian and non-emergency personnel.
- Establishment of operational zones.
- HOT
- WARM
- COLD (300' perimeter)



#### Personal Protective Equipment

- ANSI approved Harness
- Gloves appropriate for rope rescue work.
- ANSI approved Helmet
- ANSI approved Eye Protection

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#### System Implementation

- Know and understand the procedures for implementing the emergency response system.
- Know who to call and how to activate
  - Operation / Technician Level
  - Local
  - State
  - National

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#### Scene Management

- Implement site control and scene management.
  - Includes achieving and maintaining control and security of the site and perimeter.
  - Includes management of ALL civilian and non-emergency personnel.
  - Establishment of operational zones.
    - (Hot, Warm, Cold) 300' perimeter

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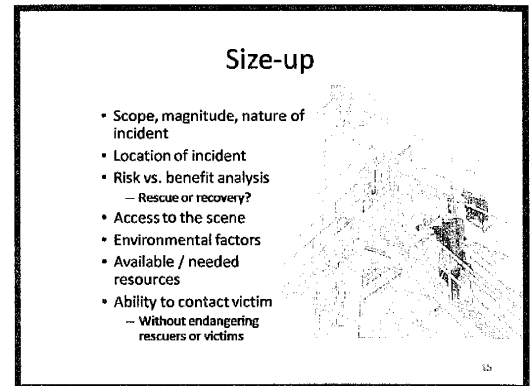
# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### ROPE

#### Size -up

- It has been said that the first 5 minutes of an operation determine the next 5 hours.
- That can never be overstated in rope rescue.
- First-due companies operating at the awareness level, are not considered “rescuers”, they have many very important tasks to complete to ensure the overall success of the operation.
- These duties include:
  - Your size-up should be continuous.
  - Size-up should start with pre-incident planning.
  - Size-up then continues with information received with the initial alarm and information given enroute.
  - Once on the scene, the size-up should remain continuous as conditions change.
  - Size-up should include, but not limited to, the initial findings on the scene including the following:
    1. Scope, magnitude, and nature of the incident.
    2. Location of the incident.
    3. Risk versus benefit analysis (rescue versus recovery)
    4. Access to the scene
    5. Environmental factors
    6. Available / necessary resources.
    7. Ability to contact victim (can this be performed without endangering rescuers or victims)





# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### ROPE

Secure the general scene around the incident.

1. This area will include an area within 300 ft. (or more, per incident command)
2. Make the area safe for rescuers
  - Control / limit traffic
  - Control / limit access to area by unnecessary personnel.
  - Identify the hazards and remove or reduce their impact.

Notify a qualified rescue team to perform the rescue. These teams should be identified by AHJ or department SOP / SOG.

#### Rope Rescue Summary

- Recognize the need for rope rescue.
- Identify resources necessary to conduct rope rescue operations.
- Identify how the emergency response system is activated when rope rescue is required.
- Identify how to conduct site control and scene management.
- Recognize general hazards associated with rope rescue.
- Identify personal protective equipment used for rope rescue incidents.

#### Size-up (con't)

- Secure the general area
  - 300' area or more
- Make area safe for rescuers
  - Control / limit traffic
  - Control / limit access
  - Identify all hazards
    - Reduce or remove them
- Notify qualified rescue team per SOG's / SOP's

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#### Rope Rescue Summary

- Recognize the need for rope rescue.
- Identify resources necessary to conduct rope rescue operations.
- Identify how the emergency response system is activated when rope rescue is required.
- Identify how to conduct site control and scene management.
- Recognize general hazards associated with rope rescue.
- Identify personal protective equipment used for rope rescue incidents.

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# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### CONFINED SPACE

#### Confined Space: Rescue

##### Awareness-level functions:

- Perform non-entry retrieval.
- Implement the emergency response system for confined space emergencies.
- Implement site control and scene management.

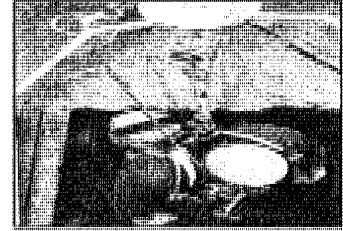
##### The Confined Space Law

The permit required confined space law was promulgated on January 1, 1993 and took effect on April 15, 1993. This law was enacted after many years of discussion and comments being relayed to OSHA. The law is Title 29 Code of Federal Regulations number 1910.146, or 29CFR1910.146.

In addition to identifying many workplace and rescue issues, it essentially identifies two basic types of confined spaces, based on their types of hazards. The first, is commonly called a “confined space”, or as the law refers to it as a “non-permit” confined space. This identifies the ingredients required to call any space something that is confining, however not necessarily dangerous to health or life by itself. The law indicates that a “confined space” means a space that:

- 1) Is large enough and so configured that an employee can bodily enter and perform assigned work; and
- 2) Has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry.); and
- 3) Is not designed for continuous employee occupancy.

#### Confined Space Rescue

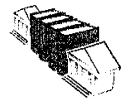


#### Awareness Level

- Awareness-level functions:
  - Perform a non-entry retrieval.
  - Implement the emergency response system for confined space emergencies.
  - Implement site control and scene management.

#### Confined Spaces

- OSHA law
  - 29 CFR 1910.146
- IDOL
  - Adopted OSHA law
- Law identifies two types of spaces
  - Permit
  - Non-Permit



#### Confined Spaces

- Non-permit
  - Large enough and so configured to bodily enter
  - Limited or restricted means of entry and exit
  - Not designed for continuous human occupancy



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### CONFINED SPACE

Note that the definition requires that the space meet ALL of the above conditions. It cannot be a confined space if it only has one or two of the characteristics.

The next definition shows that the confined space defined above is more dangerous to the entrant. The law says: Permit-required confined space (permit space) means a confined space that has one or more of the following characteristics:

- 1) Contains or has the potential to contain a hazardous atmosphere;
- 2) Contains a material that has the potential for engulfing the entrant;
- 3) Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross-section; or
- 4) Contains any other recognized serious safety or health hazard.

Regulations do *not* cover spaces that are *too small for complete bodily entry*:

- Regulations only address confined spaces that are large enough for the entire body of an employee to enter.
- Entry is considered to have occurred when any part of the entrant's body breaks the plane of the entry portal.

#### Confined Spaces

- Permit required confined space
  - A confined space that contains one of the following:
    - Contains or has the potential to contain hazardous atmosphere (IDLH)
    - Contains a substance that could engulf the entrant
    - Contains inwardly converging walls/floors that could trap the entrant causing asphyxiation
    - Other recognized serious health or safety hazard

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#### Basic Characteristics of Confined Spaces

- **Regulations do *not* cover spaces that are *too small for complete bodily entry*:**
  - Regulations only address confined spaces that are large enough for the entire body of an employee to enter.
  - Entry is considered to have occurred when any part of the entrant's body breaks the plane of the entry portal.

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# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### CONFINED SPACE

#### OSHA Statistics

The Occupational Safety and Health Administration (OSHA) has statistics indicating that 30% of the fatalities in confined spaces are would-be rescuers. The term "would-be rescuers" include bystanders or good Samaritans that simply try to jump into the space thinking they will just quickly drag the entrant out. This high mortality rate is the result of these untrained responders not understanding the hazards involving confined spaces. Up to 90% of these fatalities are results of atmospheric hazards per industry statistics.

#### Reasons to Enter Confined Spaces

- Inspections / maintenance
- Rescue
- Training

#### Generally employees who work in process vessels:

- Must squeeze in and out through narrow openings to enter and exit the space.
- Perform work in the space while cramped or contorted.
- May be exposed to hazardous substances / atmospheres.
- May be exposed to the moving parts of a mixer

#### Majority of confined space rescue incidents:

- Involve unconscious victims.
- Usually require complex rescue operations.

#### Confined Spaces

- OSHA statistics
  - Confined space deaths
    - 30% of deaths are would-be rescuers
    - Up to 90% of deaths are due to atmospheric problems
- Reasons to enter confined spaces
  - Inspections / maintenance
  - Rescue
  - Training

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#### Basic Characteristics of Confined Spaces

- Majority of confined space rescue incidents:
  - Involve unconscious victims.
  - Usually require complex rescue operations.

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# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### CONFINED SPACE

"Not designed for continuous human occupancy" focuses on the *design of the space* rather than its primary function. It is the criterion as to whether a human can occupy a space under normal operating conditions.

*All permit spaces must have danger signs, or other effective means, to designate confined spaces in the workplace.....1910.146(c)(2):*

If an employer decides that its employees will enter permit spaces....1910.146 (c)(4):

- They must develop and implement a written permit space program in compliance with 1910.146 regulations.
- They must make available for inspection by employees / authorized representatives a written permit space program.

OSHA's permit-required confined space program (permit-space program) requirements:

Employers whose employees enter a permit space are required to have a *written permit-required confined space program*.


Purpose of a *written permit space program*:

- Systematic approach to permit space operations.
- Prevent mistakes / misunderstandings of confined space operations and risks.
- Regulate employee entrance into permit spaces.
- Protection reference for employees.
- Direct / guide personnel.



Basic Characteristics of Confined Spaces

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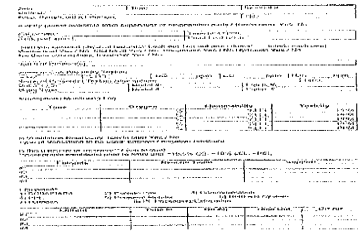


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  - Protection reference for employees.
  - Direct / guide personnel.

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### Sample Permit OSHA 1910.146



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# STUDENT MANUAL TECHNICAL RESCUE AWARENESS CONFINED SPACE

## Designated positions for a confined space operation:

### Authorized Entrant

- Means an employee who is authorized by the employer to enter a permit space.

### Attendant

- Means an individual stationed outside one or more permit spaces who monitors the authorized entrants and who performs all attendant's duties assigned in the employer's permit space program.

### Entry Supervisor

- Means the person (such as the employer, foreman, or crew chief) responsible for determining if acceptable entry conditions are present at a permit space where entry is planned, for authorizing entry and overseeing entry operations and for terminating entry as required.

An entry supervisor also may serve as an attendant or as an authorized entrant, as long as that person is trained and equipped as required for each role he or she fills. Also, the duties of entry supervisor may be passed from one individual to another during the course of an entry operation.



