

FIRE PREVENTION AND PRIVATE PROTECTION SYSTEMS

Probably the biggest single influence on the fire service in the US has been the fire insurance industry.

- The situation has changed because of better water supplies, bigger pumping engines, better trained fire departments, and building laws and construction must also be important factors.
 - o If there has been a truly significant advance in firefighting in the 20th century, it has been in the field of training.

Code Enforcement Board of appeals:

- If Board of appeals makes a change to the code, then the code must be enforced as changed, as if that is the new code.
- Board of Appeals = 3-7 Members
- Board of appeals intent is to remove vagueness from the code.

Most codes contain duty to inspect clause.

Property owner may refuse entry unless Fire Inspector has obtained a warrant or has adequate reason to believe property has fire hazards.

- Ruling by U.S. Supreme Court

Federal buildings do not fall under local fire codes, they follow federal codes.

Sequence of human behavior during a fire = Detection, Definition, Coping.

Exit Drills:

- Exit Drills in educational facilities (K-12) should be done randomly, and at varying times, monthly at different times of day.
 - o Exit drills are conducted to a predetermined point.
- Fire Drills at nursing homes, hospitals, hotels and stores should involve staff only
 - o Health Care Facilities
 - REACT
 - R- Remove those in immediate danger
 - E – Ensured that the room door is closed
 - A – Activate the fire alarm if it has not done so on its own.
 - C – Call the fire department
 - T – Try to extinguish or control the fire

Correctional facilities must have 2 means of unlocking main cellblocks.

The five types of heat energy are: Electrical, Mechanical, Chemical, Nuclear, And Solar.

Definitions:

- Ignition Temperature (solid) - point where material will continue to burn.
- Fire Point (liquid) - point where material will continue to burn.
- Flash Point (liquid) - flash at surface but not continue to burn.
- Flashover
 - o Almost always occurs at about 1000 degrees Fahrenheit
 - o The stage of fire at which all surfaces and objects in a room are heated to their ignition temperature
 - o Entire contents at ignition temperature.
- Flame over - portion of Room involved.

- Rollover - portion of Room involved.
 - o Same as flameover
- Back draft
 - o Caused by Oxygen Deficiency.
 - o Really a deflagration.
 - o Carbon monoxide is combustible and main backdraft explosive

Liquids burn through vaporization.

Solids burn through pyrolysis.

Single most important non-firefighting activity is conducting fire inspections.

Inspection:

- Fire inspectors are not held accountable for discretionary acts.
- Fire inspectors can be held liable for the manner in which they perform an act.
- The most stringent code is to be enforced if there is a conflict between codes.
- Explain appeals process, be courteous when doing inspections.
- Fire Inspector who finds violation, but fails to follow up can be held liable

It is easiest to get compliance during the planning and building phases.

A rough drawing made during the inspection is a field sketch.

When reviewing plans, the Fire Protection Plan is the sheet that would contain fire extinguishers.

Only re-inspect portion of building found on the inspection report within 30 days

Air has vapor density of one, used to compare gasses.

Water has Specific gravity of one, used to compare liquids.

Hotel evacuation procedures must be posted in rooms, near exits, in hallway. Not required to be posted in lobby desk.

Rapid Oxidation usually resulting in heat and light is fire.

Fuel being converted to a gaseous state represents the first phase of combustion.

Chemical decomposition of a substance through the action of heat is pyrolysis.

Temperature - measurement of the Intensity of the heat.

- Ordinary combustibles generate approx. 8000 BTU's / #
- Flammable/combustible Liquids generate approx. 16000 BTU's / #
- The heat of combustion of most polymers is much higher than that of most natural materials such as wood, paper, and cloth about 7200 BTUs per pound for materials and about twice that for common synthetic polymers.

A liquid will assume the shape of its container and cannot be compressed.

Four products of combustion are:

- Heat, Light (Flame), Smoke, Gasses.

Element missing in a smoldering fire is Oxygen.

Heat transfer:

- Convection
 - o The most prevalent form of heat transfer.
 - o Direct flame contact
 - o Most fires extend by convection
- Conduction
 - o Heat transfer from body to body.
 - o
- Radiation
 - o Transfer of heat waves through an opaque object.
 - o Penetrates glass easily
 - o Travels from a flame equally in all directions

Heat of solution is released by solution of matter in a liquid.

Gasses will assume the shape of their container and have no specific shape and are compressible.

Fire Hazard - what contributes to the fire start.

Fire Cause - the form of ignition of the fire.

- Intentional
- Unintentional

BTU - amount of heat required to raise one pound of water one-degree Fahrenheit.

Combustible Liquids

- Any liquid having a flash point at or above 100 degrees Fahrenheit.

Flammable Liquids

- Any liquid having a flash point under 100 Degrees Fahrenheit.

Flammable / Combustible Liquids have an explosive/flammable range. (Vapors)

Open fuel can or wood shavings are examples of a fuel supply.

Ultimate responsibility for fire investigation is the Fire Chief.

Moderate fire load in pounds of combustible material per square foot = 10 lbs/sq foot in 1 hour.

Hazards:

- Common hazard can be found in all occupancies.
- High hazard is one where contents would burn extremely fast, poisonous fumes, or explosions during the fire
- Special hazard arises from a process taking place that is particular to that occupancy.
- The Authority having Jurisdiction determines level of hazard of occupancy.
- Referring to Level of hazard, Ordinary = moderate

Fire resistance rating for room used in dry cleaning is 1 hour.

Burning:

- Open burning may be conducted >50' from structure
- Closed, approved containers must be > 25' from structure

Define:

- Volt = Pressure
- Amp = Quantity
- Ohms = Resistance

How electrical shock affects the body depends on the vital organs affected.

- An electrical shock of 100-200 milliamps can cause V-fib.
- Lethal dose of electricity is 200 miliamps.

Bonding is fastening similar objects with a conductor.

Grounding is fastening object to ground.

Conductor must be large enough to carry the largest amount of current.

The type of heat that is produced when the insulators on electrical wires is insufficient is called leakage.

Air and water are poor conductors.

Major hazards

- Batteries - hydrogen gas.
- Carbon Tetrachloride generates Phosgene.
- Hydrocyanic acid and phosgene gas are given off by burning wool and plastics
- Burning wool generates hydrogen cyanide.

Carbon Tetrachloride and Soda Acid inverted extinguishers are obsolete.

NFPA Numbers

10	Extinguishers
13	Sprinklers
	a. Small residences not included.
14	Standpipes
70	National Electrical Code
72	Alarms and Private Fire protection Systems
101	Life Safety Code
220	Building types of Construction
251	Testing of Building Construction Material
1001	Standard for Fire Fighter Professional Qualifications (1992)
1031	Inspectors

NFPA 220 Specifies 5 types of Building Construction.

- Types I/II are non-combustible
- Types II, IV, V are combustible.

There is a three-digit rating for structures,

- 1st digit is Outside Supports
- 2nd Digit is inside Supports
- 3rd digit is Floors

Fire:

- Resistance – a building's ability to maintain fire rating under fire conditions.
- Load - the amount of material there is to burn.
- Rating - the time of fire resistance.

Interior finishes:

- Classified as A, B, C
- Tested with Steiner tunnel test
 - o Determines surface burning characteristics of interior finishes
 - o Asbestos board = 0
 - o Red oak = 100
 - o Conducted in a 25 ft long and 2 ft wide funnel or long box

Floor covering material:

- Two classes, I or II
 - o The higher the CRF number the less flammable the carpeting
- Tested with radiant flux panel test.

Flame spread classification:

Class A 0-25

Class B 26-75

Class C 76-200

A ¾ inch paraffin candle is in direct contact for 1 minute. (2 Seconds fire and 30 seconds glow)

Fire Door Windows = < 144 square inches.

Glass vision panel in rated wall = 296 square inches.

Aircraft hanger has a deluge system.

Curtain boards or draft curtains must be 20% of ceiling height.

Occupancies - Life safety Code has 10 Occupancy Classes (this number is based on old test)

- Assembly - 50 or more people is considered an assembly occupancy.
 - Classes of assemblies:
 - A > 1000
 - Minimum number of exits 4
 - B 301 – 1000
 - C 50-300
 - Business
 - o Includes college classrooms
 - Educational occupancy (6/4/12)
 - o 6 or more people, 4 hours per day or 12 hours per week. K-12.
 - Industrial occupancy is a factory or assembling of products.
 - Health care – key words infirm or infirmary.

Means of egress is a continuous unobstructed way of exit travel.

- Exit access
- Exit
- Exit discharge

Doors:

- New construction minimum size of exterior door is 36" or 32". (Only one answer will appear).
- Existing exit minimum size = 28".
- Turnstile must be 39" or more in height, subject to revolving door code.

The most common type of fire protection system is the fire extinguisher.

Occupant load – maximum number of people

- An occupancy load sign must be posted at or near the main exit from the room.

