SECTION 7- THE FIRE SERVICE
UNIT 3 - FIRE SERVICE EQUIPMENT

UNIT GOAL
To introduce the student to the types of apparatus and equipment that is used by the modern fire service to control fires and other emergencies they respond to.

UNIT OBJECTIVES
The student by the end of the semester shall:
- Identify the following
  - Engine company
  - Truck company
  - rescue company
- Identify the types of equipment found on the following
  - Engine company
  - Truck company
- Identify the equipment typically worn by a firefighter

KEY TERMS

Engine Company	NFPA 1973, Gloves For Structural Firefighting For Firefighters
Truck Company	NFPA 1974, Protective Footwear For Structural Firefighting
Rescue Company	NFPA 1975, Station/work Uniforms
NFPA 1901, Standard for Automotive Fire Apparatus	NFPA 1981, Open-circuit Self-contained Breathing Apparatus For Firefighters
NFPA Standard 1961, Standard for Fire Hose	NFPA 1982, Personal Alert Safety Systems (PASS)
NFPA 1971, Protective Clothing For Structural Firefighting	NFPA 1983, Fire Service Life Safety Rope
NFPA 1972, Helmets For Structural Firefighting	

INTRODUCTION
As with any profession the tools of the trade are an important factor in how well the job is accomplished. In “manual” firefighting the tools can range from an axe to 110 aerial ladder. Depending on what job needs to be done will determine what tools will be used. If the fire is to be extinguished the tools will probably be hose, nozzles, and a pumper. If firefighters are removing victims from a burning structure they might use ground ladders, breathing apparatus, hand lights, hand tools, and possibly an aerial ladder. We can see that different tools are required for different jobs. The

first part of this unit will be a discussion on what the different types of firefighting equipment there is and what it is used for.

FIRE APPARATUS

ENGINE COMPANY

Historical Background

The first fire engines, which appeared in the 17th century, were simply tubs carried on runners, long poles, or wheels; water was still supplied to the fire site by a bucket brigade. The tub of the engine functioned as a reservoir. It sometimes housed a hand-operated pump that forced water through a pipe or nozzle. They were moved to the scene of a fire by human or animal power. In large fires, the bucket brigade method of water supply was inefficient, and the short range of the stream of water necessitated positioning the apparatus dangerously close to the fire. The introduction of more powerful pumps and flexible hose solved this problem. In 1654, Joseph Jencks was commissioned to build the first hand-operated fire engine in America. In 1721 and 1725, Richard Newsham, a British engineer, took out patents that resulted in much more powerful wheeled fire engines. They produced a continuous stream of water and allowed men to pump while simultaneously working the handles or a treadle. It was a reciprocating pump with two pistons driven alternately up and down by hand. It could produce a jet of water approximately 160 ft. high. A great advance in fire engine technology was made with the introduction of steam power. The world's first steam-driven fire engine was introduced in London in 1829 by Captain John Ericsson (1803–1889) and John Braithwaite (1797–1870). By the 1850s, it was in use in many large cities. Jon Braithwaite's 10 hp, two-cylinder steam pump of 1829 delivered 150 gallons a minute, was coal-fired, and was drawn by a single horse. America's first fire engine arrived from London in 1679 after a major fire in Boston. The first steam fire engine was built in the United States in 1840 by Paul R. Hodge, an Englishman living in New York. His fire engine also moved by steam power. Most steam pumpers were equipped with reciprocating piston pumps, although a few rotary pumps were used. Some were self-propelled, but most used horses for propulsion, conserving steam pressure for the pump. With the development of the internal-combustion engine early in the 20th century, pumpers became motorized. At first these engines were only used to drive the vehicle to the scene of a fire where the stream-driven pump was then employed. Also, because of problems in adapting geared rotary gasoline engines to pumps, the first gasoline-powered fire engines had two motors, one to drive the pump and the other to propel the vehicle. The first pumper using a single engine for pumping and propulsion was manufactured in the United States in 1907. By 1925, the steam pumper had been completely replaced by motorized pumpers. The pumps were originally of the piston or reciprocating type, but these were gradually replaced by rotary pumps and finally by centrifugal pumps, used by most modern pumpers.