### Designated Positions for Confined Space Operations

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# STUDENT MANUAL TECHNICAL RESCUE AWARENESS CONFINED SPACE

## Examples of Types of Confined Spaces

"Many workplaces contain spaces which are considered 'confined' because their configurations hinder the activities of employees who must enter, work in, and exit from them" (ref. CFR 1910.146 Federal Register, Thursday, January 14, 1993)

### Examples of types of confined spaces

- Silos - Industrial or Agricultural
- Manholes - Sanitary or Storm
- Rail Cars Liquid Tank or Dry Bulk
- Industrial Storage Tanks
  
- Other confined space examples:
 

Utility vaults	Vats
Wells	Tank cars
Tunnels	Tubs
Silos	Sewers
Septic tanks	Ship holds
Scrubbers	Vessels
Pumping stations	Pipelines
Storage tanks	Incinerators
Furnaces	Grain storage facilities
Cookers	Compartments
Caves	Crawl spaces
Boilers	Bins

## Confined Space Atmospheric Hazards

OSHA's analysis of *hazardous atmospheres* related to confined space deaths and injuries:

Basic categories:

- Asphyxiating
- Flammable and explosive
- Toxic

Examples of Types of Confined Spaces			
Utility vaults	Vats	Wells	Tank cars
Tunnels	Tubs	Silos	Sewers
Septic tanks	Ship holds	Scrubbers	Vessels
Pumping stations	Pipelines Storage tanks		
Incinerators	Grain storage facilities		Furnaces
Cookers spaces	Compartments	Caves	Crawl
Boilers	Bins		
15			

Confined Space Atmospheric Hazards
<ul style="list-style-type: none"> <li>• OSHA's analysis of hazardous atmospheres related to confined space deaths and injuries:               <ul style="list-style-type: none"> <li>Basic categories:                   <ul style="list-style-type: none"> <li>Asphyxiating</li> <li>Flammable and explosive</li> <li>Toxic</li> </ul> </li> </ul> </li> </ul> <p>Consequence of OSHA findings - final ruling - 1910.146 requirement related to hazardous atmospheres and testing:</p> <p>Employers must test and monitor entry spaces with instruments which will detect <i>all</i> aspects of hazardous atmospheres that may be encountered in the confined spaces.</p>
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# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### CONFINED SPACE

When testing for Atmospheric Hazards test in the following order:

- Oxygen deficiency
- Flammable gases / vapors
- Toxic gases / vapors

#### Oxygen-deficiency atmospheres:

OSHA term: "asphyxiating atmosphere"

Contains less than 19.5 % oxygen, which is inadequate for entrant's respiratory needs when performing physical work even if the space contains no toxic materials.

#### Flammable atmospheres:

- Causes of flammable atmospheres:
  - Oxygen in air
  - Flammable gases, vapors, or dusts in proper mixtures (**in a confined space, a flammable gas may not be in excess of 10% of its lower flammable limit or LFL**)
- If source of ignition (i.e.: sparking, electrical tool) introduced into flammable atmosphere = explosion.
- Oxygen-enriched atmosphere:
  - Above 23.5% O<sub>2</sub>
  - Can cause flammable materials (i.e.: clothing and hair) to burn
- Safety Note:
  - Never use pure oxygen to ventilate a confined space
  - Ventilate with normal air

Confined Space Atmospheric Hazards

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  - Oxygen deficiency
  - Flammable gases / vapors
  - Toxic gases / vapors

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Confined Space Atmospheric Hazards

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    - Ventilate with normal air

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# STUDENT MANUAL TECHNICAL RESCUE AWARENESS CONFINED SPACE

## Sources of toxic hazardous substances that can be found in confined spaces:

Liquids	Gases
Vapors	Mists
Solids	Dusts

## Safety notes:

- Every possible atmospheric hazard, which may be encountered in a confined space, cannot be listed.
- Your safety depends on your knowledge and application of proper rescue procedures prior to responding to a confined space emergency.
- Atmospheric testing and monitoring, as well as preplanning of rescue procedures, is a critical aspects of your safety.
- Rescuers should approach all confined spaces as having oxygen-deficiency, flammable, and toxic atmospheres until determined otherwise!

## Dome / Bridge Hazards:



Confined Space Atmospheric Hazards

- Sources of toxic hazardous substances that can be found in confined spaces:
  - Liquids
  - Vapors
  - Gases
  - Mists
  - Solids
  - Dusts

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Confined Space Atmospheric Hazards

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Confined Space Atmospheric Hazards

- Safety notes:
  - Rescuers should approach all confined spaces as having oxygen-deficiency, flammable, and toxic atmospheres until determined otherwise!

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Illustrations of dome / bridge hazards:

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# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### CONFINED SPACE

Illustration of engulfment in unstable bridged material

Grain Bin Rescue  
Over 60 deaths per year nationwide  
Non-entry rescue (cutting sidewalls)

Example of engulfment in substance attached to walls of space

#### Other Hazards:

- **Extreme temperatures** (i.e. confined space that has been just steam cleaned).
- **Slippery surfaces or drop-offs** (i.e.: can result in slips and falls; wet surface increases the likelihood of electric shock in areas where electrical circuits, equipment, and tools are used water is present).
- **Scaffoldings** (i.e.: collapse of the support system).
- **Falling objects** (i.e.: particularly in spaces which have topside openings for entry and/or work being done above rescuer).
- **Drowning** (i.e.: submersion in liquid / solid in the confined space).
- **Burns** (i.e.: contact with hot materials [steam], scalds from liquids, electrical lines).
- **Crushing** (i.e.: entrapment by compressing substances - soil, grain)
- **Impalement** (i.e.: stabbing by a sharp object).

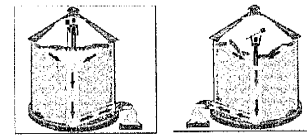
#### Psychological hazards:

- Most challenging aspect of confined space rescue = psychological stress generated by many potential hazards.



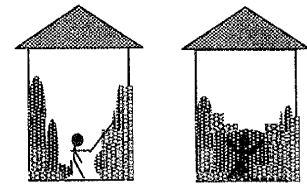
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Example of engulfment in substance attached to walls of space:



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#### Psychological Hazards

- Most challenging aspect of confined space rescue is psychological stress generated by many potential hazards.



# STUDENT MANUAL TECHNICAL RESCUE AWARENESS CONFINED SPACE

## Mechanical Hazards:

- Electrical, augers, backhoes, welding equipment
- Difficulty with isolation - the process where the space is removed from service by
- Lock out/Tag out procedures, a method for keeping equipment from being set in motion
- Removing belt and chain drives, mechanical linkages when possible
- A computer from a remote location can turn on equipment or release a product
- Blanking and bleeding - pneumatic and hydraulic lines
- Securing - mechanical moving parts within a confined space with chains, bars, chocks, blocks and other devices

## Lock-Out/Tag-Out Kit:

- Padlocks
- Hasps & tags
- Plug & valve covers
- Chain
- Electrical Tester

When lock-out procedures can not be accomplished, firefighters or law enforcement officers should be placed at the isolation point with strict orders not to allow anyone access or to reapply power to the area.



## Mechanical Hazards

- Electrical, augers, backhoes, welding equipment
- Difficulty with isolation - the process where the space is removed from service by
- Lock out and Tag out procedures - preferably at disconnect switches remote from the equipment

## Mechanical Hazards (cont)

- Removing belt and chain drives, mechanical linkages when possible
- A computer from a remote location can turn on equipment or release a product
- Blanking and bleeding - pneumatic and hydraulic lines
- Securing - mechanical moving parts within a confined space with chains, bars, chocks, blocks and other devices
- Double block and bleed

## Lock-Out/Tag-Out Kit

- Padlocks
- Hasps & tags
- Plug & valve covers
- Chain
- Electrical Tester

## When Lock-Out is not possible

Position firefighter or law enforcement officer at the isolation point with strict orders "not to allow anyone access or to reapply power to the area".



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### CONFINED SPACE

#### Size-up

The initial duties of the first due fire or rescue service companies are numerous. These first in companies must realize that there are many things that need to be accomplished or at least verified as completed prior to anyone entering a confined space.

Size-up is obviously the first task that needs to be performed. A good initial size-up will help ensure that all responding rescue personnel have an understanding of the conditions that were found early in the incident. This will also help to ensure that the incident command structure is put into place and that adequate resources are being assigned to the incident. During size-up, access to the space and number of victims should be determined. In addition, contact with the patient should be attempted if it can be done safely.

Securing the scene early in the incident will ensure that the general area is safe, not only for bystanders, but also for subsequent responding rescue units and personnel. The general area should be made safe by ensuring the control of traffic, whether vehicular or pedestrian. All unnecessary persons must be kept away from the area. This may include industrial workers who are trying to help their co-worker. Unless they are trained rescuers, knowledgeable in the space and have rescue capability, they should remain in an advisory capacity. Remember that these workers have the victim's best interest in mind, and as such, can be a very valuable asset to the rescue. They must be made aware of their role in the rescue, such as providing better access to the area or the space, and determining the proper isolation points for numerous electrical or mechanical hazards. This is considered Lockout/Tagout per 29 CFR 1910.147. There may be the need to shut down all sources of vibration or excessive noise in the area in order to complete the rescue effectively. These co-workers will help ensure this can happen.



#### Size-up

- Determine need for Technical Rescue
- Determine best access to space
- Make contact with victims if safe to do so
- Attempt to determine # of victims
- Interview attendants / acquire copy of permit
- Secure area around space
  - Control / limit traffic & sources of vibration
    - Shut down vehicles and equipment
  - Control / limit access to general area by unnecessary personnel



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### CONFINED SPACE

The attendant at the scene will be one of the most valuable sources of information as to what happened in the space. In addition, anyone who may have been in the space recently should be located to help with gathering information. This may not be feasible if the space is a utility vault or other such area, which workers access regularly without assistance.

While information is being gathered, the first responding unit(s) must ensure that a qualified rescue team is being notified to respond for assistance. This team must be identified by the AHJ prior to the incident, to ensure a quick response without any confusion.

Qualified rescue teams need to be notified. The AHJ or department SOP/SOG should identify these teams.

Don't get pushed into someone else's emergency. The law requires the owner of the permit required confined space to provide for a rescue team prior to any entry. This does not mean that we by virtue of being the Fire Department are obligated to provide this service. The owner of the space, if he wants to utilize the Fire Department instead of his rescue team, must have an agreement with that Fire Department, that they will provide this specialized service.

In addition, while information is being gathered, initial rescue actions that may be completed by awareness level units should be:

- Monitoring, to determine any potential atmospheric problems this would include oxygen levels, combustibility, and any potential toxins. Someone trained and qualified to complete the air-monitoring task should complete monitoring.
- Ventilation of the space, ensuring contaminants is not being moved to an area that could become a problem. This would include providing warm or cool air to the victims if necessary.
- Non-entry rescue if a pre-rigged device is available and the victim may be moved out without additional injury,



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### CONFINED SPACE

awareness personnel should attempt to use the device **IF** they are knowledgeable in its operation and can do so without entering the space.

Although the reasons for a confined space rescue are numerous, rescue personnel must gain information as to the types of spaces, and the type of work that was being performed prior to any rescue team attempting to enter the space. It should be assumed that if a space was deemed to be simply a confined space, the rescue team must reclassify it to a permit-required confined space if the rescue service has been called there to perform a rescue.

#### Confined Space Summary

- Recognize the need for confined space search and rescue.
- Identify contacting and communicating with victims were possible.
- Recognize and identify the hazards associated with non-entry confined space emergencies.
- Recognize confined spaces.
- Be able to perform non-entry retrieval.
- Identify the emergency response system for confined space emergencies.
- Identify site control and scene management for confined space incidents.

#### Confined Space Summary

- Recognize the need for confined space rescue.
- Identify contacting and communicating with victim were possible.
- Identify hazards associated with non-entry confined space rescue.
- Recognize Confined spaces.
- Be able to perform non-entry retrieval.
- Identify the need for lock out/tag out procedures.







# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### WATER RESCUE

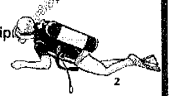
#### Water Rescue

- **Fire service need for Water Rescue Awareness:**
  - Most jurisdictions have some type of body of water.
  - Most jurisdictions have the potential for flooding.
  - Many water related incidents require expertise beyond the normal capability of some fire departments.
  - Personnel and teams trained to the operations or technician level.
  - Proper personal protective equipment.
  - Proper technical rescue equipment.
- **NFPA** recognizes four different water related disciplines at the operations and technician level: dive, ice, surf, and swift water.
- **Hazards that are associated with water rescue incidents:**
  - Human nature and the nature of fire service personnel.
  - Fire service personnel are action oriented. They want to act now.
  - Rescues are attempted without the proper training or equipment



#### Water Rescue

- Need for water rescue awareness
  - Most FD's have some body of water
  - Potential for flooding
  - Many water incidents require resources beyond capability of FD
    - Operations and technician trained
    - Proper PPE
    - Technical rescue equipment



#### NFPA 1670

- Water related disciplines
  - Dive
  - Ice
  - Surf
  - Swift water



#### Hazards Associated with Water Rescue

- Firefighter (human) nature
  - Action oriented
    - Need to do something now
  - Make rescue attempts without proper training or equipment



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### WATER RESCUE

- **Environmental hazards may include:**
  - Extreme temperatures
    - Cold temperatures causing hypothermia frostbite, and equipment malfunctions.
    - Hot temperatures causing hyperthermia and overheating in personal protective gear. Under water survival time is lost in hot temperatures.
  - Weather, including rain, snow, and high winds. Hypothermia is accelerated when personnel are wet or in the water. Body heat is lost to still water 25 times as fast as to still air of the same temperature.
- **Aquatic environment**
  - Animal life, fish, insect
  - Plant life, seaweed
  - Biohazards, Bacterial, Viral

#### Environmental Hazards

- Extreme temperatures
  - Cold
    - Hypothermia, frostbite, equipment malfunctions
      - » Effects ability to think clearly & fine motor skills
  - Heat
    - Hyperthermia, overheating in PPE
    - Underwater survival time lost in hot temperatures
      - » Exhaustion, dehydration

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#### Environmental Hazards (con't)

- Weather
  - Rain, snow, high winds, fog
    - Accelerates hypothermia
    - In still water, body heat is lost 25 times greater than in air at the same temperature
- Aquatic environment
  - Animal life, fish, insects
  - Plant life, seaweed
  - Biohazards, bacterial, viral



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# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### WATER RESCUE

- **General hazards**

- Utilities including electrical, gas, sanitary, and communications.
- Hazardous materials.
- Personal hazards including trips, falls, steep and slippery terrain, drop offs, holes, hidden obstructions that may cause injury or entanglement.

- **Hazards associated with dive operations:**


- Barotraumas including decompression sickness, nitrogen narcosis, oxygen toxicity, embolism, etc.
- Drowning. May be related to lost diver, loss of air, anxiety reactions.
- Fatigue, exhaustion, heat stress, dehydration, or hypothermia.
- Pre-existing medical conditions, smoking, or use of medications.

- Where is your closest hyperbaric chamber located?
- How long will it take to get there by ground transport?



### General hazards

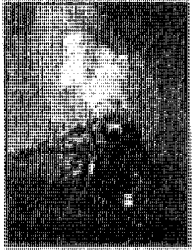
- Utilities
  - Electric, gas, sanitary, communications
- Hazardous materials
- Personal hazards – water's edge
  - Tripping, falling
  - Steep, slippery terrain
  - Drop-offs
  - Holes
  - Hidden obstructions
    - » Cause injury, entanglement



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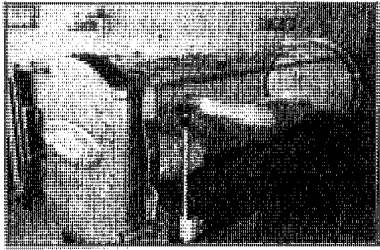
### Dive Operation Hazards

- Barotraumas
  - Decompression sickness
  - Nitrogen narcosis
  - Oxygen toxicity
  - Embolism
- Drowning
  - Fatigue
  - Lost diver
  - Loss of air
  - Anxiety reactions



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### Dive Operation Hazards



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### WATER RESCUE

#### Hazards associated with ice operations:

- Cold injuries including frostbite and hypothermia.
- Thin ice causing sudden emersion or entrapment under the ice.

#### • Hazards associated with surf operations:

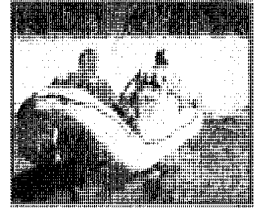
- Breaking waves generating extreme forces.
- Undertows, tides, and currents.

#### • Hazards associated with swift water operations:

- Awesome, relentless power of moving water.
- Strainers and debris.
- Holes.
- Obstructions.
  - Above the water surface.
  - Below the water surface.  
(Upstream V's and downstream V's).

#### Ice Operation Hazards

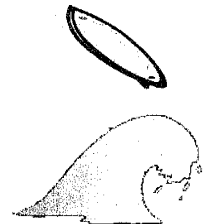
- Cold injuries
  - Frostbite
  - Hypothermia
- Thin ice
  - Sudden immersion reflex
  - Entrapment under ice



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#### Surf Operation Hazards

- Breaking waves
  - Generate extreme force
- Undertows, tides, current



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#### Swift Water Operation Hazards

- Awesome, relentless power of moving water
- Strainers & debris
  - Stationary objects
- Holes
- Obstructions
  - Above the water surface
  - Below the water surface
    - Upstream "V"
    - Downstream "V"



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# STUDENT MANUAL TECHNICAL RESCUE AWARENESS WATER RESCUE

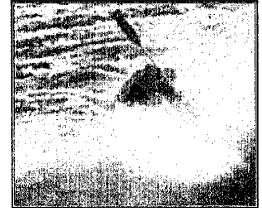
- **Current patterns.**
  - Laminar flow.
  - Helical flow (upwelling).
  - Eddies (back current).

## Forces of Water

- Water weights 62.4lbs per cubic foot
- Water typically flows downstream at 6 to 12 miles per hour.
- When a vehicle stalls in the water the water's momentum is transferred to the car.

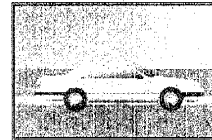
### Swift Water Operation Hazards (con't)

- Current patterns
  - Laminar flow
  - Helical flow
    - Upwelling
  - Eddies
    - Back current
- Heavy downpours
  - Make quiet streams swiftwater



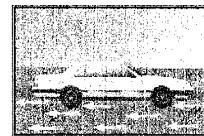
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### Swift Water Operation Hazards (con't)



Water weight 62.4 lbs per cubic foot and typically flows downstream at 6 to 12 miles per hour.

### Swift Water Operation Hazards (con't)



When a vehicle stalls in the water the water's momentum is transferred to the car. For each foot the water rises, 500 lbs. of lateral force is applied to the automobile.



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### WATER RESCUE

- For each foot the water rises 500lbs of lateral force is applied to the automobile.
- For each foot the water rises up the side of the car the car will displace 1500lbs.

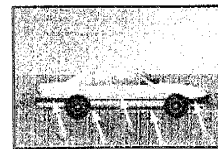
- Two feet of water will carry away most automobiles!

- **Hazards associated with low head dams, *The Killing/Drowning Machine.***

- Illusion (cannot be perceived from upstream and do not look particularly dangerous).
- Hydraulic (vertical whirlpool)
- Aeration in the hydraulic (causes cavitation to boat propellers).



#### Swift Water Operation Hazards (con't)



But the biggest factor is buoyancy. For each foot the water rises up the side of the car, the car displaces 1500 lbs. of water. In effect, the automobile weighs 1500 lbs. less for each foot the water rises.

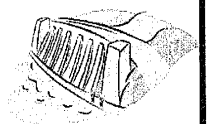
#### Swift Water Operation Hazards (con't)



Two Feet of Water Will Carry Away Most Automobiles!

#### Low Head Dam Hazards

- The killing / drowning machine
  - Boil line
    - Point where water breaks in two directions
  - Illusion
    - Cannot be perceived from upstream
    - Do not look dangerous
  - Hydraulic
    - Vertical whirlpool
  - Aeration in the hydraulic
    - Causes cavitation to boat props



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# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### WATER RESCUE

#### Personal protective equipment during water rescue incidents.




- Firefighting helmets, boots, and turnout gear are not typically appropriate for water rescue work.
- Thermal protection including wet suits and dry suits.
- PFD's (personal flotation device) should be worn while in or near the water or while in a boat. Should have a whistle, knife & strobe light or light stick.
- Tagline or lifeline.
- Helmet.

- **Cold water near drowning.**

- Age of the victim.
- Temperature of the water.
  - below 70 degrees F.
  - The patient could be below the thermocline.
- Length of submersion (under 90 minutes still in rescue mode).
- Quality BLS and ALS patient treatment

### Water Rescue PPE


- Firefighting helmets, boots, and turnout gear are **NOT** appropriate for water rescue
- Proper PPE includes the following
  - Wet suits / dry suits / exposure suits
  - Thermal protection
  - PFD's (whistle & knife & strobe light or light stick)
    - Worn by all personnel
      - In or near water
      - On a boat



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### Cold Water Near Drowning

- Age of victim
- Temperature of water
  - Below 70°F
  - Patient could be below thermocline
- Length of submersion
  - Under 90 minutes
    - Still rescue mode
  - Quality BLS & ALS treatment



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# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### WATER RESCUE

- **Water rescue response for awareness level trained personnel.**
  - Assessment phase (size-up)
    - Scope, magnitude, and type of water rescue incident.
    - Environmental factors and potential for changing conditions.
      - Change in weather conditions.
      - Loss of daylight.
      - Water levels and current changing drastically (flash flooding).
  - Assessment of hazards.
  - Location and number of victims.
  - Risk/benefit analysis (rescue vs. recovery).
  - Access to the scene.
- Initial tasks.
  - Gain control of the scene (establish site security).
  - Establish an Incident Command System.
  - Accountability and safety of personnel (This starts with proper training and equipment).
  - Evaluate the patient's condition (they may or may not be able to assist in their own rescue).
  - Evaluate the resources available and those that will be needed.



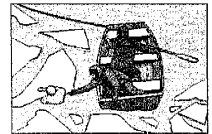
#### Size-up

- Scope, magnitude, type of water rescue incident
  - Environmental factors
    - Change in weather conditions
    - Loss of daylight
    - Water levels
    - Current changes

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#### Size-up (con't)

- Assessment of hazards
- Location & number of victims
- Risk / benefit analysis
  - Rescue vs. recovery
- Access to scene



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#### Water Rescue

- Awareness Level Personnel May:
  - Establish scene control
  - Establish IC
  - Initiate accountability & safety
  - Evaluate patient condition
    - Can patient assist with rescue?
  - Activate Needed resources



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# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### WATER RESCUE

- **Secure and interview witnesses.**
  - Try to keep witnesses at the scene.
  - Interview witnesses separately.
  - Collect the witness' personal information (they might need to be interviewed again).

- **Establish a last seen point.**
  - Triangulate with more than one witness.
  - Use of reference objects (same size as person, vehicle, or plane that went down).
  - A hole in the ice is an excellent last seen point. Don't destroy it.

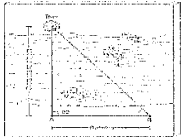
### Water Rescue

- Awareness Level Personnel May: (con't)
  - Secure & interview witnesses
    - Keep witnesses at scene
    - Interview witnesses separately
    - Collect witnesses' personal information

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### Water Rescue

- Awareness Level Personnel May: (con't)
  - Establish last seen point
    - Triangulate with multiple witnesses
    - Use a reference object
    - Hole in ice is great last seen point
    - Don't destroy it



### Water Rescue

- Awareness Level Personnel May: (con't)
  - Identify number of victims
  - Identify age and sex of victim, if possible



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### WATER RESCUE

- Notes, clothes, and footprints.
- Tire tracks, debris, oil slick, and bubbles.