Hydrants

Color Codes

Class AA	Light Blue	1,500 gpm or greater
Class A	Green	1,000 – 1,499 gpm
Class B	Orange	500 – 999 gpm
Class C	Red	less than 500 gpm

Standpipe System (remember 1+2=3)

- From a firefighting standpoint the most important feature of a high rise building is the standpipe.
- Visual inspection
- Types
 - Class I
 - 2 ½ in hose used by trained personnel in heavy streams.
 - Sufficient supply to provide 500 gpm for at least 30 minutes
 - Residual of 65 psi at the topmost outlet with 500 gpm flowing
 - If multiple standpipes are required the minimum supply shall be 500 gpm for the first standpipe, and 250 for each additional for 30 minutes
 - Class II
 - 1 ½ hose used by building occupants
 - Supply to provide 100 gpm for 30 minutes
 - Residual of 65 psi at the topmost outlet with 100 gpm flowing
 - Class III
 - Both 1 ½ and 2 ½
 - Occupants and trained personnel in heavy streams
 - 500 gpm/65 psi residual as per Class I
- Acceptance test must flow for 30 Minutes.
- Hydrostatic test at 200 psi for 2 hours every 5 years.
- Standpipe maximum per zone = 275'
 - o 600 ft high building has 3 zones, 275' per zone
- When pressure at a standpipe outlet exceeds 100 psi, an approved device should reduce the pressure to 100 psi.
- Where pressure is greater than 150 psi, an appropriate warning sign should be installed.
- Standpipe hose cabinet not over 6' from floor

Default inspection frequency is 1 year. If you don't know, guess 1 year.

Exception: Smoke detectors Semi annually (change clock, change batteries)

Exception: Hood systems Semi Annually.

FDC:

- 2 outlets per standpipe zone (Siamese) 2-½ outlets pump at 150 PSI

- 3 outlets pump at 175 – 200 PSI
- If FDC is leaking water, then check valve is not properly seated.

Sprinklers:

- Sprinkler systems have been in existence for over 100 years.
- 96% or 98% effective (Both answers will not appear).
 - o Failure rate of 2%
 - o From 1984 – 1987 automatic sprinklers failed to control the fire 24 of 1,225 losses.
- Gravity tank for sprinklers must be at least 35' above sprinklers using it.
- A pressure tank must be 2/3 full and 75 PSI to provide pressure gradient.
- Volume rather than high pressure is required to supply sprinklers
- Supply sprinkler from a pumper at 150 psi, which is capacity.
- Maximum sq/ft coverage of a single sprinkler head in a light hazard occupancy 225 sq/ft
- Residual psi at most highest and remote head = 15 psi
- Local water flow alarm is a water gong
- 18 percent of large loss building fires occur in sprinkled buildings.
 - o Usually human error is to blame
- Estimating the volume of water needed to supply a number of sprinkler heads in a fire area.
 - o $Q=A/4$
 - Q = gpm needed
 - A = Area in square feet
- Clearance
 - o Normal Sprinkler clearance is 18"
 - o High Stacked is 36" clearance.
- Sprinkler System Types:
 - o Wet - Charged with Water
 - o Dry – Charged with air (15-50 PSI > Trip Pressure)
 - Dry pipe systems use Mechanical or Differential valves.
 - Dry Surface to Water surface ratio is 6:1
 - o Deluge – Open Heads
 - o Pre-Action – Form of deluge system but closed heads, dry system, detection devices
 - What system is used when it is important that water damage be prevented even if the sprinkler pipes should break accidentally? Pre-action.
- Pipes
 - o Minimum pipe size for residential is $\frac{3}{4}$ inch
- Valves:
 - o Main Control Valve – Shuts off water to system – Fully open and back $\frac{1}{4}$ turn, chained open or monitored with tamper switch.
 - o OS&Y (most popular)
 - o PIV, PIVA (Assembly = Butterfly), WPIV
 - o Check valves allow water to only flow in one direction.
 - o Alarm test valve located on pipe
 - Connects the supply side of the alarm check valve to retard chamber
- Sprinkler heads:
 - o Components
 - Heat sensitive device, deflector and discharge orifice
 - o Upright, pendant, Sidewall
 - o Typical orifice size of a sprinkler head is $\frac{1}{2}$ "
 - o Pintel is an indicator that there is a different orifice size in the sprinkler head.

- o Heads must be changed out every 50 years.
- o Spare heads
 - 1-300 sprinklers - 6 and wrench in cabinet
 - 301- 1,000 – 12
 - 1,001 or more - 24
- Colors
 - o "Ugly White Boys Rarely Get Off"
 - o Unpainted – 135-170 Ordinary (165 degrees – most popular)
 - o White - intermediate
 - o Blue – high
 - o Red – extra high
 - o Green – Very extra high
 - o Orange – ultra high 500-550 degrees.
 - What is the frame color of ultra high sprinkler heads? Orange.
- Testing
 - o Inspection test simulate 1 head going off
 - o Dry system = 15 – 50 psi air above clapper
 - o Air pressure = 15 – 20 above trip
 - o 2" Main Drain test quarterly
 - Inspection is a close and critical examination by a competent authority

Inspections of Wet Systems conducted monthly.

Everything else is annually.

(If annual does not appear, then pick Quarterly).

Smoke detectors = semiannually

Hood systems = semiannually

Dry systems are inspected visually weekly.

Alarm test monthly

Everything else = annually (or quarterly if no annual)

Fire Alarms

- Local - alerts building Occupants
- Auxiliary system is director to fire station
 - o Served by multiple firebox
- Central Station
 - o Outside contracted service point monitoring
 - o Monitored off premises
 - o Monitors multiple properties
- Remote station system is similar to auxiliary system that is connected directly to FD dispatch center
- Proprietary - user owned

Detection Devices:

- There are several different types of rate-of-rise detectors in use. All rate of rise detectors reset automatically.
- Pneumatic rate-of-rise is the most common detector in use.
- Thermoelectric detector
 - o Operates on the principle that two wires are made of dissimilar metals, when twisted together and heated at one end, will cause an electrical current to be generated at the other end.
- Replace non-resetting detectors
 - o 2% every 15 years pulled for testing

- Bi-metallic Detector is considered self-resetting.
 - o A bimetallic detector uses two types of metal that have different heat expansion ratios
- Fixed temperature is most reliable, but not very responsive
 - o Preset
- Types of Smoke Detectors:
 - Photoelectric (visible products of combustion)
 - o Uses a photo electric cell coupled with a specific light source. The light is focused across an area and when a beam of light is interrupted the detector is activated.
 - Ionization (invisible products of combustion)
 - o Activated by receiving an air sample in the room that contains smoke.

Smoke removal systems must be capable of changing air 6 times per hour.

Permanent records kept 5 years.

Dry Pipe system may have:

- An exhauster - located at dry pipe valve –on pressure side of system
 - o Discharges to atmosphere.
- Or accelerator (unbalances differential in the dry pipe valve) to speed activation by assisting expelling air from system.

Riser is a vertical pipe

Extinguishers

- Classes
 - o Class A
 - Ordinary combustibles
 - o Class B
 - Flammable or combustible liquids or gasses
 - Liquid fires
 - Shallow spill
 - Deeper spill
 - Deep seated fires
 - o Class C
 - Energized electrical equipment
 - o Class D
 - Combustible metals
- Testing
 - o How often must a stored pressure extinguisher be hydrostatically tested? 5 years.
- Mounting
 - o Less than 40 pounds a maximum of 5 feet off the floor and a minimum of 4 inches off the floor
 - o More than 40 pounds a maximum of 3 ½ feet off the floor and a minimum of 4 inches off the floor
 - Except wheeled units
 - o Class A extinguishers need to be a maximum of 75 feet apart from each other
 - o NFPA 10 recommends that the maximum distance of travel for class D fire extinguishers be not more than 75 feet.

- Types
 - o Classes
 - Class A
 - 1-A = 1 ¼ gallons of water
 - 1 gallon of water needed to absorb the heat generated by 1 pound of burning wood
 - Water extinguishes fire by cooling the fuel source to the point where fuel vapor stops.
 - Class B
 - Number indicates the approximate area in square feet of fire involving a 2 inch layer of n-heptane in an 8-inch deep pan that can be extinguished.
 - Rating for untrained operator
 - Expert can extinguish 2.5 x untrained operator
 - Without depth
 - ¼ inch “with depth”
 - Class C
 - o Lettering
 - Class A - green triangle
 - Class B – red square
 - Class C – blue circle
 - Class D – yellow star
 - o Water
 - 1-A = 1 ¼ gallons of water
 - o Dry Chemical
 - Ordinary Dry Chemical
 - Sodium bicarbonate, potassium bicarbonate, urea potassium bicarbonate, or potassium chloride.
 - o Sodium bicarbonate is effective on Class B and Class C fires
 - Multipurpose Dry Chemical
 - Monoammonium phosphate
 - Lith-X
 - Dry powder consisting of a graphite base that conducts heat away from the fire.
 - NA-X
 - Dry powder for use on sodium and potassium fires but not suitable for magnesium fires.
 - MET-L-X
 - Dry powder for use on magnesium, sodium, and potassium fires.
 - o Wet Chemical – makes soap
 - Potassium Carbonate
 - Potassium Acetate
 - o Carbon Dioxide
 - Not good in deep seated Class A fires
 - Requires pre-discharge alarm
 - Displaces O₂
 - Change at 10% drop in weight
 - o Halon
 - Breaks down and inhibits combustion reaction
 - Requires 3%-7% to extinguish fire
 - Becomes health hazard at 20%
 - Halon systems have larger valves.
 - B & C fires (stops chemical reaction)

- High value occupancies
 - Fur vaults, computer rooms, records storage
- Inspected semi-annually
- Types:
 - 1211
 - 1301
 - o 1st digit is Carbon
 - o 2nd digit is Fluorine
 - o 3rd digit is Chlorine
 - o 4th digit is Bromine
 - o 5th digit is Iodine
 - o 1301 can be occupied for short periods of time.
 - o Burning halon 1301 produces hydrogen fluoride

“Cold Flow”

- Weak sprinkler heads, creeping and sliding of fusible link device
- Leaking of sprinkler head happens when heads are routinely heated near fuse temperature

Generators = weakly

Foam

- Fluoroprotein is used for subsurface injection.
 - o Use fluoroprotein foam when you think you can't extinguish the fire but need a long lasting blanket.
- Fluoroprotein foam – has surfactant added to it, resists breakdown and will not become saturated with the product, withstands temperature exposure longer and doesn't breakdown.
 - o Surfactant detergent foams penetrate the surface to extinguish
 - o Sheds hydrocarbon fuels for subsurface penetration
- Polar Solvents must have alcohol resistant foam used
 - o Ordinary foams are not effective on alcohols, esters, ketones, acetone, lacquer thinner.
 - Fire in these liquids call for a special foam commonly known as alcohol foam.
 - Otherwise the solvents destroy the foam blanket
 - Water soluble
- Types
 - o Low-expansion foam
 - Used for vapor suppression on un-ignited spills
 - o Medium-expansion foam
 - Expansion ratio between 20:1 and 200:1
 - Space filling agent
 - o High-expansion foam
 - 200:1 to about 1,000:1
 - Space filling agent
 - Wetting agent for penetrating bulk-bailed commodities such as paper, rags, and cardboard

Most fatalities in sprinkled buildings are from asphyxiation.