An **Engine Company** is an organized fire service group that has one or more pumpers. Historically, hand pumps were called engines, which was later used for steam and internal combustion engine apparatus. The main role of the Engine Company is the provision and layout of hoses for fire attack and exposure protection. Some of the common functions of an engine company are :

- Providing water supply
- Attacking fire with hose lines
- Supporting sprinkler systems
- Rescue
- Overhaul

While engine or pumping apparatus is the most common piece of equipment in the fire service, the size and style will differ from community to community. While there are differences, all fire apparatus must conform to ***NFPA Standard 1901, Standard for Automotive Fire Apparatus***. Most engines are classified by their pump size, i.e., 1250 g.p.m., 1500 g.p.m., etc. all engines must have the following - a pump, a water tank and fire hose to be used for fire attack and supply. **[See Figure 1]**

Figure 1 - Typical Fire Engine

The Fire Pump

Modern engines use a centrifugal fire pump. This pump operates on the following principle - It consists of an impeller that is encased and rotated at high speed to force water movement. The force of rotation imparts a velocity pressure to the fluid, causing it to flow . These pumps are rated by the amount of water they can flow. This is measured in gallons per minute [G.P.M.**]**. Modern fire pumps range in size from 500 g.p.m. to 2,000 g.p.m.., but there are some that are larger. The rated g.p.m. is based on the amount of water the pump can flow when receiving water from a static source [pond , lake, stream, etc.] at a certain pressure or psi.

The Water Tank

All engines carry their own water in a tank located on board the engine. This water is used for initial fire attack or for small fires that the engine company may respond to. They typically range in size from 250 gallons up to 1,000 gallon. A fire apparatus with a tank larger than 1,000 gallons is usually called a tanker or a tender.

Fire Hose

Every engine is required by NFPA 1901 to carry a minimum amount of hose for fire attack and for water supply. They may carry more if they wish. Fire hose on apparatus must meet the requirements of ***NFPA Standard 1961, Standard forFire Hose*** and ***NFPA Standard 1963 Standard for Fire Hose Connections***. Fire hose is defined as a "flexible conduit for channeling water to fire control and suppression devices. (nozzles)." Fire hoses enable firefighters to work closer to the fire without endangering their engines and to increase the accuracy of water placement. It also makes it possible to draw water from rivers and ponds.

Historical Background

The earliest notation of a type of fire hose is from ancient times. The Greek engineer and architect Apollodorus (fl. early 2nd century AD), who worked primarily for the Roman emperor Trajan (reigned 98–117), stated that to convey water to a high place exposed to "fiery darts," the gut of an ox having a bag filled with water attached to it might be employed, for on compressing the bag, the water would be forced up through the gut to the place of destination. In 1673, Jan (then the Superintendent of the

Amsterdam Fire Brigade in Holland) and Nicholas Van Der Heiden (father and son), are credited with creating and using the first reliable flexible fire hose by sewing strips of leather together longitudinally. They used strong linen thread to close the seams of the hose. The English referred to their invention as "hose" after the popular word for stockings. The Van Der Heiden's hose was notorious for leaks, but was found more useful than a bucket brigade, which was used at the time. Seamless woven hose made of hemp and later of linen was produced in Europe in the 1720s, but it was less durable than the leather hose, failing after short usage time. In 1808, the Philadelphia firm of Sellers and Pennock developed leather hose that replaced linen seaming thread with iron rivets (later copper, circa 1819) that provided a tight, leakproof seam. The 50-ft. lengths coupled with brass fittings enabled firefighters to convey water through narrow passages, up stairways, and into buildings, while the pumps operated in the street.
The first fire hose of rubber lined cotton weave to replace riveted leather hose was invented by James Boyd of Boston, Massachusetts. He obtained a patent on May 30, 1821 on a "new and useful improvement in the mode of manufacturing fire engine hose." In 1819, he established James Boyd & Sons in Boston and manufactured Boyd's Patent Double Fire Engine Hose. This type of hose was used until 1870 when rubber lined cotton hose took over and became the standard type. Standards on fire hoses for both mill and fire department use were among the earliest standards issued by the National Fire Protection Association (NFPA). It issued its first standard on fire hose in 1898. Luminous fire hoses are now available that assist firefighters in a darkened smoke-filled environment.