- **Identifying the need for a water rescue response beyond the awareness level.**

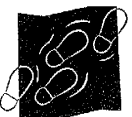
- The AHJ should have an emergency response system established for water related incidents. This may include the response of:
  - Operations and technician level trained personnel (divers, ice divers, swift water technicians, etc.).
  - Police and evidence technicians.
  - Specialized equipment (boats, tow trucks, extrication equipment, etc.)
  - EMS response.
- An ambulance for each patient and one for dive support.
- Air transport to a level I trauma facility.

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### Water Rescue

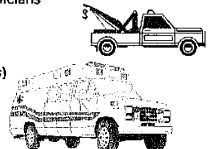
- Awareness Level Personnel May: (con't)
  - Evaluate physical evidence
    - Notes
    - Clothes
    - Footprints
    - Tire tracks
    - Debris
    - Oil slick
    - Bubbles



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### Water Rescue

- Beyond the awareness level
  - AHJ must have emergency response plan
    - Operations & technician level personnel
    - Police & evidence technicians
    - Specialized equipment
      - Boats, tow trucks, etc.
    - EMS response
      - Ambulance for patient(s)
      - Ambulance for divers
      - Aeromedical transport



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# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

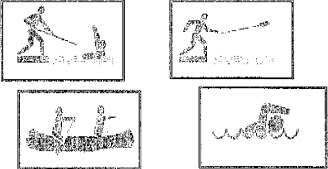
### WATER RESCUE

- 
- **An operational plan may include: Reach, Throw, Row and Go.**

- 
- 
- Consider requesting divers early in an incident.
  - Victims at the surface may slip under the water before a surface rescue can be executed.
  - Divers can only last so long before they need rehab. Keep the incident operating in rescue mode.

#### Scene Considerations


- Rehab personnel early
- Operational plan
  - Reach, throw, row, go



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#### Scene Considerations

- Request divers early in an incident
  - Victims at the surface may submerge
  - Keep incident operating in rescue mode



# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### WATER RESCUE

#### Water Summary

- Recognize the need for water search and rescue.
- Describe implementing the assessment phase.
- Identify the resources necessary to conduct safe and effective water rescue operations.
- Identify the emergency response system for water rescue emergencies.
- Identify the site control and scene management procedures at water rescue incidents.
- Identify the general hazards associated with a water rescue incident.
- Identify the rescue vs. recovery mode when concerned with cold water near drowning patient.
- Identify the site control and scene management procedures at water rescue incidents.  
Identify the rescue vs. recovery mode when concerned with cold water near drowning patient

#### Water Rescue Summary

- Recognize the need for water search and rescue.
- Describe implementing the assessment phase.
- Identify the resources necessary to conduct safe and effective water rescue operations.
- Identify the emergency response system for water rescue emergencies.

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#### Water Rescue Summary

- Identify the site control and scene management procedures at water rescue incidents.
- Identify the general hazards associated with a water rescue incident.
- Identify the rescue vs. recovery mode when concerned with a cold water near drowning patient.

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# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### VEHICLE / MACHINERY

#### Vehicle and Machinery:

Vehicle extrication and machinery rescue can occur any where in the United States. We can have entrapment of arms or hands in punch presses in rural manufacture plants. Or we can have multiple car accidents with entangled bodies on any expressway in any major city. Fire fighters will handle a great majority of these incidents whether they are volunteer, paid on call, or full time.

When rescue personnel arrive on the scene of these accidents, they must survey the site for a safe and workable condition. **Rescuer safety is first priority.** The first item to look at is the size up of the scene. There are many ideas that can encompass size up but we will be looking at three major areas -, scene conditions patient injuries and. environmental conditions

#### On Scene Approach

Scene conditions are the first subject of size up that will be explored. The major areas are listed below:

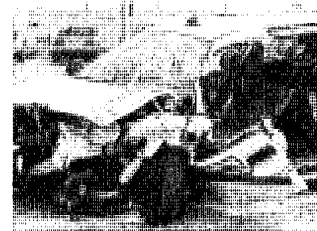
The Scene survey will be a six sided approach to an accident: top, bottom, front, back, left side and right side. We also use inside and outside circle referencing areas of concern for safety

Stabilization is the first tactical objective to any accident of a machine or vehicle. Stabilization will maximize the contact surface between the car and the ground or provide support the key points in the machinery. It should also prevent further injury to the patient and safety for the rescue personnel.

Hazardous materials is another area that should be addressed for rescuer's safety. Hazardous materials should be identified, addressed or removed before any rescue personnel are allowed to continue the rescue.



#### Vehicle & Machinery Rescue



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#### On Scene Approach

- Survey scene
  - Six-sided approach
  - Inside / Outside Circles
- Scene conditions
  - Fire
    - Fuels
  - Crowd control
  - Hydraulic bumpers
    - Shocks, hood/hatch pistons, suspension



2

#### Scene Conditions

- Vehicle stability
  - Maximize contact surface between car & ground
  - Support key points on machines
    - Prevents further injury to victim
- Hazardous materials
  - Identify
  - Control
  - Remove



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# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### VEHICLE / MACHINERY

Electrical problems can exist in many ways:

Vehicle battery - the location of the batteries in cars could be under the hood (high or low) -hidden, under the back seat, or in the trunk. The power cable will run along or in the rocker panel. On trucks, the batteries will be in the battery box, under the hood or in the wheel wells.

Utilities - if the power lines are down, they could be in the immediate area or could spread to electrify metal fences, guard rails, downed phone lines or cable lines. If anyone comes in contact with these lines, it could be fatal. So let the power company handle the problem.

Machinery power - should be turned off at the main electrical panel with a lock out/ tag out equipment applied.

Fire is a large concern in vehicle accidents because of the fuel that is being used. The use of a charged hose line at the scene of an extrication should be used to protect the rescue personnel.

Crowd control should be addressed by the police department. The crowds could restrict or hamper the rescuer's activities thus needing a longer time to extricate the patient(s).

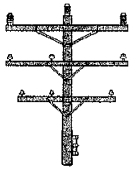
The police should also control the traffic around an accident. Consider using the fire apparatus for blocking traffic.

Hydraulic shocks, absorbing bumpers, hatch back, hood pistons and hydraulic suspension systems that are found on cars, vans and trucks can be very explosive under a fire condition. Bumpers have been known to be launched as far as 100 feet or could wrap around the vehicle



### Scene Conditions

- Electrical hazards
  - Vehicles
    - Batteries
    - Capacitors
  - Utilities
    - Power lines
  - Machines
    - Lock out / tag out
    - Multiple sources



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# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### VEHICLE / MACHINERY

The patient's injuries will occur from the mechanism that will come in contact with the body. The mechanism of injury can come from a windshield, air bag, steering wheel, dashboard, "A" or "B" posts, rear view mirror, door, roof, auger, conveyor belt, etc. The injury of the patient could be external and/ or internal. The possible external injuries that the EMS personnel may see are injuries to the head, neck, shoulder, arm, hand, back, hip, leg, foot, etc.. Internal injuries can involve the organs, spine, brain, blood vessels, etc.. The damage to these body parts can be bruises, lacerations, fractures, amputation, etc.

Environmental conditions deal with the weather. We can have extreme heat and cold situations that may affect the rescue operation and our personnel. These conditions can also create added problems for the patients we are trying to disentangle. Rain, sleet and snow are other dilemmas that we may face. The ability for us to respond and work at the scene is dependent upon traction of the work surface. In several conditions, the patient's state may deteriorate at a faster pace. The last concern is darkness. The rescuer acknowledges the problems and will react in a faster manner. Whereas, in a low light or dark condition, rescuers are restricted or handicapped to the amount of lighting provided.



#### Patient Injuries

- Mechanism of injury

- Trauma

- Head, face, hand and arms
  - » Windshield, airbags, steering wheel, A/B post, rear view mirror, roof, auger, roller, conveyor, belt etc.
- Chest, stomach and hips
  - » Steering wheel, airbag, door, seat belts, etc.
- Legs and feet
  - » Steering wheel, dash board, door, etc.



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#### Patient Injuries (con't)

- Internal

- Organs, spine, brain, blood vessels, etc.

- External

- Head, neck, shoulders, arms, hands, legs, feet, back, hips, etc.
  - Bruises, fractures, lacerations, amputations

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#### Environmental Conditions

- Extreme heat & cold
- Rain, sleet and snow
- Darkness



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# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### VEHICLE / MACHINERY

Depending of the type of emergency system that can be found in the region, there could be as many as four agencies that may responding to the incident. In some systems, all of the following could be under one department. But, all of the following must be addressed at any accident.

The police are responsible for maintaining crowd control, traffic control and preserving the scene for reconstruction and investigation.

The fire department has the responsibility for:

Maintaining scene safety by extinguishing fires, preventing any fires from starting and handling any spills or leaks of hazardous materials.

Maintaining vehicle safety by checking the fuel system and handling any fuel spills or leaks, checking the electrical system and removing the power to the vehicle or machinery, and assist the EMS and /or the rescue personnel.

The emergency medical services has the responsibility for:

Patient assessment of medical problems

Patient packaging for removal

Assess the patient's disentanglement and extrication needs

Patient removal and handling

Transportation of the patient

#### Identify & Notify Resources

- Safe & effective operation

- Police
  - Crowd control
  - Traffic control
  - Preserve scene
    - » Accident reconstruction
    - » Investigation



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#### Identify & Notify Resources (con't)

- Fire department
  - Maintain scene safety
    - Extinguish fires
    - Prevent fires
    - Spills / leaks
      - » Fuels
      - » Haz-mat
  - Maintain vehicle safety
    - Fuel system
    - Electrical system
  - Assist EMS / extrication



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#### Identify & Notify Resources (con't)

- EMS
  - Patient assessment
  - Packaging
  - Assess patient disentanglement & extrication
  - Patient handling
  - Transportation



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# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### VEHICLE / MACHINERY

The extrication rescue personnel are responsible for:

- Vehicle or machinery stabilization
- Create a safe access for the EMS personnel
- Initiate safe disentanglement procedures/guidelines as necessary for all patients
- Assist the EMS personnel with removal of the patient

There are many possible hazards that are found at the scene of vehicle or machinery accidents. The following are the most pronounced risks.

Air bag systems are found in most vehicles. These systems are marked with the following logos: SRS, SIR, Air Bags, Side Air Bags, Knee Impact Bag, Head Impact Bag, Head Curtain Bag, etc.

Electrical drain time after the battery power has been disconnected could range from 30 seconds to 30 minutes.

For safety of the rescue personnel and the patient, the distance of 5" for side air bag, 10" for driver's air bag and 18" for passenger air bag should be maintained away from the bags.

#### Identify & Notify Resources (con't)

- Tactical Objectives for Extrication
  - Scene Safe / Fire Suppression
  - Vehicle stabilization
  - Create safe access for EMS
  - Safe disentanglement of patient
  - Assist EMS



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#### Identify Hazards

- Air bag systems
  - Logos
    - SRS, SLR, airbag, side airbag, knee impact airbags, head impact airbag, head curtain bag, etc.
  - Electrical drain time
    - After battery disconnected
      - » 30 seconds - 30 minutes
  - Safety distances
    - » Keep space between rescuers / patients
      - » 5" - side airbags
      - » 10" - drivers airbag
      - » 18" - passengers airbag

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# STUDENT MANUAL TECHNICAL RESCUE AWARENESS VEHICLE / MACHINERY

There are four major types of fuels used in vehicles.

Gasoline is the most used fuel found in most vehicles. Gasoline is a flammable fuel.