CO2 systems require replenishment when down 10% by weight.

A severe magnitude = extra hazard.

If a fire protection system will be out of service for more than 4 hours a fire watch must be posted.
GFI = 6"6" from water

Heavy timber 6 or 8"

Woodworking hazard = dust hogger

Automatic roof vents use fusible link below 300 degrees or drop out panel.

STCC – Standard Transport Commodity Code

ERP – Emergency Response Plan
Integrates the response and planning components of both the LEPC and the SERC
Establishes methods and options

SARA – Superfund was big legislation for hazardous materials.

POA – Identifies strategic goals, tactical objectives, and methods.

Hazardous Materials

Bill of lading is for trucks

What is the color of an explosive label? Orange with black letters.

Aircraft:

- The primary goal of aircraft incidents is rescue.
- The best place to enter an aircraft is through the existing doors first, then through existing windows, then through holes opened from wreckage.
- Federal regulations permit moving cargo, wreckage and other articles for rescue and firefighting operations, but emergency responders need to limit such movement in order to help the accident investigators.

The class A protection suit is the most protective class of Haz-Mat suits.

A hazard that is high explosive, poisonous gas, or etiological is what? Special.

Highly volatile liquid boiling point <68 degrees Fahrenheit.

The most dangerous product to transport, according to DOT, is radioactive.

DOT has 9 classes in order of volatility:

- Radioactive
- Poison A
- Flammable gas
- Non-flammable gas
- Flammable liquid
- Oxidizer
- Flammable solid
- Corrosive liquid
- Poison B

Motor Carrier

- MC 312 is for corrosive liquids – answer on test is hydrochloric acid. Others are

- o MC 312 – corrosive liquids
- o MC 306 – flammable/combustible
- o MC 307 - flammable/combustible under pressure
- o MC 331 – LPG and anhydrous ammonia

Liquid/air release is a spill that ran into the dry storm drain

- A spill that is in the sewer or storm drain is not subsurface because a subsurface release must release right into the soil.

29 CFR. When do you need to know which hospitals can receive haz-mat contaminated patients? Pre-plan.

Hazardous atmospheres are broken down into 3 classes and 2 divisions

Who can plug a leak on a tanker? Hazardous Materials Technician.

Rule of thumb is not to neutralize more than 55 gallons.

Exposure getting through haz-mat suit at the molecular level is permeation, not penetration.

White single shelled tank of 500 to 30,000 gallons? Pressurized horizontal container.

Aluminum tanker, what are the considerations? Weight not strength.

First two digits from the DOT for hazardous materials are 49.

OSHA 1910.120 is for hazardous materials

It is important to understand the relationships of materials. This question has to do with the relationship of liquid when it changes to a gas. So know the difference between expansion ratio and vaporization.

NFPA 704 placard has 4 colors with 5 classes of hazards ranked 0 – 4. (4 is the worst)

- Blue; health; left
- Red; flammable; top
- Yellow; reactivity; right
- White; special information; bottom

Dip tank hazards are from fires involving liquids, explosions, and air mixtures.

Dry Cleaning Facility roof must have a one-hour rating.

Door rating for a smoke proof enclosure is 20 minutes.

Bleachers require 18" per person.

Carbon steel cannot be used in cryogenic tanks.

Rate of rise detector = expansion.

Flammable liquids rooms require a 4' sill, 2 hour rating and liquid tight non-combustible door.

There must be 18" of non-combustible clearance around a hood system.

Hazardous Materials Storage

- A container shall hold a minimum of greater than 60 gallons of flammable or combustible liquids in order to be classified as a storage tank.
- Minimum spacing between Storage Tanks
 - o 3' of a I, II, IIIA 1/6 of diameter
 - o Unstable material is 1/2 of total diameter.
 - o LP Gas tanks must be spaced 20' apart.
- Hazmat Storage Containers:
 - Safety Can = 5 gallons or less
 - Storage container < 60 Gallons and Fixed
 - Portable tank > 60 Gallons (Not fixed)
 - Storage tank > 60 Gallons fixed

The life of in-ground storage tanks are 20 years.

The minimum gallons an inside storage tank used for the storage of flammable or combustible liquids can be before the requirements to install additional safety equipment is 660 gallons.

If fusible vents are employed on portable flammable liquid tanks they must be designed to operate at a temperature not exceeding 300 degrees.

Bulk storage tanks 5,000 to 30,000 gallon capacities have cone roofs.

MSST and self-accelerating decomposition time (SADT) is associated with organic peroxides.

An oxidizer will release oxygen during decomposition and will support combustion.

What is the biggest problem concerning fires involving compressed gas containers? BLEVE.

ORM-D is Other Regulated Materials Class D.

The most common tank construction is the cone roof.

DOT guide for LNG is 214.

DOT placard for multiple commodities less than 1000 pounds is danger.

Pipeline cycle is 10 days.

Primary concern of hazardous materials is rescue (life safety)

Size of auxiliary fuel tanks on trucks is 20 to 200 gallons.

There are three airbrake controls on tractor-trailers.

- Yellow is for the tractor.
- Blue is the emergency brake.
- Red is for the trailer.

Expansion of LPG is 270:1

Change of states:

Liquid to a gas and then back to liquid is distillation

Solid to a gas and back to a solid is sublimation

Vaporization is the substance change from liquid to a gas

States of matter

- Solid
- Liquid

c. Gas

Firepoint is the temperature the liquid must be to have sustained combustion.

Explosives such as TNT, Nitro, and Dynamite are secondary high explosives (or high if secondary is not a choice)

Rack storage > 25' in height must be sprinkled.

How high may rack storage go before sprinklers are required? 12 feet depending on commodity and method of storing.

Fire pumps:

- Most common type is:
 - o Horizontal Split Shaft
 - o Electric drive
 - o 500 - 1500 GPM
- Jockey Pump
 - o Prevents pressure fluctuation
- Pumps should be run weekly

Main drain test –

Observe, open, observe, close.

- What is the exact sequence on conducting a main drain test?
 - o 1. Observe and record pressure on gauge (static)
 - o 2. Fully open the main drain
 - o 3. Observe and record residual pressure
 - o 4. Close and compare to last year

MFPA Placard P= Auto Polymerization.

Ordinary construction walls are made of masonry.

Elevation Pressure = .434 PSI per Foot of elevation.

For every 18 degree Fahrenheit increase, fire will double in intensity.

What type of heating is used for microwave? Dielectric

Inspection report should inform, analyze, recommend.

Fire stop type “F” is a physical fire stop.

A household light bulb releases 10% light, 90% heat.

Class I air conditioning filters will not contribute fuel to fire.

Dip tanks must have at least 6" free board.

Tunnels 50' or greater in length require 2 exits.

4 classes of ovens. Worst case is class a, potential for fire hazard/explosion.

Demolition of building, last fire equipment to be removed is the standpipe system.

Tar kettles

- Must be no closer than 10 feet to exit.
- Two approved 20B:C fire extinguishers shall be provide and maintained within 25 feet of tar kettle.

A fire load of 80,000 BTU per sq/ft or 10 lbs of ordinary combustibles per sq/ft is approximately the equivalent of a one hour exposure to the standard fire endurance test. 160,000 BTU per sq/ft is equivalent to 2 hour exposure.

BUILDING CONSTRUCTION

The most important reason for knowing building terms is safety.

Loads:

- The weight of a building itself and any equipment permanently attached or built in the structure is a dead load.
- Dead loads can be accurately calculated and live loads are indeterminate.
- An axial load is a force that passes through the centroid of the section under construction.

According to Brannigan the term fire load is defined as the “Potential fuel available to a fire.”

Wood

- Boards – lumber less than two inches thick
- Nominal lumber is the size lumber should be, the actual size is due to planning. 2 inch lumber used to be 1 5/8 now is 1 1/2 inches thick.
- Heavy timber = lumber 8” or more in its smallest dimension
- Wood has modulus of elasticity of 410,000 and 1,240,000 psi
- Chamfer – to cut off the corners of a timber to retard ignition
- Engineered wood
 - o Wood modified from its natural state
 - Plywood, laminated timbers, wooden I beams, trusses, flitch plate girders, wood and plastic composite roof panels
 - Chip board = wood chips glued together

Arches

- A segmented arch is one which describes a portion of the circumference of a circle.
- Arches tend to push outward at the base and therefore must be either braced or tied.
- Components:
 - o Key stone – the last stone set in place
 - o Voussoirs – the other stones

Plate glass is not safety glass

Beams

- The oldest construction member = beam
- A cantilever is a beam supported at only one-end, but rigidly held in position at that end.