Types of Hose

There are two types of hose found on engines; the first is *supply hose*. This ranges in size, measured in the cross sectional diameter of the hose, from 2 ½" to 5". This hose is used to connect the engine to a water source, i.e., hydrant, or connect the engine to another engine to provide a relay. Larger supply hose, 4" and 5", have become more common over the past 20 years due to their ability to move larger amounts of water greater distances with a minimal loss of pressure. 2 ½" and 3", while still common, are used for shorter lays of supply hose and for connecting to sprinkler and standpipe connections.
Attack hose is a hose attached to a nozzle used in manual firefighting efforts to attack a fire incident.. Attack hose ranges in size from 1" to 2 ½" diameter. One inch hose, called booster line, is rarely used for fire attack purposes due to its limited flow capabilities (30 g.p.m.). The more common attack hose or line is 1½" to 2" diameter, with 1¾" being the most common.. Attack hose is usually chosen for its ease of maneuver and water flow capabilities. While flows from attack hose nozzles will vary depending on conditions a typical flow for the following would be:

- 1 ½" - 100 g.p.m. to 125 g.p.m.
- 1 ¾" - 150 g.p.m. to 175 g.p.m.
- 2" - 200 g.p.m. to 255 g.p.m.

2½ " hose is somewhat of a crossover, in that, it is both a supply and a attack hose. In the early and mid 20th century many fire department used 2½" hose for supply and attack hose. Depending on the size of the nozzle a 2 ½" hose can flow between 150 g.p.m. and 325 g.p.m. With the advent of smaller diameter hose 2 ½" has been relegated to being used only when there is a large volume of fire and a quick knockdown is required. One other type of hose is a "*hard suction hose* ". This hose is a noncollapsible hose primarily used by mobile firewater pumps for drafting large volumes of water from supplies (lakes, rivers, wells, etc.) without any head conditions, that is, they need to be pumped (or lifted) to be utilized. It may also be used for supplying pumps on fire apparatus from hydrants if specified for that purpose. The hose contains an integral semi-rigid or rigid reinforcement designed to prevent collapse of the hose under partial vacuum or vacuum conditions created from the suction of a pump. Common drafting hoses used with pumpers in the United States have an internal diameter of 4.5 in., but can range from 2.5 to 6 in.. In the early 1670s, the first fire engine drafting hoses were invented

by Jan of Holland and were called “water snakes.” They were made of sailcloth and stiffened with cement. Metal rings were provided on the ends to maintain the shape of the hose and were used with manually operated fire engines containing piston pumps. Later hoses were made of metallic cylinders placed end to end, and covered with leather, or stout spiral wire covered with leather in order to prevent collapse. Prior to the invention of the suction hose, leather water buckets were used in a bucket brigade to fill the hand pumper or to fight a fire.

Engine Equipment

Nozzles [See Figure 2]

In order to get the water on to the fire in the proper configuration to be most effective the fire department uses a nozzle. A nozzle is defined as a “device for directing a pressurized water stream in a desired pattern, density, and direction.” Various nozzles are capable of projecting solid, heavy streams of water, curtains of spray, or fog. Nozzles have three main functions:

- they control flow
- they provide shape
- reach for firewater application.