Diesel fuel systems is very popular in the trucking and farming industry. Diesel is a combustible fuel and will often have a large quantity on board the vehicle.

Compressed natural gas or liquefied petroleum gas systems are not too widely used. These systems may be found in forklift trucks and natural gas company vehicles. The trucks and cars will be marked to indicate that it is powered by that gas. This type of system will have heavy, high pressure tanks on the vehicle.

Electrical cars are becoming more common. The largest concern for electrical cars is the presence of high voltage batteries and acid.

Hydraulic shocks, absorbing bumpers, hatch back, hood pistons and hydraulic suspension systems that are found on cars, vans and trucks can be very explosive under a fire condition. Bumpers have been known to be launched as far as 100 feet or could wrap around the vehicle.

Vehicle battery - the location of the batteries in cars could be under the hood (high or low -hidden), under the back seat, or in the trunk. The power cable will run along or in the rocker panel. On trucks, the batteries will be in the battery box, under the hood or in the wheel wells.

## Identify Hazards (con't)

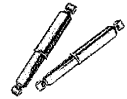
- Fuel systems
  - Gasoline
  - Diesel
    - Large quantities
  - Compressed natural gas or LPG
  - Electrical systems
    - Electric cars / industrial machines
      - » Battery acid
  - Hybrid Vehicles
    - Capacitors used for energy surge



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## Identify Hazards (con't)

- Hydraulic shocks
  - Absorbing bumpers
    - Bumpers have been known to be launched as far as 100 feet or could wrap around the vehicle.
  - Hood / hatch back pistons
- Battery locations
  - Under hood (high or low)
  - Under back seat
  - Trunk
  - Wheel wells



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# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### VEHICLE / MACHINERY

The seat belt pretensioner is a device that will draw the person back into the seat on a frontal accident. The location of the pretensioners ( if equipped ) will be in one of the following places:

- B post (low or mid point)
- C post (low)
- Inner front or rear seat buckler area

In the machinery rescue area, the use of gears, chains, pulleys, augers and conveyor belts are very extensive. The use of these items in manufacturing, farming, material movement, etc. are quite common. There are some basic items to be aware of:

The power source could be electrical, motor, air driven or hydraulic.

This equipment is very rugged in its construction. There could be a chemical hazard because of the equipment's usage. The accident could be in a remote area.

There could be a time delay getting to the scene.

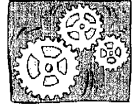
Great caution should be used because of stored potential energy or full cycle machinery which may continue to move or complete cycle after power is removed.

When shutting down machinery, the lock out/ tag out procedure should be used.

When disassembling of equipment is needed, the assistance of the maintenance man would be of great help.

#### Identify Hazards (con't)

- Seat belt pretensioners
  - Low and mid B post
  - C post low
  - Inner front and rear seat bucklers
- Gears, chains, pulleys, augers & conveyor belts
  - Power source
    - Electric, motor, air or hydraulic
    - Lock out / tag out
  - Rugged construction
  - Chemical hazards
  - Stored potential energy
  - Full cycle machines



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#### **CAUTION!**

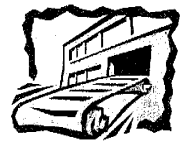
*Beware of stored potential energy or full cycle machinery*

*Example: machinery that continues to move after power is removed*

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#### Identify Hazards (con't)

- Gears, chains, pulleys, augers & conveyor belts (cont)
  - Remote areas
    - Delay getting to patient
  - Disassembly of machines
    - Maintenance personnel
      - » Very helpful



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# STUDENT MANUAL

## TECHNICAL RESCUE AWARENESS

### VEHICLE / MACHINERY

#### Initial Awareness Actions

- 1) The scene protection at an auto accident can be achieved by utilizing the apparatus in controlling the traffic. It may also be achieved by using traffic cones, flares and other devices. When a machinery accident occurs, the rescuer can control the movement of personnel by traffic cones, caution tape, locking doors, etc.
- 2) The access to the vehicle involved in an accident can be as simple as opening the door with the car's handle. More entailed equipment should be used by trained personnel. Access into machinery can be as simple as unscrewing an access panel.
- 3) Stabilization of a vehicle can be achieved by the rescuers by putting the vehicle in park or apply the parking brake. The use of basic cribbing can also achieve stabilization. When dealing with machinery, just shutting off the power may not stabilize the equipment.
- 4)

#### Scene Control at an Incident

- 1) Traffic needs to be controlled for the safety of the rescue personnel. Crowds could restrict the rescuers' activities at the scene
- 2) Machine can be controlled in two ways: Electrical power can be shut down and locked out at the main electrical box and mechanical power (hydraulic, pneumatic or motor) can be shut down and locked out.

**CAUTION:** Beware of stored potential energy or full cycle machinery

**EXAMPLE:** Machinery that continues to move after power is removed or must complete a full cycle or operation.

#### Vehicle & Machinery Rescue

- Awareness Level Personnel may assist with:
  - Scene safety
    - Protection of rescuers #1 priority
    - Control access
  - Clear initial access to vehicle or machine
  - Assist with initial stabilization
    - Cribbing

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# STUDENT MANUAL TECHNICAL RESCUE AWARENESS VEHICLE / MACHINERY

## Vehicles & Machinery Summary

- Recognize the need for vehicle and machinery search and rescue.
- Identify the resources necessary to conduct safe and effective operations.
- Identify the emergency response system for vehicle and machinery incidents.
- Describe the need for control at the scene of a vehicle or machinery incident.
- Identify the general hazards associated with vehicle and machinery rescues.
- Identify crowd control procedures.

### Size-up

- Establish need for Technical Rescue
- Identify number and location of patients
- Establish scene control
- Establish traffic control
  - Rescuer safety
- Crowd control
  - Crowds restrict rescuers' activities
- Verify machines rendered safe
  - Shut off power
    - Main disconnect(s)
      - Lock out / tag out

FIRE LINE DO NOT CROSS

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### Vehicle & Machinery Summary

- Recognize the need for vehicle and machinery search and rescue.
- Identify the resources necessary to conduct safe and effective operations.
- Identify the emergency response system for vehicle and machinery incidents.

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### Vehicle & Machinery Summary

- Describe the need for site control and scene management at vehicle or machinery incident.
- Identify the general hazards associated with vehicle and machinery rescues.
- Identify traffic / crowd control procedures.

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# STUDENT MANUAL TECHNICAL RESCUE AWARENESS WILDERNESS SEARCH

Define Wilderness: Wilderness is generally defined as a natural environment on Earth that has not been modified by human activity.

Will searches always take place in the wilderness?

## Introduction

National Search and Rescue Plan established in 1956. Updated 1999.

The National Search and Rescue plan designates the United States Coast Guard as the federal agency responsible for maritime SAR and the United States Air Force as the federal agency responsible for inland SAR.

Most Wilderness Searches are handled by local agencies and do not require a national level response.

## DEFINE SAR "Search And Rescue"

- The process of locating lost, missing, or overdue individuals and removing them from danger.
- SAR is a service not a hobby

## SAR RESPONSIBILITIES

- US Coast Guard: Responsible for maritime search on waterways.
- US Air Force: Responsible for inland SAR operations.
- Department of Interior: Responsible for national parks.
- Department of Agriculture: Responsible for US forest land.
- Bureau of Land Management: Responsible for all other US owned land.





# STUDENT MANUAL TECHNICAL RESCUE AWARENESS WILDERNESS SEARCH

## Indiana Department Of Homeland Security

The Indiana Department of Homeland Security operates Search and Rescue support functions. Resources from the state should be requested through your local Emergency Management Agency.

- Training
- Response
- Support

## Search Training is a 3 Tier System.

- Awareness
- Operations
- Technician

## Local Search and Rescue Jurisdiction

Indiana law changed July 2007 requiring that all missing persons, adult and child, runaways and abductions must have immediate police response and an investigation conducted by the Law Enforcement Agency that it occurred in. Law Enforcement has overall responsibility for missing persons.

Remember All Missing, Abduction and Runaway scenes are considered crime scenes.

### INDIANA DEPARTMENT OF HOMELAND SECURITY

- The Indiana Department of Homeland Security operates Search and Rescue support functions. Resources from the State should be requested through your local Emergency Management Agency.
  - Training
  - Response
  - Support

### INDIANA SAR PLAN

- Title 10 of the Indiana Code makes reference to disaster SAR, only.
- There is currently no plan for Civil SAR.



# STUDENT MANUAL TECHNICAL RESCUE AWARENESS WILDERNESS SEARCH

## What are you searching for?

- Elderly Walkaways
- Alzheimer's Patients
- Despondents

## Drug-Affected

- Missing Children
- Mentally Retarded
- Lost Hikers
- Disaster Related Search
- Response to Criminal-Abduction and fugitive Incidents

## What should you not do as a first responder.

- Conduct interviews without Law Enforcement
- Conduct investigation
- Walk in potential crime scenes
- Law Enforcement is the best resource to obtain information and secure a scene.

## Recognize the need for Search and Rescue

Upon your arrival it has been determined jointly by Fire and Police that information gathered indicates that a person is missing. If local trained assets are not on the scene a pre-determined response plan should be placed into action.

## Initiating Site Control and Scene Management

The Incident Command System (ICS) is the preferred method of on-scene incident management for all SAR operations.

- All Search & Rescue operations will be managed by the concepts of the Incident Command System (ICS)/National Incident Management Systems (NIMS), with the responsible Law Enforcement Agency as the Command Agency.

## WHAT ARE YOU SEARCHING FOR

- Elderly Walk-aways
- Alzheimer's Patients
- Despondent's
- Drug-Affected
- Missing Children
- Mentally Retarded
- Lost Hikers
- Disaster Related Search
- Response to Criminal-Abduction and fugitive Incidents

## WHAT YOU SHOULD NOT DO AS A FIRST RESPONDER

- Conduct interviews without Law Enforcement
- Conduct investigation
- Walk in potential crime scenes
- Law Enforcement is the best resource to obtain information and secure a scene.



## INITIATING SITE CONTROL AND SCENE MANAGEMENT

- The Incident Command System (ICS) is the preferred method of on-scene incident management for all SAR operations.
- All Search & Rescue operations will be managed by the concepts of the Incident Command System (ICS)/National Incident Management Systems (NIMS), with the responsible Law Enforcement Agency as the Command Agency.



# STUDENT MANUAL TECHNICAL RESCUE AWARENESS WILDERNESS SEARCH

## Initial task of first in agencies

- Establish ICS
- Evaluate search urgency
- Obtain lost person report
- Determine type of response
- Determine available resources
- Determine probable search area

## Site Control

- Non-Emergency Personnel
- Self Dispatched Agencies or Individuals
- Search Dogs
- Isolation of Family

## There are four core elements in Wilderness SAR operations:

1. Locate the victim
2. Access the victim
3. Stabilize the victim
4. Transport the victim

Many times in a wilderness search and rescue, the time is spent in trying to locate the victim. Due to this time in determining the location of the victim, the other areas might have to be reduced for survivability.



## SITE CONTROL

- Non-Emergency Personnel
- Self Dispatched Agencies or Individuals
- Search Dogs
- Isolation of Family



## CORE ELEMENTS

- Locate the victim
- Access the victim
- Stabilize the victim
- Transport the victim



# STUDENT MANUAL TECHNICAL RESCUE AWARENESS WILDERNESS SEARCH

There are seven (7) components that are used to complete the elements of a SAR operation:

1. **Pre-planning** - The Organization and Management Guidelines. Includes call-out procedures/guidelines and equipment.
2. **Notification** - We have to be notified of a problem before we can handle it.
3. **Planning and Strategy** - The process of gathering information so that an assessment can be done.
4. **Tactics** - Type of response or solution to handle the problem.
5. **Operations** - The field phase where the tactical solutions are carried out.
6. **Suspension** - Operation is discontinued.
7. **Post Incident Analysis** - Evaluation of the participants, methods and strategies.