- A simple wood beam floor is satisfactory for buildings up to a practical limit of about 25 feet in width.
- The only way to connect wood beams and wood girders and receive the full benefit of the time it takes the wood to burn through is to set the Beam atop the Girder
- Purlins are beams, usually channels, set at right angles to trusses or roof rafters to provide support for light weight roofing.

A fire-cut is a method of allowing the floors to fail during a fire and leaving the walls standing.

Fire stop

- Limit movement through relatively small concealed passages such as under stairs and inside walls.
- In Type III, IV and V, what type of fire stopping or fire damping is used?
 - o Firestopping material may consist of at least 2 inch nominal lumber, 2 thicknesses of 1 inch nominal lumber with broken up lap joints, or ¾ inch plywood or other approved material
- “Legal” firestopping is installed with no other purpose than to meet the requirements
 - o Firefoam

Columns

- Piers
 - o Short squat columns fail by crushing
- Long slender columns fail by buckling – S shaped
- Intermediate can fail either way

Roof coverings are given in classes

- The best is Class A.
 - Class A roof is effective against severe fire exposures, afford an increase degree of fire protection to roof deck, do not slip from position, and do not present flying brand hazard.

Max landing to stair distance = 4'

Birds mouth cut = rafter fits flush

Compression = concrete

Scissor stairs

- Located in the same shaft with each stair entering a different floor.
- Standpipe on alternating floors

Truss

- Components of a truss, which work on the triangular principle are:
 - o Top chord
 - Under compression
 - o Bottom chord
 - Under tension
 - o Web
- Top chord - top of truss
- Rising Truss
 - o Metal plate wooden truss system made with juvenile wood, bowing upward causing separation of ceilings from walls.
- Bowstring truss has the greatest distance from one load bearing wall to another load bearing wall.
- Lattice Truss

NFPA standards suggest a parapet height of at least 3 feet to protect a combustible roof.

Types of construction

- Ordinary
 - o Exterior walls are made of masonry
 - o Problems presented to the FD by ordinary construction can be divided into the following categories:
 - The structural stability of the masonry wall
 - The stability of the interior column, girder, and beam system
 - The masonry wall as a barrier to fire extension

A Building:

- All things being equal, a building's strength is greatest when all loads are axial.
- Is pinned when connected by simple connections.
 - o Bolts, rivets or welding joints
 - o Will not reroute forces
- Rigid frame
 - o Connections are strong enough to reroute
 - o Rigid frames can provide clear spans to about 100 feet

Beams

- A simple wood beam floor is satisfactory for building up to 25 feet in width. For a wider building or one with an irregular floor plan, masonry walls or a column, girder, and beam system must be provided.
- Wood beam joists are ok to a length of up to 25 feet.

Gusset plate = connection of web members

Hip rafter = 45degree angle to ridge board

Dead load = permanently fixed to building

Live load = all other loads

Impact load = delivered in short time

Static load = in one point/area

Sheathing is the covering which is applied to the studs or framing of a structure, for the exterior.

Concrete/Masonry

- Ashlar masonry is stone cut in square or rectangle
- Masonry buildings with spans greater than 25 feet must have interior load bearing walls.
 - o In older buildings these walls are usually of balloon frame construction unless made of masonry.
 - Interior masonry walls can be distinguished from wooden interior walls by their greater thickness.
- Concrete has good compressive strength and poor tensile strength.
- Falsework represents 60% of the cost of concrete structure.
- Saddles or Chairs raise steel off ground for concrete.
- Vertical reinforcing bars in concrete beams designed to prevent cracking under shear stress are called stirrups.
- Ordinary brick wall height = 6 stories
- Spreaders = connects tie rods to masonry walls
- To breach a concrete or masonry wall, use a triangle cut.
- Spreaders connect masonry tie rods to building.
- Concrete is far more fire resistive than steel.

- Concrete cures in = 28 days
 - Heat of hydration is generated by concrete during curing
- Post tension = done on site
- Pre tension = done off site
- Brick buildings erected in the early 1900s and before have lime mortar connecting the bricks. Those erected in more recent years use Portland cement as a bond.
- Sand lime mortar = water soluble
- Wythe = one course of masonry thick
- Stretcher course = bricks laid length wise
- When concrete is subjected to heat and the surface material explodes due to increase molecular movement of water molecules in the concrete this is called spalling.

Thermoplastics can produce flaming dripping plastic, melt and flow, which will produce secondary fires.

Continuous beam = 3 or more points

Cantilever beam = fixed at one end
 = Seesaw effect
 = Compression at top tension at bottom

Chase = passage way usually verticle

Most common means of fire travel by vertical arteries such as open stairways, light and air shafts, dumbwaiter shafts and utility shafts.

Fire cut = angle cut @ end of rafter

Flitch plate girder = steel between 2 pieces of wood

Party wall = common to 2 buildings

Veneer wall = non-load bearing

Partition wall = load and non-load bearing

Some old buildings are bolstered by tie rods which hold opposite walls, this process is known as anchoring a building.

Lintel = spans masonry openings

Header spans wood openings

Atrium = series of floor openings

Axial = center of column

Eccentric = off center

Platform frame

- A platform frame building is limited to 3 stories or less
- Western construction

Balloon frame

- A balloon frame building, the studs run two or more stories high from the foundation to the eave line.
- Open space in walls from cellar to attic
- Eastern construction

Garden apartments

- Row house townhouse
- 3 stories or less
 - o 30 feet

Ordinary const. = masonry walls

Wood beam = 25' typical max length

Ordinary const. = 1hr rated ext walls

Plywood = delaminated or separates when heated
= external/internal use diff glues/adhesives

Marble = chalk when exposed to heat

Steel

- Steel's compressive strength is equal to its tensile strength. Its shear strength is about $\frac{3}{4}$ of its tensile strength.
- Steel conducts heat, when heated it elongates at 9 inches per 100 feet, and when heated it can push out walls or twist.
- Tension = Steel 15x stronger than concrete
- Steel elongates at = 1000
- Cold drawn steel cables fails at 800 degrees Fahrenheit.
- Steel tension and compression = equal
- Unprotected steel connections can often be found in pre-cast reinforced concrete buildings.
 - o Unprotected steel rods and cables (fail at 800 degrees) are often used to tie failing buildings together or to provide some additional resistance to earthquake movement.
- Steel increases .07 percent of its length for each 100 degree rise in temp. 0.1 inch for each foot of length when the temp rises 1,200 degrees. Unprotected steel will have lost 90 percent of its strength at about 1,400 degrees which is common in the ceiling of a fire.
- Steel will expand at 0.06 to 0.07 % in length for each Fahrenheit in temperature and elongates 9 to 9 ½ inches.
- Large sections of wood, over 6 inches thick can actually prove to be more resistant to fire than exposed steel.
 - o Steel does not burn, but fire temperatures in excess of approximately 1000 degrees causes steel to soften and bend like a pretzel.
 - o The surface of the heavy wood merely chars, limiting further burning
- Lally columns are steel pipes filled with concrete to increase their load-carrying capacity.
- Three negative characteristics of steel in fire:
 - o Conducts heat
 - o Elongates
 - o Fails at about 1000 to 1100

Girder = beam supporting other beams

Underground mortar = type M

Exit enclosures = 3 story or less 1hr rating
= 4 story or more 2hr rating

Freight elevator door = counterbalanced

Beam shape C or U = channel

Rigid beam span = 100'

Rough cut timber = lost to fire in 5 min.

Draft curtain = prevents mushroom effect

Passive fire defense = fire wall and doors

Active fire defense = sprinkler systems

Pre cast tilt wall const. = stabilized by roof

Basement exceeds 2500sq' = sprinkler sys

A fire wall is constructed from the ground to above the roof with a parapet.

50% of fire doors work

Fire escape access opening = no higher than 12" above floor

Short squat columns = piers

Bond = pattern in which masonry units are laid

Most ff deaths = ordinary const.

#4 rebar = 25" splice

Stack effect = air temp outside compared to inside

Kip = 1000lbs

Gypsum does not yield heat when burned in pure oxygen

Residential sprinklers = 18gpm

A Splice in #4 Rebar must extend beyond 25".

Stack effect depends on differential of temperature inside/outside a building.

KIP = Engineering term for 1000 psi.

Course Design

Training Aids

- Colors are important for visual aids
- 6/6 rule = 6 lines of text, 6 words per line as a maximum for training aids.
- A training aid is a device that promotes learning.
- Functions of a training aid:
 - o Illustrates, demonstrates, emphasizes what we are trying to accomplish.
- Qualities that make a training aid effective:

Legible	Durable
Simple	Colorful
Accurate	Realistic

Manageable

- o A flip chart is the least expensive and perhaps the most effective visual medium to use in presentations to groups of fewer than 30 participants because it does not require the lighting to be dimmed.