The flow of water is controlled by the size of the orifice of the nozzle. The nozzle itself creates a restriction at the end of the waterway that changes the water pressure into velocity, which allows the water to travel distances. The design features of the nozzle create the shape of the water spray that is produced from straight stream to fog patterns. Different situations require different methods of applying water or foam. There are four basic types of firefighting nozzles: the smooth bore, the single gallonage (sometimes called variable pressure/variable flow), the adjustable gallonage, and the automatic or constant pressure. The latter three nozzles make up a group of nozzles called combination nozzles because they have the capability to produce both a straight stream and a fog stream. Nozzles are selected according to the amount of heat that must be absorbed. Manual firefighting nozzles can apply water in the form of streams, spray, or fog at rates of flow between 15 gallons to more than 100 gallons per minute. Straight streams of water have greater reach and penetration, but fog absorbs heat more quickly because the water droplets present a greater surface area and distribute the water more widely. Fog nozzles may be used to disperse vapors from flammable liquids, although foam is generally used to extinguish fires in flammable liquids and seal the liquid surface to prevent vapor release. The first firewater nozzles on fire engines were provided directly to the outlet pipe of the pump. They were usually 6 or 7 ft.long and made of copper or brass. As fire hose became available to provide water directly to a fire source, the length of nozzles decreased. Early nozzles had a diameter of ⅞” to 1 ½ “. Fog or spray nozzles were not developed until the 1930s and were not widely adopted by fire departments until the early 1950s.

Solid stream

A solid stream nozzle delivers an unbroken or solid stream of water at the nozzle tip towards the fire. The flow from the nozzle is based on the pressure at the tip of the nozzle and the interior diameter of the nozzle. Over the years the fire service has swung back and forth in their preference of the solid stream or the fog nozzle. There are numerous fire departments that exclusively use solid stream nozzles, and find them very effective.

Fog stream

This is a firefighting water nozzle capable of producing a spray of water that contains water droplets with a mass medium diameter smaller than 0.03 in. in diameter. Water fog is most effective for heat absorption when the droplet size is small and therefore highly beneficial for fire suppression. Water fog and spray are produced by the impingement of converging water jets or by forcing the water through specially designed teeth, which break it up into fine particles. Chief Glen Griswold of the Los Angeles

County Fire Department was responsible for the early testing and development of the fog nozzle for combating oil fires. He conducted various experiments on fog nozzles in the 1930s and developed a fan pattern, impinging spray fog nozzle, which he patented in 1931. This was the first practical fog nozzle made commercially in the United States. Spray nozzles for firefighting have been mentioned in historical literature on firefighting as early as 1863. Fog nozzles, also commonly referred to as spray nozzles, were tested and adopted for widespread firefighting applications use in the 1940s and early 1950s. They were tested for marine firefighting applications during and just after WWII by both the US Navy and Coast Guard. These applications would eventually lead to improvements in the automatic sprinkler, culminating in the standard spray sprinkler design in 1950 that produced a smaller droplet size than the earlier manufactured sprinklers. The use of water sprays (fog) for firefighting was considered one of the major advances in firefighting technology, after the application of power-driven drives for pumping equipment..

Figure 2 - Assorted Nozzles

Master stream [See Figure 3]

This is a large capacity portable or fixed firefighting water delivery appliance classification formed by either multiple fire hose lines or fixed piping. Master streams are delivered by monitor nozzles, hydrant-mounted monitor nozzles, or portable deluge sets. It generally has a capability of flowing in excess of approximately 250 to 350 g.p.m. of water or water-based extinguishing agent with nozzles pressures of 80 to 100 psi into large streams of extended reach for firefighting applications. Master streams are beyond the capability to control through manual manipulation by hose nozzles because of the reaction forces involved. It may also be called a heavy stream. Nozzles on master stream devices may be either fog or solid stream.

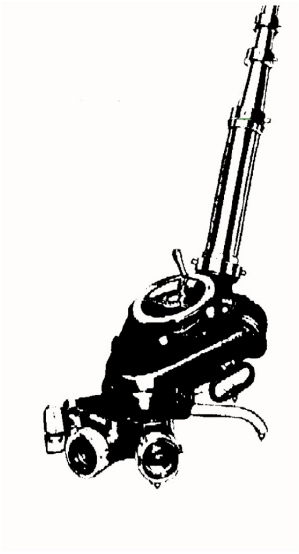

Figure 3 - Example of Masterstream Device

Special purpose nozzles

Over the years the fire service has developed nozzles for a variety of purposes. Some of the more common types are:

- Cellar nozzles
- Piercing or partition nozzles
- Water curtain nozzles

Other Equipment Found on Engines

While the primary job of an engine is to provide water at the scene of a fire incident. It, at times, can perform other functions. If no truck company is available, the functions of a truck company fall to the engine company. For this reason most engine companies, as per NFPA 1901, carry the following:

- Forcible entry equipment [axe, halligan bar, pike poles, pry bars, etc.]
- Ground ladders [14' roof ladder, 24' or 35' extension ladder, and sometimes an attic ladder]
- Ventilation equipment [fans]
- Salvage covers
- Rope for rescue and/or crowd control
- Self Contained breathing Apparatus [SCBA]
- Portable fire extinguishers

LADDER / TRUCK COMPANY

A Ladder Truck a fire truck that is provided with aerial ladders or elevating platforms. An aerial ladder truck has a metal extension ladder mounted on a turntable. Most trucks can raise the ladder to 100 ft., or eight stories, while some even higher. The elevating platform truck is commonly called a snorkel and has a cage-like platform that can hold several people. The platform is attached to a lifting device, either an articulating boom or a telescoping boom, which is mounted on a turntable. A built-in hose is provided for the length of the boom and is used to direct water onto a fire. The primary purpose to provide support to the engine company so confinement & extinguishment can be accomplished. Some of the activities include

- Forcible entry
- Ventilation
- Laddering of building
- Search & rescue
- Salvage & overhaul

Types of ladder trucks [See Figure 4]

Tower Ladder is a term used to describe a telescoping aerial platform of a fire apparatus.

Aerial Ladder is a fire truck with an extendable ladder on a power-operated turntable used in fire rescue operations at elevated locations. The ladder is provided in several sections and extends to various heights. Extension of the ladder may be by electrical, hydraulic, or mechanical power devices. Early aerial ladders were made of wood and called “the big stick.” Modern ladders are made of aluminum or steel.

Aerial Platform is a snorkel aerial platform truck was invented in 1958 by fire commissioner Robert Quinn, of the Chicago Fire Department who was inspired by watching workers moving an aerial basket. One of its first fires were the “Our lady of the Angles” in December of 1958, where approximately 100 children and teachers died. The aerial platform allows for stability and maneuverability that the ladder truck does not provide. It also provides a more stable rescue platform since personnel will not slip on water-soaked ladders. The platforms can typically support 900 lbs. of weight and provide a stream of 1,000 g.p.m.. It may also be called an elevating platform.

Quad—Fire service terminology applied to a fire truck that is supplied with quadruple level of fire equipment: water tank, pump, ladders, and hose. This apparatus does not carry an aerial device**..**