## Valuable resources in wilderness search and rescue:

- Search dogs are able to cover a tremendous amount of area in a short period as compared to humans.
- Trackers are trained to look for clues and many times familiar with the area.
- Aircraft is able to cover a large area and technology allows the crew to search more in depth.
- Ground air search specialist.
- Rope rescue specialists.
- Water rescue specialists.
- Trench rescue specialist.
- Collapse rescue specialist

## Types of Search K-9's

- Air scent
- Trailing
- Cadaver / Human Remains
- Disaster
- Articles



## RESOURCES

- Search dogs
- Trackers
- Aircraft
- Ground / Air search specialist
- Rope Rescue Specialist
- Water Rescue Specialist
- Trench Rescue Specialist
- Collapse Rescue Specialist



## TYPES OF SEARCH K-9's

- Air scent
- Trailing
- Cadaver / Human Remains
- Disaster
- Articles



# STUDENT MANUAL TECHNICAL RESCUE AWARENESS WILDERNESS SEARCH

Calculating search urgency is a tool that can be used to determine the response that is going to be given to a search and rescue. The following factors are taken into consideration: (See Relative Urgency Rating form)

- Subject Profile
- Weather Profile
- Equipment Profile
- Subject Experience Profile
- Terrain and Hazards Profile
- History of Incidents in this area
- Bastard Search (see definition in front of book)

**Note:**     **The lower the value of each factor and of the sum of all factors, the more urgent the situation. ( See Relative Urgency Rating Factors Sheet)**

**There are three broad types of responses used dependant on search urgency.**

- 1)     **Emergency Response** - Based on information, convinced death or serious injury could occur if help does not arrive.     Blitz or Hasty Team - minimum number of experienced rescuers that are sent out to locate the victim. This is followed by a support team with additional equipment. The margin of safety is fairly narrow and a perceptible amount of risk involved in the necessary response.
- 2)     **Measured Response** - based on when appropriate information on hand is insufficient to dictate the exact outline of a search and rescue action plan.
- 3)     **Evaluative Response** - Occurs when the reported problem is unconfirmed or seems likely to resolve itself.



The lower the value of each factor and of the sum of all factors, the more urgent the situation.



# STUDENT MANUAL TECHNICAL RESCUE AWARENESS WILDERNESS SEARCH

## **Isolating witnesses or reporting parties**

Lost person searches are very stressful events for everyone, but especially for the family and friends involved.

Unfortunately, everyone who walks up to offer assistance wants to loiter around the family or the witnesses and ask questions.

The family members then end up answering the same questions over and over and over.

Move the witnesses or family members to areas where they will not be disturbed by bystanders and responders.

This provides the interviewer with the best setting to obtain information.

Buildings, Tents, or Response vehicles can be used.

## **Lost person(s) report**

This goal of interviewing and obtaining information from participant(s) or witnesses is to devise an effective course of action.

Each lost person receives a file.

Part I - Is information that is critical in determining decisions of the initiation phases of a search.

Part II - May be significant later in the mission.

As with any rescue operation rescuers are faced with certain hazards. There are four general hazards associated with wilderness SAR operations:

1. **Personal Hazards** include blisters, scrapes, scratches, falls, blows, bruises, dehydration, etc.
2. **Environmental Hazards** include insect bites and stings, poisonous plants, exposure injuries, snow-blindness, altitude illness, lightning, sunburn, dangerous wildlife, etc.
3. **Terrain Hazards** include cliffs, avalanches, standing water (e.g., ponds, lakes), flat ice (e.g., ponds, lakes), moving water, caves, mines, wells, high winds, snow, coastal white water surf, etc.



# STUDENT MANUAL TECHNICAL RESCUE AWARENESS WILDERNESS SEARCH

4. **Man-Made Hazards** include booby-trapped stills and labs, hazardous materials dumps, trained attack dogs, etc.

**There are four basic methods of establishing a probable search area:**

1. **The Theoretical Method.** The probable search area is generated in this method by using tables that express the area as a function of distance traveled by the lost subject. This necessitates a reliable determination of the Point Last Seen (PLS). The area's boundary is a circle drawn on the map centered on the PLS. The length of its radius is the maximum distance the victim could have journeyed in that terrain in the time elapsed since he was last seen.
2. **The Statistical Method.** Case studies of people in the wilderness provide the data for this method.
3. **The Subjective Method.** Historical data, intuition, the location of the natural barriers and clues, and consideration of the physical and mental limitations of the victim are taken into account.
4. **The Mattson Method.** Balances subjective and objective information and uses individual personnel to view their probable search area independently, then combining their percentage of where he/she thinks they are to the rest of the group. The total percentage from all personnel involved is added and the greatest percent is where the search will be started.



# STUDENT MANUAL TECHNICAL RESCUE AWARENESS WILDERNESS SEARCH

Three types of search tactics used to search for the victim(s):

**Type I** (Detection Phase) - Hasty Teams (Minimum number of experienced rescuers that are sent out to locate the victim)

**Type II -** Open Grid is relatively fast, efficient search of locales of high probability using methods that produce the highest results per hour using search dogs, wide search patterns flown by aircraft, and open grid sweep searches. with three to seven searchers widely spaced at approximately 300-600 feet.

**Type III -** Close grid

- 30 searchers
- Walk a line 15-20 ft. apart
- Maybe less for evidence recovery





# STUDENT MANUAL TECHNICAL RESCUE AWARENESS WILDERNESS SEARCH

## Wilderness SAR Summary

- Recognize the need for wilderness search and rescue.
- Identify the emergency response system of wilderness search and rescue incidents.
- Identify site control and scene management procedures for wilderness search and rescue incidents.
- Recognize the general hazards associated with wilderness search and rescue incidents.
- Recognize the type of terrain involved in wilderness search and rescue incidents.
- Recognize the limitations of conventional emergency response skills and equipment in various wilderness environments.
- Identify the collection and recording information necessary to assist operational personnel in wilderness search and rescue.



**STUDENT MANUAL  
TECHNICAL RESCUE AWARENESS  
WILDERNESS SEARCH**





# STUDENT MANUAL TECHNICAL RESCUE AWARENESS TRENCH

**NIOSH** Conducts research on various safety & health problems

## Trench & Excavation Fatalities 1992-2001:

- 452 Fatalities
- 54 per year average
- 76% of the fatalities occurred from cave-ins

## Human Nature

OSHA statistics are riddled with workers who have been disemboweled or decapitated by backhoes, and would-be rescuers are frequently buried in secondary collapses. **In fact, as many as 65% of all deaths in trench cave-ins are would-be rescuers.** Trench rescues are a risk in all jurisdictions, however are not common occurrences.

## Facts You Should Know

- 1,000 to 4,000 injuries per year
- Most deaths occur in trenches 5 ft to 10 ft in depth



## NIOSH

- ◆ Conducts research on various safety & health problems

Trench & Excavation Fatalities 1992-2001:

- ◆ 452 Fatalities
- ◆ 54 per year average
- ◆ 76% of the fatalities occurred from cave-ins

## Human Nature

- ◆ Would-be rescuers jump in & start digging
- ◆ Backhoe operators try to dig victim out
- ◆ *As many as 65% of all deaths in trench cave-ins are would-be rescuers.*

## Facts You Should Know

- 1,000 to 4,000 injuries per year
- Most deaths occur in trenches 5 ft to 10 ft in depth

### Causes of Death:

◆ Excavation/trenching/cave-in	411	75.8%
◆ Struck by Object	35	6.5%
◆ Struck by vehicle/equipment	19	3.5%
◆ Caught in or compressed by equip.	14	2.6%
◆ All others	63	11.6%

◆ Leading cause in excavation/trenching/cave-in - suffocation



# STUDENT MANUAL TECHNICAL RESCUE AWARENESS TRENCH

## Causes of Death:

Excavation/trenching/cave-in	411
75.8%	
Struck by Object	35
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All others	63
11.6%	

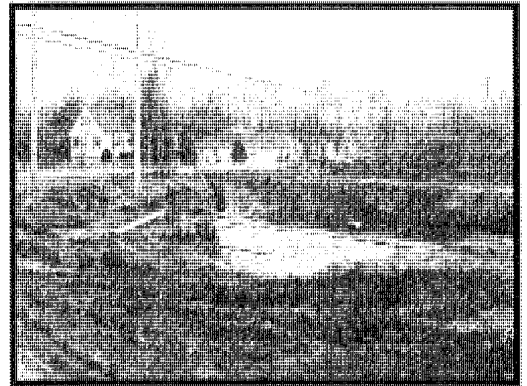
## Excavation

Man-made cavity or depression in the earth's surface, which may include any excavation from basements to highways. **Excavations are wider than they are deep**

**Excavation**

Man-made cavity or depression in the earth's surface which may include any excavation from basements to highways. **Excavations are wider than they are deep**

5



# STUDENT MANUAL TECHNICAL RESCUE AWARENESS TRENCH

## Trench

Temporary excavation in which the length of the bottom exceeds the width of the bottom (generally limited to excavations that are less than 15 feet wide at the bottom and less than 20 feet deep); narrow excavation (in relation to the length) made below the surface of the ground. **Trenches are deeper than they are wide**

## Terms to Know

Angle of repose	Safing
Sloping	Compact soil
Spoil pile	Excavation
Disturbed soil	Tension cracks
Saturated soil	Trench
Running soil	Virgin soil

*These are only a few of the terms you need to know*

## Soil Facts to Consider

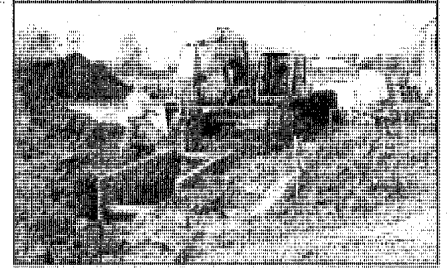
What is the average weight of a cubic foot of soil?  
(1 foot long X 1 foot wide X 1 foot deep = 1 cubic foot)

**Cubic foot:** 100 or more pounds depending on moisture content, air, etc.

**Cubic yard:** about 3000 pounds (1-1/2 tons)

Weight of average small Collapse approximately 4000 lbs. (two tons)

## A trench according to OSHA



## Terms to Know

Angle of repose	Safing
Sloping	Compact soil
Spoil pile	Excavation
Disturbed soil	Tension cracks
Saturated soil	Trench
Running soil	Virgin soil

*These are only a few of the terms you need to know*

## Soil Facts to Consider



# STUDENT MANUAL TECHNICAL RESCUE AWARENESS TRENCH

## Facts

Most trench incidents occur between 5' to 10' in depth & less than 6' wide.

Clay looks strong, but is very deceptive.

## Soil

	<u>Number of Failures</u>
Clay and/or mud	32
Sand	21
Wet Dirt (probably silty clay)	10
Sand, gravel and clay	8
Rock	7
Gravel	4
Sand and gravel	2

## **Trench Requirements**

> 4ft you must ladder

> 5ft you must shore

Ladder within 25' reach

Ladder must extend 3' above lip of trench

## Facts

◆ Most trench incidents occur between 5' to 10' in depth & less than 6' wide.

◆ Clay is the least dangerous!!  
True or False

Clay looks strong, but is very deceptive.