Preparation and Setup

- Being prepared for class is important.
- Preparation of days or weeks before class is typical
- The top list of preferences for most trainers is:
 - o A fully controllable lighting and sound system
 - o Infinitely flexible furniture
 - o Magnetized walls
 - o PC hookups to a network
 - o Wiring or cabling to accommodate videoconferencing
 - o Carpeting and plush swivel chairs
 - o Liquid crystal display panels and computer projection
 - o Reliable temperature controls
- Physical set up of classroom
 - o Horseshoe is best
 - o Most common to allow student interaction

Presentation

- To gain leadership establish firm ground rules and stick with them.
- Any progress that you might have made towards establishing a rapport with your group can go to waste immediately if you are not careful during the most important time period of your training program, the first 30 minutes.
 - o It is during the initial segment in time, however, that participants decide how they perceive you, what role they expect you to play in the training program, and what they intend to accomplish during the course.
 - o First 30 minutes of a training program are the most important.
 - o Knowing that the first thirty minutes of your training set the tone for the entire program.
- Body language used in presenting material can affect learning..
- Deal with boredom by using subject matter.
- Don't assume everyone knows the subject matter.
- Getting the groups attention is important.
- Increase receptivity of leadership of instructor; get participants to tell you what they need.
- Organize presentation with simple subject matter to start, must be interesting.
- Making smooth linkages and transitions between one topic and the next in your lecture or presentation involves briefly reminding the participants of what you have already covered, then indicating what is to follow.
- How do you coax a lively discussion out of a group intimidated by the quiet aftermath of a presentation or lecture? Starting a discussion is no different from beginning a lecture. You have to build interest.
- Start off a discussion with an open ended question.

Problems, Conflicts and Disruptive Behavior

- Entire group may become hostile towards instructor, i.e. they are forced to be here.
- Negative behavior of individuals is dealt with by getting them involved, change their behavior.
- Disruptive people should be talked to at break.
- Do not take negative behavior personally
- Responsibility of instructor is to entire class.

- Maintaining control in the face of participant conflict by connecting on a personal level (Believability/credibility).
- Summarize participant's viewpoints; intervene only when conflict interferes with entire class (requires intervention).
- How change affects an individual will affect entire department.
- Change group format in training program and reorganize group in new configuration.
- Mediate differences of opinions between participants and relieve any tensions that may be brewing
- When you think its appropriate, end the debate.
- Intervene only if the problem is repetitive or affects the entire training program.

Group Learning

- Start discussion with open-ended questions; leave room for debate and discussions.
 - o Don't get caught in the power struggle
- Use good natured humor to deflect conflicts
- Allow for active debate/feedback. Encourage Feedback.
- Make sure groups understand direction, take time to explain program, explain steps from beginning to end, open discussion and participation.
- Assist sub groups having problems understanding the activities.
- Too large a team (group) will get bogged down in decision-making.
- Look at personalities when putting people into groups.
- Building learning teams is a major goal.
- Ask groups of five or more to elect a facilitator
- Vary the number of people in any activity based upon that exercises specific requirement
- Gather group to memorable moments throughout the training program
- Elaborate of participants contribution to a group discussion with examples of other ways to view the problem.

Wrap up and Evaluation

- One of the many possible options is to leave plenty of time at the end of your program for reviewing program content. Also invite questions or concerns.
- When a program concludes participants are often times reluctant to ask questions for fear of delaying the end of the class. Make sure to avoid this situation.
- Two ways of obtaining group feedback:
 - o Oral
 - o Written
- Obtaining written/oral feedback is important.
 - o Written feedback is not as threatening.
- Final for training classes
 - o Final assessment.
 - o Reaction
 - What the student learned, what the teacher learned, see if a change needs to be made.
- Getting others to follow a preconceived course is teaching.
- Review or allow participant to recap information frequently

Principles of Learning

- People take notes at 20 words per minute.
- When teaching you must avoid making threats because you must follow through once made.
- Teaching is the process by which we get others to follow a preconceived course of action.
- Three P's of effective speech are Preparation, Presentation, and Personality.

- The Allen 4-step method of teaching is Preparation, Presentation, Application, and Evaluation.
- Learning through natural senses:
 - o Hearing – 11%
 - o Seeing – 83%
- 4 steps of teaching
 - o Preparation, presentation, application, evaluation.
- Directed learning is a specific learning goal or objective.
- Trial and error is random learning.
- Retention Rates:
 - o Read 10%
 - o Hear 20%
 - o See 30%
 - o See and Hear 50%
 - o Say 70%
 - o Say and Do 90%
- Learning climate is concerned with the overall environment in which learning occurs.
- Factors which influence the learning environment:
 - o Instructor, Student, Course material, Facilities.
- How to handle different types of learners:
 - o Do nothing – Get them involved.
 - o Wise Guy – Shame
 - o Know it all – talk to them at break.
- Question directed to:
 - o Individual = Direct
 - o Entire Group = Overhead
 - o To promote thinking = rhetorical.
 - o An overhead question from student to instructor is a relay question.

Entire group involved in discussion process to answer questions and promote group thinking is a buzz session.

Entire group thinking creatively rather than practically is brainstorming.

45% of average adult's communication time is spent listening.

Language habits:

Writing – 9%
 Speaking – 30%
 Reading – 16%
 Listening- 45%

Basic principles of effective speech:

Personality, preparation, presentation.

Critique is a critical review of what has been said and done.

Guide to teaching is an instructor's lesson plan.

First step of lesson plan is to write objectives. Good lesson plan will include: Guide to lessons, arrangement of site, logical presentation of plan, provides uniformity when using substitute instructors, itemized survey of what is to be covered.

A performance objective is a learning goal expressed in measurable terms. It describes the expected performance of the student.

Condition describes a job condition of performance.

A Criterion identifies minimal acceptable student performance in measurable terms.

A Standard identifies a minimum standard that must be met to demonstrate mastery of an objective.

Brainstorming is where creative thinking is more important than practical thinking and gives good feedback.

When an instructor is flooded with questions by the students and then relays them back in either direct or overhead questions, this action is? Good because it regains control of the class by slowing the class down.

Why do we test a student?

- To see if learning has occurred.
- Reveal student's weaknesses.
- Hold student accountable.
- Basis for grades.
- Make changes as necessary.

Types of testing:

- Normal reference testing – compares one student to another.
- Criterion reference testing – compares student performance against a standard.
- Central Testing – Exam made by someone other than the instructor.

Test must yield validity (measures what was taught) and reliability (must yield same result test to test).

When writing tests:

- Arrange items in order
- Group like items together.
- Make first several questions easy.

Different types of tests:

- True/False – Test large amounts of information in a short time.
- Completion – Measures memory and ability to recall facts.
- Multiple Choice – Statement with a series of alternatives.
- Matching – 2 lists of related items or information.
- Identification – measures students ability to recognize names or pieces of equipment.
- Short essay – respond in student's own words.

Advantage of multiple choice– measures judgment and memory, may measure reading ability unfairly.

Advantage of completion – student must remember specific facts, but measures memory rather than judgment.

Advantages of identification is measures knowledge, but graphic representations may be poor.

Advantage to True/False can cover wide range, but allows for a 50% chance of guessing correctly.

Advantage of short essay is easy to construct, but may be difficult to score objectively.

Strategy and Tactics

Many fire departments make the strategic error of gearing for the usual and not the potential.

An analysis of a fire situation is not of full value until it is used to formulate an action plan.

Strategy

- The planning process
 - o What is to be done
 - o Basic rules of strategy
 - Plan of action:
 - Locate the fire
 - Confine the fire
 - Extinguish the fire
 - o Large scale general plan
 - What to do
 - What resources are needed
 - Who will do it

Tactics

- Commitment of manpower and equipment to tasks
 - o How to do it
 - o Ways of implementing strategy
- Tactical Plan
 - o Accuracy, ability to execute, feasibility
- Adding "How to do it" changes a strategic plan into a tactical plan
- Main observable factors that influence a choice of tactics are"
 - o Life hazard
 - o Location of the fire
 - o Extension probability
 - o Type of fire
 - o Size of fire

There are 13 points to the action plan.

The successful control of a major fire depends not only on the selection of the correct tactics, but also on good direction and coordination.

Three greatest hazards to firefighters are collapse, smoke and explosion.

Temperature curve reaches 1000 degrees in 5 minutes. 1700 degrees in 1 hour.

Exothermic means heat is emitted, endothermic means heat is absorbed.

The rate of reaction is roughly doubled for every 18 degrees Fahrenheit rise in temperature

Flashover is imminent

Sudden unaccountable increase in room temperature then flashover

Tests have shown repeatedly that modern fire apparatus in many cities can maintain an average road speed of 30 MPH per run while responding.

Life hazard

- Danger to:

- o Occupants
 - Most in need of help close to the fire on the same level
 - On the floor immediately above the fire
 - On the topmost floor of the building
 - On other floors above the fire
- o Firefighters
- o Others

The outer shell of fire protection gear is required to give only 15 seconds of flashover protection.

Location of the fire determines the life hazards and the extent and probability of extension.

Each pound of carbon should combine with oxygen to make 2.6 pounds of carbon dioxide.

Routine transport of invalid patients is not part of the definition for “rescue”.

Europeans have been using self-contained oxygen or air units for almost 100 years.

15-point size-up “weather” has wind, temperature and humidity. The question asks for the one that doesn’t apply in relation to the wind.