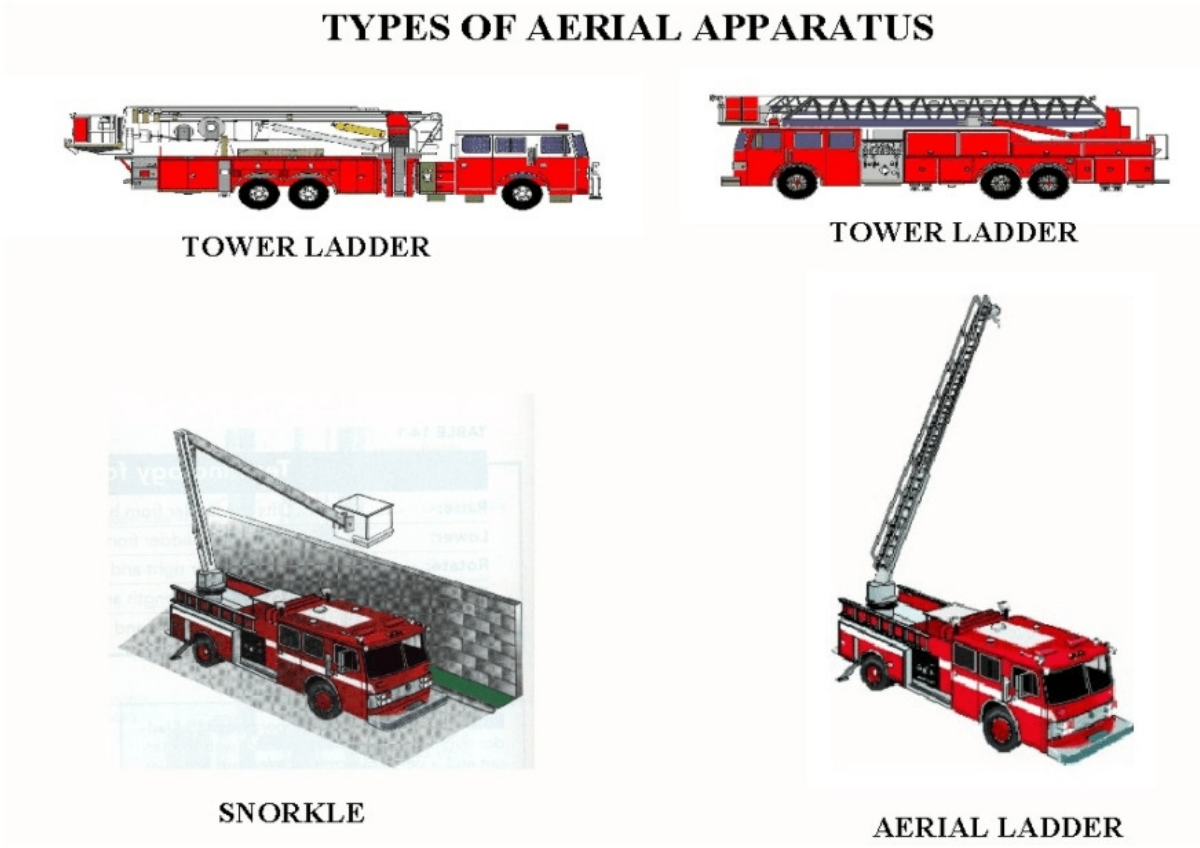

Figure 4

Aerial Equipment Used on Trucks

As mentioned before a truck company covers the following functions:

- Forcible entry
- Ventilation
- Laddering of building
- Search & rescue
- Salvage & overhaul

In order to perform these functions the truck must possess some of the following equipment.

Forcible Entry and Ventilation [See Figure 5]

Fire Axe

A Fire Axe is a long-handled ax with a blade on one side of the head and pick at the opposite side used to support firefighting activities forcible entry to inaccessible areas, locked or obstructed entry, support investigations, etc.), by chopping, prying, or pulling. The handle is normally provided with a slight curve at its end to prevent slippage from wet hands or frozen gloves..

Halligan bar

A Halligan Tool is a forcible entry tool used by the fire service. It consists of a long bar with a claw at one end and one or two spikes at right angles at the opposite end. It is generally used to pry open locked

or stuck doors and windows to gain access for firefighting operations or rescue activities. It was designed by Chief Halligan of the New York City Fire Department. It may also be called a Hooligan Tool.

Pike Pole

A Pike Pole or Ceiling Hook is a long pole with a prong and hook attached, primarily designed for fire service use to pierce a ceiling to allow water to escape and prevent collapse of the ceiling. It is also used to turn over debris, to probe combustibles for hot spots, and to pull and drag materials. The prong or hook is shaped in the fashion of an old battle pike, hence its name.

K-Tool

The K-tool is used to perform a through-the-lock method of forcible entry, where the lock cylinder is removed from the door with minimal damage. The K-tool is used in conjunction with the axe and the halligan tool