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## Soil and Wall Collapse

<u>Soil</u>	<u>Number of Failures</u>
Clay and/or mud	32
Sand	21
Wet Dirt (probably silty clay)	10
Sand, gravel and clay	8
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## Trench Requirements

◆ > 4 ft you must ladder

◆ > 5 ft you must shore

◆ Ladder within 25' reach

◆ Ladder must be extend 3' above lip of trench

14



# STUDENT MANUAL TECHNICAL RESCUE AWARENESS TRENCH

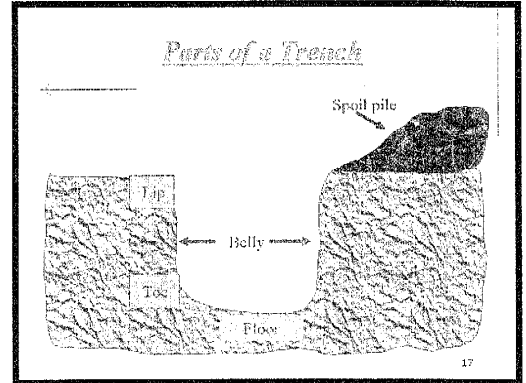
## Parts of a Trench

Lip	Toe
Floor	Belly
Spoil Pile	

### Slough-In (Belly In)



### Sidewall-In (Side Wall Shear)



## Visual Check

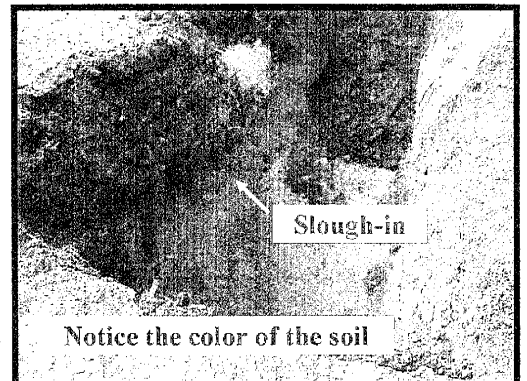
**LOOK:**  
At, In & Around  
Trench for Soil  
Characteristics

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## Types of Collapses

- ◆ Slough-in (Belly In)
- ◆ Sidewall-in (Side Wall Shear)
- ◆ Shear-in (Lip Slide)
- ◆ Spoil-in (Spoil Pile Slide In)

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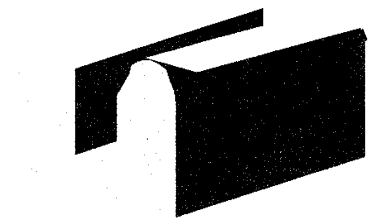


# STUDENT MANUAL TECHNICAL RESCUE AWARENESS TRENCH

Shear-In (Lip Slide)



Spoil-In (Spoil Pile Slide In)



## Vibration

Vibration is extremely destructive to trench stability. Vibration will speed-up the collapse of the walls, and will magnify any other factors, which are affecting the trench. The most common sources of vibration are the digging operations themselves and vehicles passing by. Other sources to consider are trains, processing operations from nearby industry, and motors running near the trench. Vibration is particularly dangerous at rescue scenes, but is usually a factor, which can often be controlled. Rescuers must be careful to not add vibration to a scene by careless use of vehicles, generators, or other equipment.



## Vibration

- ◆ Extremely dangerous
- ◆ Typical sources
- ◆ Roadways
- ◆ Railroads
- ◆ Digging operations
- ◆ Nearby construction/industry



# STUDENT MANUAL TECHNICAL RESCUE AWARENESS TRENCH

## Stop sources of vibration

Vibration contributes significantly to the likelihood of further collapses. *Eliminate sources of vibrations by stopping traffic for at least 300 feet.* Search for other possible sources of vibration such as train tracks, nearby industry, or machinery operating near the site and shut down these operations.

## Superimposed loads

- ◆ Add weight & stress to trench
- ◆ Examples
  - Spoil pile
  - Heavy equipment
  - Work materials (cable, vaults, pipe)
  - People

## Surface Encumbrances

- ◆ Other structures whose support relies on the soil at or near the trench
- ◆ Examples
  - Roadways
  - Utility poles
  - Foundations

## Environmental factors affecting trench stability

## Superimposed Load



## Surface Encumbrances

- ◆ Other structures whose support relies on the soil at or near the trench
- ◆ Examples
  - Roadways
  - Utility poles
  - Foundations



# STUDENT MANUAL TECHNICAL RESCUE AWARENESS TRENCH

## Wet soils (saturated) / Submerged Soils

Wet soils of any type are dangerous due to the added weight of the water, the loss of friction due to the moisture, and the mechanics of the movement of the water through the soil. Trenches, which have been dug below the water table, will "draw" water into the open hole. Water seeping into the trench will undermine the trench walls pulling them into the trench. This will lead to wall collapse, entrapment and/or drowning of anyone in the trench.

## Exposure to Elements

Time the longer the trench is open, the more unstable it will become

Sun and wind will dry out the soil allowing cracks to develop

Freezing and thawing will work soil loose and develop cracks

## Previously disturbed soils

The most stable soils are those, which have gone undisturbed for thousands of years. Each grain of soil was dropped or blown into its position creating a "locking" effect between grains. Once the earth has been disturbed, it is impossible to return it to its original stability. Excavation within last 25 yrs is disturbed.

### Wet Soils/Submerged Soils

- ◆ Added weight
- ◆ Loss of friction
- ◆ Movement of water carrying soil
- ◆ Standing water undermining trench walls

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### Exposure to Elements

- ◆ Time - longer trench is open the more unstable it will be
- ◆ Sun and wind
- ◆ Freezing / Thawing

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**Previously disturbed soils are common due to trenches being located in easements**

**Excavation within last 25 years makes soil previously disturbed**

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# STUDENT MANUAL TECHNICAL RESCUE AWARENESS TRENCH

## Buried utilities (Call 811 in Indiana)

Trenches are excavated to allow for the installation of various utilities. Since most utilities run in easements, it is almost certain that some form of underground utility will be encountered during excavation.

### Buried Utilities

- ◆ Must be located
- ◆ Often requires time-consuming hand digging
- ◆ Common problem since most trenches are located in easements
- ◆ OSHA requires that all utilities or other structures exposed in trenches be properly supported.

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### Call 811

Two working days before you dig

#### MARKINGS COLOR CODE

##### Communications

Electric

Red

##### Excavation Boundaries

Natural Gas

Sewer

Green

Water

Blue

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## Secondary collapses

By far the most lethal hazard in trench rescues is the likelihood of secondary collapse. Once a collapse has occurred, the remaining sections of trench wall will have much less stability. The fallen section of dirt typically leaves a larger section unsupported, which in-turn fails, which leaves an even larger section unsupported, which also fails. Unfortunately, these secondary collapses seem to occur just about the time that a rescuer is attempting to dig out the initial victim and are responsible for the high number of rescuer deaths.

### Secondary Collapses

- ◆ Walls are undermined from initial collapse
- ◆ Walls are often left more unstable than before initial collapse
- ◆ Often occur while "quick" rescue attempt is being made

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# STUDENT MANUAL TECHNICAL RESCUE AWARENESS TRENCH

## Speed of Collapsing Dirt.

Studies have shown that *trench walls often collapse in less than 1/10th of a second*. A well-intentioned rescuer who thinks that he can climb out, or can be pulled-out by a rope before a collapse catches him, is inviting trouble.

## Rescues are usually long operations

People who are buried in cave-ins are usually "frozen" in the position they were in when the collapse occurred. Often arms and legs are bent at odd positions and in many cases, the victim has suffered fractures. Victims cannot merely be pulled-out from under the dirt. Therefore, *the victim must be completely uncovered before he can be removed from the trench*. Attempting to "yank" a victim will only result in additional injury, and will not release the victim. Most rescues require as much as 4-10 hours to complete.

## Trenches dug too deep or too wide

OSHA provides guidelines for the general construction of trenches up to 20 feet deep and 15 feet wide. Excavations beyond these dimensions require special engineering by a Registered Professional Engineer (RPE).

### Speed of Collapsing Dirt

- ◆ Often less than 1/10 of a second
- ◆ Normal escape methods ineffective
- ◆ Being pulled out with a rope
- ◆ Running out

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### Rescues are Usually Long Operations

- ◆ Commonly last 4-10 hours
- ◆ Victims must be completely uncovered before removed
  - ↳ Often frozen in position
  - ↳ Limbs commonly bent at odd angles
  - ↳ Fractures are common

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### Contractors Often Ignore OSHA Limits

- ◆ OSHA only provides regulations for trenches up to 20' deep; deeper requires special engineering
- ◆ Contractors who have ignored safety requirements may have also ignored the 20' limit

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# STUDENT MANUAL TECHNICAL RESCUE AWARENESS TRENCH

## OSHA regulations

OSHA has published regulations dealing with trenches in 29 CFR Part 1926, subpart P. This standard regulates the construction and occupation of trenches over 5 feet deep and shallower trenches with special hazards. These regulations apply to rescuers as well as workers.

Indiana has adopted OSHA regulations through the Indiana Department of Labor.

## PROTECTIVE SYSTEMS

OSHA provides three methods for protecting workers in trenches...sloping/benching, shielding, and shoring. No worker is to enter a trench greater than 5 feet deep unless one of these protections is in place.

## Types of Worker Protective Systems

- ◆ Sloping
- ◆ Benching
- ◆ Shielding
- ◆ Shoring

### Determined by:

- ◆ Soil class
- ◆ Workspace required
- ◆ Economic factors



## State Level

- ◆ Follow OSHA regulations
  - 29 CFR 1926 Subpart P - Excavation
- ◆ Must adopt equal or more stringent regulations

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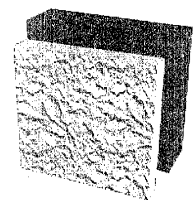
## Indiana

- ◆ Is an OSHA State
  - Federal OSHA - Oversees State Program
  - IDOL governs state & municipal employees
- ◆ Has adopted-by-reference Federal OSHA regulations
  - 29 CFR Part 1926
- Failure to comply results in large fines

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## Types of Worker Protective Systems

- ◆ Sloping
- ◆ Benching
- ◆ Shielding
- ◆ Shoring



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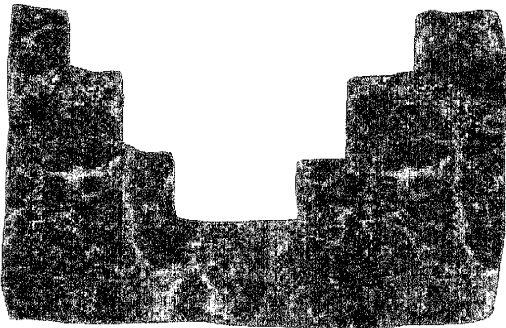
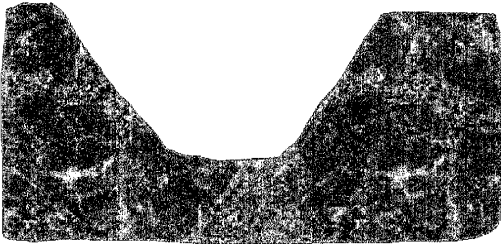


# STUDENT MANUAL TECHNICAL RESCUE AWARENESS TRENCH

## Sloping/Benching

Sloping involves cutting back the sides of a trench to an angle at which the earth will no longer slide. OSHA defines sloping angles for each class of soil. The angle, which is sought, is referred to as the "**angle of repose**" and is merely the angle at which the soil will no longer slide.