Size up

- Enables officers to determine procedures
- Size up
 - o Points of size up
 - Fire
 - Location of fire
 - Most important because it determines life hazard and the probability of extension
 - Type
 - Size
 - Extension probability and possibility
 - Life hazard
 - Time
 - Weather
 - Construction
 - The greatest hazard in firefighting is building collapse
 - Height
 - Area
 - Occupancy
 - Access
 - Internal protection
 - Water supply
 - Apparatus
 - Firefighting personnel
 - Terrain
- Rescue
 - o Removal of person(s) from hazardous environment to place of safety.
 - o Generally in rescue operations, persons in the most danger are located on the fire floor.
 - o Use the quickest, safest and easiest means of rescue, rather than the most dramatic.
 - o Most persons killed at fires have succumbed by the time that the firefighters have arrived.
 - o Rescue companies came into being in NY City in 1915
 - o The term rescue is much abused and vaguely used
- Ventilation

- o Planned and systematic removal of smoke and heated gasses
- o Using fog stream for ventilation
 - Fog streams can move from 10,000 to 30,000 cubic feet of air per minute for ventilation.
 - Cover 75-90% of window, back 2 feet, 60 degree pattern.
- o Most important tactics at a taxpayer fire are to cut large hole for ventilation, delay horizontal spread. Do not do trench cut.
- Salvage
 - o The portion of the fire operation that has undergone the greatest strategic change
 - o Part of the action plan and begins on arrival of first engine
 - o Planned systematic protection of property not yet involved in fire
- Extinguishment
 - o Removal of the main body of the fire
 - o Small burning objects
 - Completely submerge in water
 - o Beware of using water on substances whose first name ends in "um" and the second name ends in "ide".
 - o Water will absorb more heat into fog and a greater percentage of it will be turned into steam which expands the water 1650 times.
 - o One gallon of water is needed to absorb the heat generated by a pound of burning wood
 - o Water has the ability to absorb more heat than other readily available substances
 - o Water not helpful with flammable liquid fires that give off vapors with less than 100 degrees F.
 - o Fog nozzles and water are effective on high flash point liquid fires; straight streams are not.
- Overhaul
 - o Phase of firefighting where most injuries occur.
 - o Must have charged lines in place.
 - o Hidden fires most often found around doors and windows
 - o Carbon monoxide generation in a void with restricted air flow can be as much as 50 times what would be evolved in burning in the open
 - o Carbon monoxide flammability range is from 12.5 to 74 % and its ignition temperature is 1128 degrees Fahrenheit.
 - Carbon monoxide is the most potent threat to life. Over 95% of fire deaths are from CO.
- Critique
 - o Critical review of what was done
- Exposure
 - o Any area fire can spread to

Temperatures inside a CLOSED room fully involved are 1/3 less at the floor than the ceiling.

Smoke

- Black smoke is a well-involved fire.
- Color of smoke in a completely involved building and contents fire is very dark.
- Wood smoke smells different from that of smoke produced by paper, which in turn smells unlike smoke for cloth, plastic, or rubber.
- Smoke color is different by day and by night.
 - o Much wood involvement would show a brown smoke by day, but the same smoke would appear light at night.

Firefighting Hazards

- Age of structure

- o Determines how fire will affect a structure
- Roof type most prone to early collapse is arch truss
- Leading cause of multiple firefighter deaths is building collapse.
- Greatest hazards to firefighters are:
 - o Explosion, structural failure, smoke.
 - o

A mixture of CO₂ and oxygen will ignite at 1100 degrees Fahrenheit that is commonly exceeded at the ceiling of a room where a fire has been burning.

Primary objective in a nursing home fire is to extinguish the fire.

The most common type of fires are dwelling fires that account for the largest number of structure fires.

What percentage of fire fatalities occur in residential occupancies? 80 percent.

In factory fires the first line should go into the standpipe Siamese, even if the building has a wet standpipe system the pressure and volume are probably insufficient for the heavy streams needed.

High Rise Fires

In high rise fires, there should be a lower command post established in the lobby, an upper command post two floors below the fire and a staging area on the floor below that.

If taking an elevator to the fire, the safest way is to get off elevator one floor or even two below the fire and walk up the stairs to the fire floor.

In all high rise buildings there is a stack effect and neutral pressure plane. If the air in the building is warmer than the air outdoors, there will be an upward movement of air in the vertical shafts, such as those for elevator, stair, and trash; however if it is warmer outside than in, the air in those shafts moves downward.

If evacuation of a building is necessary the best procedure to use is stairways and fire escapes.

In a high rise fire, the people in the most danger are on the fire floor, then the floor above the fire, the top floor, and then the floors in-between.

Most common movement of fire in multi story buildings is open stairwells.

Fire on the 6th floor of a 6 story building. Connect to the standpipe first, not the sprinkler; anything on the 5th floor or above is standpipe first. Under the 5th floor is sprinkler first, then standpipe.

Aerial platforms are not quicker to set up than aerial ladders.

Taxpayer Buildings

Taxpayer buildings are not intended to last. They are built as cheaply as possible and consequently from the fire protection standpoint are full of flaws. Construction is usually poor. An uninterrupted cockloft frequently covers several stores.

The insurance industry has been the biggest single influence in the fire service in America.

A principal concern for insurance was conflagration (vulnerability of a city).

UL 704 Placard has no green segment (red/White/Blue/Yellow)

Balloon Frame Construction

- 2 or more stories, studs run from foundation to eaves.
- Type of construction where fire can travel rapidly upward in a space between outer wall and inner wall due to the lack of fire stops.
- Check attic for extension first

Automotive electrical fires – disconnect the battery.

In a mattress fire the mattress should be shoved out the nearest window.

Central core construction

- Elevator shafts, exits and stairwells are contiguous to each other in a center core that runs vertically through the center of the building.

Pause is colder air over warmer air

- Inversion layer
- Atmospheric air does what the higher it gets
 - o Colder
 - o Lapse

Critical flow rate is the Minimum amount of water required to extinguish fire.

- Minimum flow in gallons per minute needed to extinguish a given fire

Ideal flow rate formula does not calculate water or manpower.

Ideal flow rate used to figure water/pumpers/manpower

Ideal rate of flow

V = volume cubic feet

GPM = flow rate needed to extinguish fire

$V/100 = \text{GPM}$

Need one pumper for each 500 gpm

Need one firefighter for each 50 gpm ideal rate of flow

With adequate water on the fire, how long to control? One minute.

$L \times W \times H / 100 = \text{GPM}$

Results of the tactical plan depend on the accuracy of the analysis and the ability to execute the plan.

Hose streams never oppose each other

Elevated platform is most useful for elevated fire streams.

Element of a pre fire plan are:

Pinpoint, record needs, and provide for meeting the needs.

Combustion process

Firefighter must know to protect self

Temperature

Measurement of molecular velocity

Smoke

Incomplete combustion

Heat travel

Upward and outward

Flashover

Almost always occurs at about 1000 degrees

Ladder Truck Operations – ROVERS

- R-rescue
- O-overhaul
- V-ventilation
- E-entry
- R-reconnaissance
- S-search

Incident Command

Horizontal command is by function.

- Horizontal command distribution duties are by tasks (operationally)
- Horizontal command is adapted for large incidents.
- Officers are assigned by tactical effect rather than location
 - o Water supply, safety, ventilation, etc.

Vertical command distribution duties are geographical

- Vertical command system is one in which the command duties are distributed geographically
 - o Front, sides, rear, top, interior, etc.

ICS structure may be expanded once implemented.

ICS improves safety by monitoring firefighter placement, anticipating building hazards, provides accountability.

The operational chart is based on the series of five the five sector commanders each command five battalions the five battalion commanders direct five companies each.

Enhancement of professional image is not a function of ICS.

Used at all fires and Incidents

Functions:

- Command
 - o The officer in command must have sufficient knowledge of fire behavior, firefighting strategy and tactics and how tactics and fire behavior interact.
- Operations
 - o Coordinates tactical objectives
- Planning
 - o Evaluates information
- Logistics
 - o Provision of needed supplies and services.
- Finance

Incident Command is staffed at all incidents.

Staff positions:

- Liaison, Safety, and Information.

Firefighters must understand the combustion process in order to protect themselves from fire.

Potential energy of a substance releases during combustion as heat/light.

Temperature is the measure of molecular velocity.

Oxygen, fuel and ignition temperature must come together for fire to begin.

Ceiling Flash over temperature is 1000 degrees.

Back draft cannot occur in the free burning stage.

Company Officer

Risk Management Estimates and assigns the possibility of loss or injury; provides incentives for the prevention of loss or injury, and puts a premium on training programs that emphasize safety.

Management by Objectives: is more effective when the organization's and the manager's goals are integrated; First used in 1954 by Peter Drucker as a method to motivate managers to achieve greater efficiency and effectiveness.

Requires managers to set quantitative objectives within a set of overall guidelines, requires the manager's personal work goals to be measurable, attainable, and not trivial.

Was found after some time not to be effective in the fire service because success judgment was impossible from the community standpoint.

Zero Based Budgeting: Requires an organization to justify funding for any on going as well as any newly proposed program; assigns a priority order to all programs that are to be funded; weeds out programs that are not necessary or no longer useful; requires a manager to be a salesman of sorts.

Master Planning: Affected largely by short falls in budgeting of the current fiscal year; the most important ingredient is commitment by the entire community as well as representatives of the community; involves long range planning; used widely by military, government, law enforcement and the fire service.

Accountability is an aspect of responsibility, however, accountability can be delegated. Responsibility cannot be delegated.

Empathy is the ability to put yourself in another's place.

- Simulating that person's feelings, prejudices and values.

Projection is the assigning to others possibly in disguised form the wishes and fears we cannot openly admit that we have.

Which of the following is not a defense mechanism

Subversion – not projection, conversion, and subversion.

Centrality is the concept of the focal element, which causes energy and ideas to advance from the group.

The 6 basic psychological needs of the working man are : to maintain face, of recognition, for accomplishment, to be heard, fair treatment, be part of a group.

A habit is any action, way of thinking, or way of feeling that is repeated many times by an individual and gives them a feeling of satisfaction.