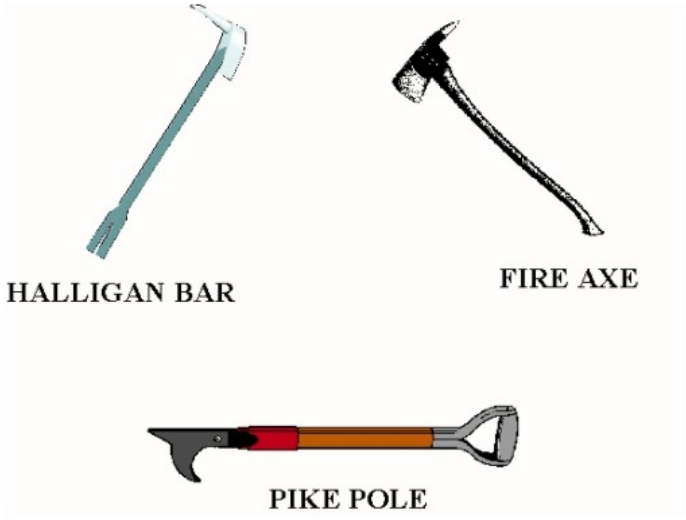

Figure 5 - Example of Truck Company Tools

Ground ladders

These ladders range in length from 12' to 50' in length. The shorter ladders up to 20' are usuall single piece ladders, called straight ladders. From 24' to 50' ladders are called extension ladders. These are two or three piece ladders that are raised to a given height with the aid of a rope connected to the ladder called a halyard. Early ladders were made of wood, but modern ladders are made either of fiberglass or aluminum. Ladder design and maintenance are setforth in the NFPA Standard 1931.

Other equipment

In order to complete the other functions the truck company carries the following:

- Salvage covers
- Lights and generators
- Rescue and utility rope
- Self Contained breathing Apparatus [SCBA]
- Portable fire extinguishers
- Supply and attack hose, if the truck has a pump on it,

RESCUE COMPANY

Thes are specially trained members of the department that carry out life saving procedures at fire and other emergencies. May be designated as light rescue or heavy rescue depending on the needs of the community. Some of the activities include

- Structural search & rescue
- Emergency medical assistance
- Vehicle extrication
- Confined space rescue
- High-angle rescue
- Water / ice rescue
- Mountain rescue
- Elevator rescue
- Structural collapse search and rescue

Equipment on rescue vehicles

- Breathing apparatus
- Scuba gear
- Hand tools
- Ladders
- Repelling equipment
- Hydraulic rescue tools
- Hazardous gas detectors
- Oxygen resuscitators
- Emergency medical supplies
- Shoring equipment for collapse
- Ropes for rescue and utility work

HAZARDOUS MATERIALS UNITS

Purpose is to control and contain any hazardous spills or leaks that may occur. They are usually a very specialized unit. These types of units are usually found in larger fire departments. Smaller departments usually rely on county or regional response teams. Some of the equipment carried on apparatus includes

- Protective suits for hazardous entry
- Absorbent material
- Air monitoring equipment
- Dry chemical & foam extinguishing agents
- Breathing apparatus
- Decontamination equipment
- Emergency medical supplies
- Hazardous material reference material

COMMAND VEHICLES

Command vehicles provide a command post for the incident commander to work in or around. They vary in size from a station wagon to a full length trailer pulled by a truck. Some of the equipment on command vehicles include

- Resource material
- Radios and scanners

- Status boards for commanding the incident
- Strategic & tactical procedures for various types of incidents

SPECIAL UNITS

Examples of this include brush fire trucks, utility units (lighting, breathing air) and airport crash trucks which are a fire pumper that sprays foam or dry chemicals on aircraft that are on fire at airports or have the potential for a fire incident.. It may also be called an Aircraft Rescue Firefighting (ARFF) vehicle..

FIREFIGHTER PERSONNEL PROTECTIVE EQUIPMENT [See Figures 6 & 7]

Turnout Clothing or **Gear** are protective garments used for fighting a fire beyond its incipient stage. Turnout clothing includes a helmet with face shield, coat, trousers, gloves, and insulated firefighters' boots. NFPA Standard 1971, *Protective Clothing for Structural Fire Fighting*, specifies performance, testing, and fire resistance of protective coats and trousers. NFPA 1972, *Standard for Helmets for Structural Fire Fighting,* specifies helmet performance requirements for impact, penetration, flammability, thermal endurance, retention, and limited electrical insulation. NFPA 1973, *Standard on Gloves for Structural Fire Fighting*, provides specifications for gloves to protect firefighters against adverse environmental effects to the hands and wrists during structural firefighting and skin exposure to blood or other liquidborne pathogens and exposure to limited common liquids. NFPA 1974, *Standard on Protective Footwear for Structural Fire Fighting* provides specifications to mitigate adverse environmental effects to the foot and ankle during structural firefighting. It may also be called structural firefighting protective clothing or bunker gear.