- For departments with no equipment.
- Best for recovery, not rescue
- Tabulated data sheet is used as guide



## Sloping Principles

- ◆ Laying back soil to its Angle of Repose
- ◆ Requires opening a lot of land
- ◆ Only option in some soils



# STUDENT MANUAL TECHNICAL RESCUE AWARENESS TRENCH

## Shielding Principles

Shielding involves the use of extremely strong metal boxes, which have been engineered to withstand the pressure of the earth for the size trench that is being worked in. Trench shields (also called trench boxes) are strong enough to protect a worker from cave-ins as long as the worker stays within the shield. Trench shields must be installed no more than 2 feet off the bottom of the trench and even with or above the trench lip.

### Two basic types of shields:

- Steel, non-adjustable
- Aluminum, adjustable

## Shoring Concept

Shoring is a method of protecting the worker by constructing a support system within the trench, which will pressurize the trench walls, enough to create "arches" of support, which will hold-up the trench walls. *Shoring is designed to be strong enough to stop the walls from starting to move, but is not designed to be strong enough to stop moving dirt.*



## Shielding Principles

- ◆ Strong metal "boxes" designed to withhold the pressure of collapsing soil
- ◆ Must be engineered for size trench & soil class
- ◆ Must be level with or extend above lip of trench.
- ◆ Must not be more than 2' up off the bottom
- ◆ Usually dragged down a trench - worker may be inside as long as no lifting is required

48

## Two basic types of shields

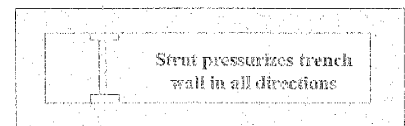
- ◆ Steel, non-adjustable
- ◆ Aluminum, adjustable

Manual  
Hydraulic  
Pneumatic

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## Shoring Concept

- ◆ Works by creating "double funnel effect"



- ◆ Strong enough to prevent soil from starting to move, but not strong enough to stop moving dirt

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# STUDENT MANUAL TECHNICAL RESCUE AWARENESS TRENCH

Shoring systems may be constructed with a variety of materials and may be constructed in a variety of configurations. The simplest system contains two elements, crossbraces and uprights. The crossbraces pressurize the walls while the uprights distribute the pressure vertically. As more strength is required, additional elements are added to strengthen the system, much like beams are added to a structure. These beam-like members are called walers.

OSHA provides charts for timber shoring and hydraulic shoring for dry trenches up to 15 feet wide and 20 feet deep. Manufactured Shoring Systems come with documentation of component strength for various conditions. This documentation is prepared by a registered professional engineer and is called Tabulated Data.

In general, the weaker, deeper and wider the trench, the stronger and more numerous the shoring members must be.

## Specific Types of Shores

- ◆ Manufactured Shoring systems come with documentation of component strength for various conditions. This documentation is prepared by registered professional engineer and is called Tabulated Data. Which should be referenced frequently.



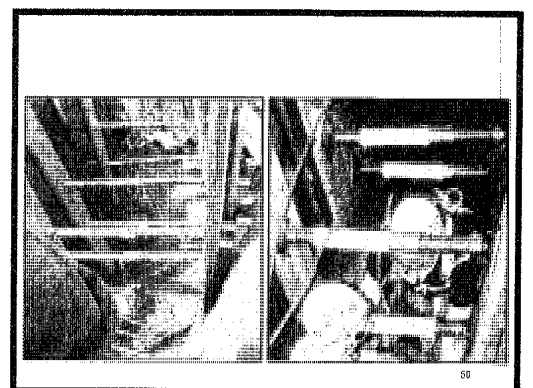
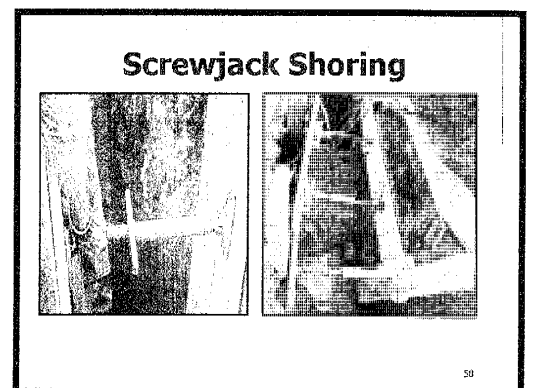
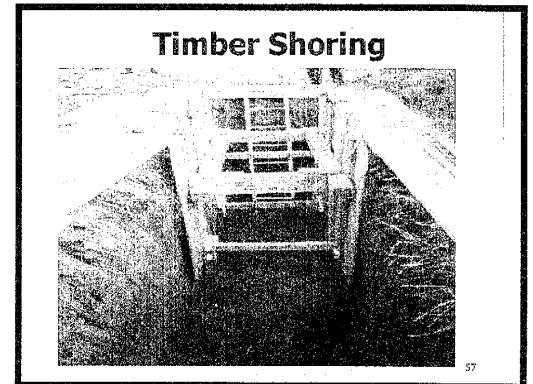
# STUDENT MANUAL TECHNICAL RESCUE AWARENESS TRENCH

## Specific Types of Shores

- Timber
- Screw jack
- Pneumatic

## Pneumatic

- ◆ Most expensive
- ◆ Air driven with locking collar & pin
- ◆ Limited working range
- ◆ Relies on OSHA timber charts for uprights & walers



# STUDENT MANUAL TECHNICAL RESCUE AWARENESS TRENCH

## Size- Up Considerations for Rescue Operations

Depth of Trench  
Soil Type  
Entry Point  
Weather Conditions  
Width of Trench  
Spoil Pile  
Exit Point  
Level of Training

Water Content  
Impact of Loads  
Location of Victims  
Angle of Repose  
Supports in place  
Manpower  
Equipment Availability  
Gathering of Information  
EMS (life support)

### Size –Up Considerations

- ◆ Depth of Trench
- ◆ Width of Trench
- ◆ Soil Type
- ◆ Spoil pile
- ◆ Entry point
- ◆ Exit point
- ◆ Weather conditions
- ◆ Level of Training

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### Size –Up Considerations (cont)

- ◆ Water content in Trench
- ◆ Impact of nearby LOADS
- ◆ Location of Victim(s)
- ◆ Angle of Repose
- ◆ Supports in place

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### Size –Up Considerations (cont)

- ◆ Manpower
- ◆ Equipment availability
- ◆ Witness Information
- ◆ EMS (life support)

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# STUDENT MANUAL TECHNICAL RESCUE AWARENESS TRENCH

## Secure Immediate Area

- Prevent use of heavy equipment
- Stop sources of vibration within 300'
- Set-up Zones (Hot, Warm, Cold)
- Attempt to locate and mark victim location

### **Do not allow the use of heavy equipment**

Do not allow the contractor to use his backhoe to try and uncover the victim. This will most likely only injure the victim further and bury him deeper when the vibration causes more of the walls to collapse.

## Personal protective equipment

At minimum:

- Head Protection (Construction Helmet)
- Eye Protection (Safety Glasses)
- Hand Protection (Leather Work Gloves)
- Foot Protection (Steel Toe / shank Boots)

## View Trench by Approaching from end

- Stay at least 10 feet away from incident site
- Inspect trench for spoil pile location (is it too close or steep?)
- Inspect walls for signs of impending or recent failure
- Evaluate both ends for possible hazards prior to approaching the open trench

## Secure Immediate Area

- ◆ Prevent use of heavy equipment
- ◆ Stop sources of vibration within 300'
- ◆ Set-up zones (Hot, Warm, Cold)
- ◆ Attempt to locate and mark victims position

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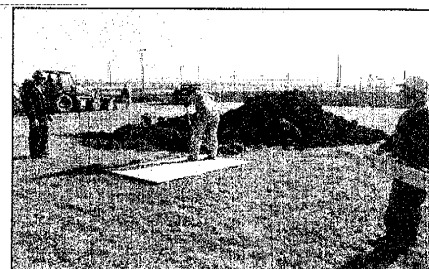


# STUDENT MANUAL TECHNICAL RESCUE AWARENESS TRENCH

## Establish Ground Pads if Available

Sheeting material or dimensional lumber

## Establish Ground Pads if Available



## Consider Non-Entry Rescue

Place ladder as soon as possible for non-entry rescue and emergency escape of responders who may fall into the trench

## Consider Non-Entry Rescue



## Air Quality Monitoring

May be considered confined space if dug in areas where air is bad.

Should monitor all trenches to be safe

## Air Quality Monitoring

- ◆ May be considered confined spaces if dug in areas where air is bad
- ◆ Should monitor all trenches to be safe



# STUDENT MANUAL TECHNICAL RESCUE AWARENESS TRENCH

## Establish Ventilation

Consider utilizing smoke ejectors to provide ventilation for victims

## Establish Ventilation



## Implement Water Removal Systems

### Pumps

Above ground level pumping

Monitor air in trench for CO from pumps

If contractor has a de-watering system going, keep it running unless it is unsafe

## Set up Pumps to De-Water the trench



## Attempt to Locate and Mark Victims Position

Throw a rope to victim if arms are free (have victim tie themselves off if possible)

Mark horizontal position within trench if possible

Measure and record trench depth at the victim

If no victim visible, mark soil level

## Attempt to Locate and Mark Victims Position

- ◆ Throw a rope to them if arms are free (have them tie themselves off if possible)
- ◆ Mark horizontal position within trench
- ◆ Measure & record trench depth at victim:
  - Tape measure
  - Pike pole or stick
- ◆ If no victim visible, mark soil level



# STUDENT MANUAL TECHNICAL RESCUE AWARENESS TRENCH

## Initiate Removal of Superimposed Loads

Use personnel with shovels to begin removing spoil pile at least 2' provided the lip is safe and groundpads are available to distribute the weight of personnel working near the lip.

## Have EMS Prepare for Injuries

Fractures, Lung injuries, Head injuries, Spinal injuries, Respiratory system injuries, Hypothermia, Crush syndrome.

## Steps to Trench Rescue

- Preparation
- Response
- Assessment
- Hazard Control
- Support Operations

## Steps to Trench Rescue

- Gaining Access
- Disentanglement
- Packaging
- Removal
- Termination

## Prepare for injuries

- ◆ Fractures
- ◆ Lung injuries
- ◆ Head injuries
- ◆ Spinal injuries
- ◆ Respiratory system injuries
- ◆ Hypothermia
- ◆ Crush syndrome

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## 10 Steps to Trench Rescue

- ◆ Preparation
- ◆ Response
- ◆ Assessment
- ◆ Hazard Control
- ◆ Support Operations

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## 10 Steps to Trench Rescue

- ◆ Gaining Access
- ◆ Disentanglement
- ◆ Packaging
- ◆ Removal
- ◆ Termination

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# STUDENT MANUAL

## TECHNICAL RESCUE

### AWARENESS

### TRENCH

#### **Trench & Excavation Summary**

- Recognize the need for trench and excavation rescue.
- Identify the resource necessary to conduct safe and effective trench and excavation emergency operations.
- Identify the emergency response system for trench and excavation incidents.
- Identify site control and scene management procedures for trench and excavation incident.
- Recognize the general hazards associated with trench and excavation emergency incidents.
- Recognize typical trench and excavation collapse patterns, the reasons trenches and excavations collapse, and the potential for secondary collapse.
- Identify how a rapid, non-entry extrication of non-injured or minimally injured victims is initiated.
- Recognize the unique hazards associated with the weight of soil and its associated entrapping characteristics.