The ability to put into words as clearly and concisely as possible, the use of properly worded questions and the ability to apply the result of feedback or to answer a question is communication.

Leadership is the art of getting someone to do what you want done because he wants to do it.

- With enthusiasm and confidence.

Leaders:

- Authoritarian leader
 - o Usually insecure in position and lacks in technical knowledge, views subordinates as a threat.
- Democratic leader
 - o Has genuine respect for their subordinates, rather than be reluctant; they will readily share the workload and delegate authority.
- Free Rein leader
 - o Reluctant to accept responsibility; often times led by subordinates and seldom offer any leadership.
- In effective leadership, flexibility is the key word and the situation determines the type of leadership you will employ.
 - o A good leader is flexible, honest, objective, and consistent.
- Experience has shown us that in the Fire Service there is no best method that can be used in the management of a department or unit.

The individual that discovered that groups have more than one leader and the way change affects a group was Elton Mayo.

Channeling primitive energies into socially approved or not approved activities is sublimation.

Morale is the climate prevailing within the company.

The main prerequisite for developing good communication skills is listening.

Setting benchmarks is very important. Set a goal, accomplish the goal, and move to the next step.

Maslow's hierarchy of needs:

- Self-realization and fulfillment
- Esteem and status
- Belonging and social activity
- Safety and security
- Basic physiologic needs

Behavior training as opposed to punishment is discipline.
A company officer must be objective with discipline.

Official leader of a group – de jure
Unofficial – de facto

Forcing threatening impulses into physical (functional) disorders is conversion.

Cooperation is working together toward a common goal.

Grievances

- Establish the validity of the grievance, is it real or imagined. Have individual or individuals state their grievance and have them trained to offer some sort of solution to the problem.

Resistance to Change

- The degree of resistance will be governed by how the change affects each individual.
 - o The more change affects a person, the more resistance they will exhibit.

One of the ways to alleviate hostility is the implementation of good communication. This can be accomplished by having all the members of the team participate in the planning stages prior to the change.

Unity of Command

- The more completely an individual has a reporting relationship with a single supervisor, the less the problem of conflicting instructions and the greater the feeling of personal responsibility for results.

Five types of communication are :

Upward/downward/horizontal/external/multi directional

Management is the process of getting things done with people.

Elton Mayo discovered:

Workers are not a collection of individuals
They perceive themselves as members of a group
Interpersonal values were superior to managerial ones.
Group members were vulnerable to peer pressure.

Rationalization is the process of explaining plausibly, yet incorrectly, to others, and ourselves why we think, behave or feel the way we do.

The number of people you can successfully and effectively supervise (usually 4-6) is span of control.

McGregor

- Author of theories X and Y
- Theory X is that all employees are inherently lazy and must be motivated.
- Theory Y is that all employees want to do a good job and excel and therefore just need to be guided and supported.

DC McClelland hypothesized that individuals are motivated to seek pleasant affect and to avoid negative affect.

The Ego Motives – They are referred to as the desire to achieve and maintain a sense of personal worth and importance.

One element that is often neglected of communication is perception. By this we mean the way in which an individual perceives what is communicated to them.

The dictator type of leader who might be tough and unreasonable is authoritarian.

Unity of command is having only one supervisor to report to.

Usually characterized as a wishy-wash, spineless and irresponsible person – free reign.

Synatlity – what the group does for the individual.

Lewin says that the resistance to change is in direct proportion to how it will affect the group or individual.

Lewin recommends that you should use the informal group.

Three things can be done with the informal group:
Use it, ignore it, Destroy it.

A Democratic leader practices a hands-off policy in his dealings and lets the group decide their fate by a majority rule.

Functions of Management

- Planning is deciding which objectives or goals will be perused, when and how they will be achieved, and how manpower, equipment and time is to be used.
- Organizing involves the establishment of structured roles, identifies activities required to achieve group goals, and assigns tasks along with delegation of authority to carry them out.
- Staffing is the process that involves manning and keeping manned the positions created by the organizational structure and insuring that the positions are manned by the most qualified people.
- Directing is the process involving guiding and leading subordinates, and revolves around the reinforcement of company policy and tradition.
- Controlling is the on going process that measures and corrects activities and evaluates the effectiveness of your programs.

The essence of responsibility is obligation.

Miscellaneous Workbook

Fire Prevention Code is used to regulate activities within a building once it has been constructed.

BOCA – Building Officials and Code Administrators International

ICBO – International Conference of Building Officials

SBCCI – Southern Building Code Congress International

APW – Air pressurized Water

RTI – Response Time Index

UBC – Uniform Building Code

SBC – Standard Building Code

BCMC – Board for Coordination of Model Codes

A Rain Test measures if rain adversely affects a roof's fire retardant ability.

Roof Tests:

Class A - effective against severe fire exposures

Class B – effective against moderate fire exposures

Class C – effective against light fire exposures

Rated fire door has complied with ASTM Test E512

Steiner Tunnel Test designation

UL 723

ASTM E84

NFPA 255

Building Materials Directory gives flame spread ratings for construction materials.

Machine shop with noncombustible floors has moderately severe fire load.

A typical fire load greater than 20 psf is classified as severe.

Field test for flammability – flame tip held ½ inch below the material for 12 seconds. The material should not support combustion or continue to flame for more than 2 seconds after flame is removed.

NIST – National Institute for Standards and Technology

ASTM – American Society for Testing and Materials

Class B refrigerant is toxic in concentrations of less than 400 ppm.

Fluid coating – coating process that uses an air spray gun.

Powder coating – process that suspends electrostatically charged particles in air.

Continuous coater – moving racks pass parts through a fluid- or powder- coating enclosure.

Decorating machine is used to apply paint strips or other patterns on automobile parts.

Baffle maze – device in which reusable panels accumulate particles from paint overspray.

Cascade scrubber – device that captures paint overspray particles in water.

Furnaces:

Class A - atmospheric pressure. Potential for explosion or fire hazard when volatiles or combustible materials are processed or heated in the furnace.

Class B – Atmospheric pressure – no volatile or combustible materials or heated.

Class C – Potential hazard.

Class D – Operate at temperatures from above ambient to over 5,000 degrees. Operate below atmospheric pressures.

Mechanical equipment in an HVAC system must be enclosed in a separate room with a minimum fire-resistance rating of one hour.

Oil quenching tank over 500 gallons must have a bottom drain that will open automatically or manually in the event of a fire.

Fires in approved burn containers should not be within 25 feet of a structure.

A fire inspector must actually visit a site proposed for open burning before issuing a permit.

Inside storage of tires – NFPA 231D

Open yard storage, maximum recommended height for stacks of wood in a lumberyard is 20 feet.

Maximum recommended dimensions for a driveway grid in an open storage lumberyard is 50 by 150 feet.

Local codes contain specific requirements for lumberyards.

Incineration reduces wastes 95%

Fuel-fire incinerators should be preheated for 30 minutes.

Welding and thermal cutting –heat and oxygen are fire triangle elements always present.

Primary fire hazard associated with oxy-fuel gas equipment is storage of the oxygen and fuel gas cylinders.

At welding or cutting operations, 35 feet area should be protected from sparks or slag.

Fire watch is required at welding or thermal cutting operations for 30 minutes.

Static accumulation is major cause of fires in powder coating processes.

Flash point of mediums used for heated quenching is 500 degrees.

Quenching tanks should be built within dikes.

At quenching operations, three flammable liquid storage cabinets may be allowed in process area without AHJ approval.

Grain storage operations – access doors must be provided and emergency action plan should include the location of MSDS.

High expansion foam is not effective for suppressing inside tire storage fires.

HPM – Hazardous Production Materials.

OFW – oxy-fuel gas welding.

Building Construction Types:

- I – Fire Resistive
- II – Noncombustible or limited
- III – Ordinary
- IV – Heavy timber
- V – Wood frame

BCMC – Board for Coordination of Model Codes.

Residential-custodial care facility is health care occupancy.

NFPA 101 classifies 4 residents as detention and correctional facility.

College dorm is residential occupancy.

A Shopping mall is not a mercantile occupancy.

A college classroom with rooms for fewer than 50 people is a business occupancy.

Reaction is the result of force exerted by a beam on a support.

Euler's law applies to very long and thin columns.

The Tunnel Test for wood is 10 minutes in length.

The Tunnel Test for pressure treated wood is 30 minutes.

Pressure treated wood decreases its allowed load by 25 percent.

Wood shingles are tested to NFPA 256.

When exposed to NFPA 251, Standard Fire Exposure Test, solid sawn beams lasted about five minutes per inch of thickness.

The flammability range of carbon monoxide is 12.5 to 74 percent.

Ordinary wood-joisted floors are not formally rated.

Demolition Operations is known as NFPA 241.

The usual height limit for garden apartments is 3 stories in height.

Plumbing fixtures in garden apartments are vertically aligned for economy and speed of construction.

Standard fire-resistance test, the minimum size of the:
Column test specimen is 9 feet.
Beam and girder test specimen is 12 feet
Partition and wall test is 100 square feet
Floor and roof test specimen is 180 square feet

To pass the standard fire-resistance test, a floor structure must not permit an average temperature rise on the unexposed surface of 250 degrees.

The standard fire-resistance test for columns is ended when the average temperature exceeds 1000 degrees.

The modulus of elasticity for steel is 29 million psi.

The tensile strength of steel is equal to its compressive strength.

The shear strength of steel is about 75% of the tensile strength.

Steel plates less than 6 inches in width are known as bars.

Box columns are large hollow columns built from steel plates.