Self-Contained Breathing Apparatus

Self-Contained Breathing Apparatus [SCBA] is a type of respiratory protection in which a self-contained air supply and related equipment are worn or attached to the user. Fire service SCBA is required to be of the positive-pressure type. Most SCBA units have a duration of 30 minutes, but there are some that have a 60 minute duration.

Personal Alert Safety System [PASS]

Personal Alert Safety System is a device that emits a loud alert or warning that the wearer is motionless. These can be worn on the protective clothing or as an integral part of the SCBA

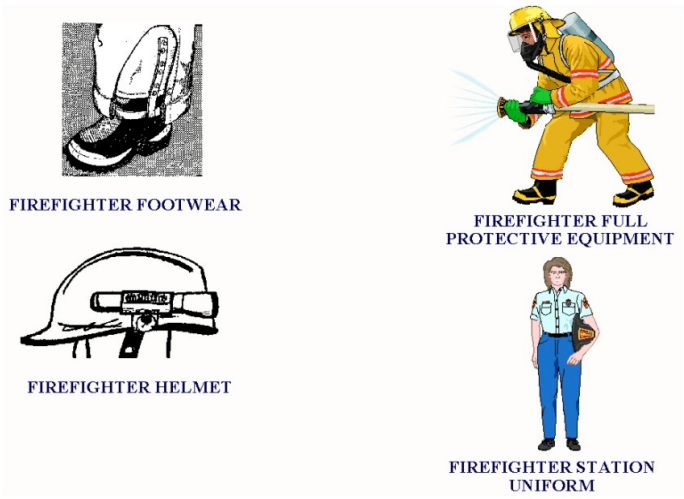

Figure 6 - Firefighter Protective Clothing

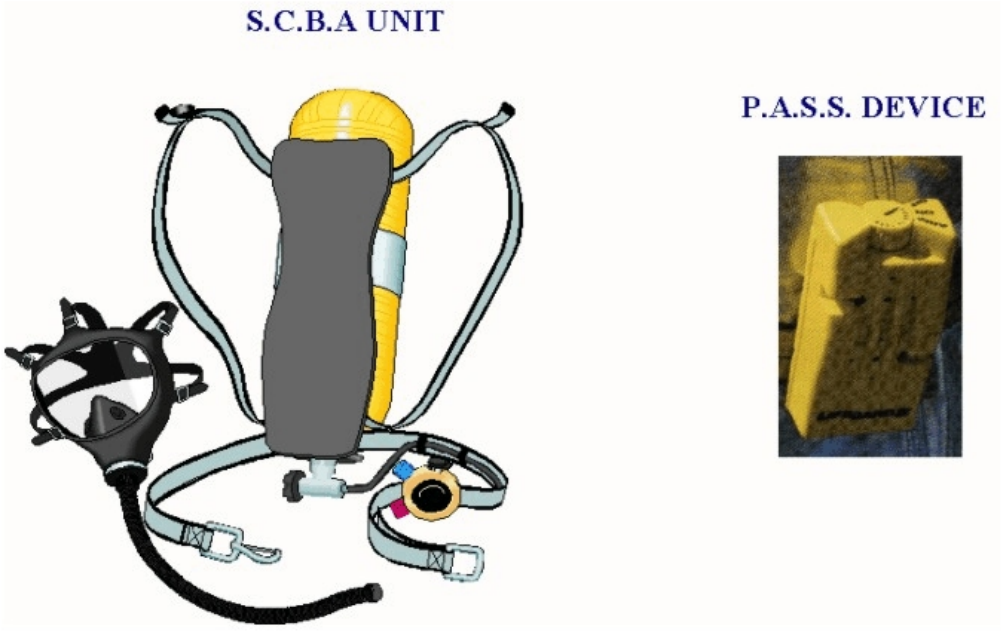

Figure 7 - Example of SCBA Unit and a PASS Device