Channels are steel structural components which have a square U-shaped cross section.

Plates are flat pieces of steel.

A plate girder is a girder built from steel plates with angles riveted on each side of the top and bottom to form a flange.

A lattice is a column made of vertical units connected with diagonal pieces.

WI is a wide-flanged I beam.

Purlins are beams, usually channels, set at right angles to trusses or roof rafters to provide support for light-weight roofing.

Spandrels are girders that tie wall columns together in a framed building.

Rigid frame columns can be used to provide clear spans up to about 100 feet.

Composite concrete block and brick or concrete block walls are the most common in unprotected steel-frame buildings.

Asphalt asbestos protected metal is used to protect galvanized steel walls from the weather when heat conservation is not of importance.

Patch riveting is placing temporary bolts in rivet holes of steel construction.

Soldier beams are rows of vertical steel beams driven into the ground for excavation bracing.

Walers are horizontal beams which are used to tie the vertical beams together in excavation bracing.

Rakers are diagonal columns used to brace the entire support structure in excavation bracing.

In excavation bracing, the diagonal columns may be loaded to twice as much of the load that would be permitted if they were permanent structures.

Basic type of construction should be the first consideration in studying a potential fire in an unprotected steel building.

Steel supported roofs are not required to be protected if the distance above the floor is 20 to 30 feet.

Skewbacks are tiles that are shaped to fit around steel.

FM requires a 3 hour fire protection rating for all columns.

FM tests have shown that it take 800 degrees for 5 minutes to start a self-sustaining roof fire on the surface of steel decking.

During a fire only ½ of all fire doors actually operate.

Water supplies for spray streams designed to protect tanks and steel supports from flammable liquid spill fires are calculated on a requirement of .25 gallons per minute per square foot.

Encasing steel is considered to be passive.

Concrete blocks built to the specs of UL are known as Underwriters blocks.

Protruding rods are a serious sign of potential collapse in columns.

Reinforcing rods are located in the top of the beam in a cantilever beam.

Stirrups are vertical reinforcing bars in concrete beams designed to prevent cracking under shear stress.

Steel has 15 times the compressive strength of concrete.

Pre-cast cored concrete is a type of floor unit cast with lengthwise cylindrical openings that remove unnecessary weight and provide channels for building utility services.

Falsework can represent 60 percent of the cost of a concrete structure.

With falsework, a fluid load can create a head pressure of up to 150 psi per each foot of height.

Foamed plastic insulation should be protected by ½ inch gypsum board.

FM groups telephone or cable lines into three flammability groups.

Group I – resists fire propagation, can be used in noncombustible construction without sprinklers

Group III – exhibits very rapid intense fire propagation

Lime plaster absorbs heat and slows the progress of fire.

Time to reach flashover is 15 minutes.

Fluorescent light fixtures with a defective ballast can reach 1500 degrees.

Non-listed surface-mounted fixtures containing a ballast are to be installed on combustible low-density cellulose fiberboard, must be space not less than 1 ½ inches.

Combustible low-density cellulose fiberboard includes sheets, panels and tiles that have a density of up to 20 pounds per cubic foot.

A test sample for the Steiner Tunnel Test is 2 feet wide.

A flame spread rating of 20 is a Class A.
A flame spread rating of 80 is a Class C.
A flame spread rating of 200 is a Class C.

A Class B occupancy that is fitted with full sprinkler protection could become a Class C.

Test samples for the Radiant Panel Flame Spread Test is 6 inches by 18 inches.

A corner test is an FM test.

The Radiant Flux Test NFPA 253 measures the ability of the interior floor finish to resist flame spread.

Habel's rule states that any exposure in which the concentration (ppm) multiplies times the exposure time (in minutes) equals 33,000.

Gravity is generally considered to be the chief mover of smoke in a fire.

Gravity vents should be used where a substance which is lighter than air is handled.

Pre-World War II buildings were built primarily of Steel-framed construction.

Modern high-rise buildings weigh approximately 8 pounds per cubic foot.

Concerning stairways in some buildings, doors are locked at all floors to prevent re-entry. Some codes require that doors be unlocked for re-entry at no more than four intervening floors between locked doors.

The principal smoke-moving mechanism in a fire is the thermal energy of fire.

When atmospheric temperature is constantly decreasing as height increases, the condition is termed lapse. This will cause the smoke to move up and away from the fire.

Pause is the condition in a high-rise when there is a layer of warm air above a cooler layer.

Inversion layer is the layer of air that is created by having a warmer layer above a cooler layer.

Wind blowing against a building seems to split about two-thirds of the way up the building, creating a vortex.

Stack effect occurs in tightly sealed buildings.

The winter stack effect has the greatest flow of air from the floor into the vertical opening on the first floor. It has the least flow of air at about one-third to one-half of the way up the building.

Smoke that loses its thermal energy can still rise due to the stack effect.

Smoke found in refrigeration plants that moves downward is called cold smoke.

The type of system will determine if airconditioning is a significant factor in smoke movement.

NY Board of Fire Underwriters found that of 1394 fires in high-rise buildings over 10 years, 23 were not controlled by sprinklers. Of these, in all but two the operating valves were turned off.

Compressive members of a truss are called a strut.

Tensile connecting members of a truss are called ties.

The connections in a truss are called panel points.

A Truss Web consists of struts, ties, and panel points.

Tied arches are those in which a steel tension rod ties the ends of the arch together to eliminate the need for masonry.

The space produced by very deep-parallel-chord trusses is interstitial space.

Dormer windows are a clue that can lead to the assumption that parallel-chord trusses have been used as roof rafters.

A space frame is a three-dimensional truss.

In sketches of trusses, compression members are shown as a thick line. Tension members are shown as a thin line.

A King truss has a single compression member.

A Queen truss has two compression members.

Juvenile wood is very prone to shrinkage and warping.

Gusset plate teeth are approximately 3/8 inch long.

Unprotected steel open-web bar joists reach 1200 degrees in 6 to 8 minutes.

Insulated metal deck roofs are often used in conjunction with steel bar joists.

Carbon monoxide ignition temperature is 1128 degrees Fahrenheit.

A few breaths of carbon monoxide at 12,500 ppm can be fatal.

Exposure to 3500 ppm of carbon monoxide would be hazardous and possibly incapacitating in approximately 10 minutes.

Wooden I-beams are manufactured in lengths up to 60 feet.

There are six major classifications of sprinkler systems

Loss of life in cellar fires has cause many cities to require sprinklers in basements in excess of 2500 square feet.

Sprinkler piping is tested to 175 psi after it is installed.

NFPA 13 states that if the ceiling is within six inches of the joists, sprinklers are allowed to be omitted.

Early suppression fast response sprinklers have an orifice size of .70 inches.

Early suppression fast response sprinklers can protect rack storage of high density plastics up to 25 feet without the use of in-rack sprinklers.

Sprinkler systems do not require a FDC if it has less than 21 sprinkler heads.

Pallet storage systems provide 36 times the surface area of the boxes that are stacked solid.

Fire walls are passive.

In many warehouse fires, sprinkler systems have failed due to collapsing roofs.

Low expansion foam sprinkler systems are used for flammable liquid fires.

Highly Protected Risk occupancy sprinkler systems are not designed to extinguish the fire.

Warehouse fires with rack storage that have tilt slab concrete. When the roof fails, the walls may fall out.

Building corners are the least dangerous area in a collapse.

Upon arrival at a warehouse heavily involved in fire, back up the sprinkler system.

Positive pressure ventilation has proven to be effective against winds of up to 25 mph.

For every cubic foot of oxygen delivered to a fire, 537 BTUs are generated.

Life Safety Code {142-143}

Class A ramp

Maximum slope of 1:10

Class B ramp

Maximum slope of 1:8

Evacuation {154}

Phase I

Phase II

Evacuation of an entire zone of a healthcare facility

Phase III

Entire floor of a healthcare facility, as well as zones on the floor above the fire floor

The width of a public way should have a width and height of at least 12 feet.

Inmates may be released from correctional facilities by electrical, mechanical or master keys.

Exit stairs {141}

Landings must be provided to break up excessively long individual flights

Fire escape stairs (143-144)

Must be exposed to the fewest possible door or window openings.

Exit illumination: {144}

Exit signs must be positioned so that no point in the exit area is more than 100 feet from the nearest opening.

Affinity law is a mathematical relationship used to correlate pump performance at any speed to its rated speed.

A Gravity system delivers water from a source to distribution system without pumping.

A grid is a network of water mains that makes up a distribution system.

A dead-end hydrant receives water from one direction.

A circulating hydrant receives water from two or more directions

Primary feeders are the largest pipes in a distribution system.

Secondary feeders are pipes that reinforce the grid system with a concentrated supply of water.

Distributors are pipes that serve individual hydrants and blocks of customers.

A dry-barrel hydrant is a hydrant with a base valve located below the frost line.

A wet-barrel hydrant has a compression valve at each outlet.

A fire flow test is a test to determine the rate of water flow available at various locations within a distribution system.

A test hydrant is a hydrant where static pressure and residual pressure are taken during a flow test.

For residential systems with two or more sprinklers, NFPA 13D requires a 13 gpm water supply for each sprinkler if 2 or more.

Fixed fire pumps are not rated at a fixed pressure.

When an electric horizontal split-case pump is tested, the measured voltage should never be more than 5% below or 10% above the rated voltage.

NFPA 750 covers water mist systems.

Refrigerated tanker of CO₂ liquid @ 300 psi at 0 degrees
High Pressure liquid CO₂ – 850 psi @ 70 degrees
5 year hydro