Utility Emergencies & Foam Instructor Manual

New Hampshire Department of Safety
Division of Fire Standards & Training
And Emergency Medical Services

Mailing Address: 33 Hazen Drive, Concord, NH 03305
Location: 98 Smokey Bear Blvd., Concord, NH
Telephone: 603-223-4200FAX: 603-271-1091

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UTILITY EMERGENCIES & FOAM

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UTILITY EMERGENCIES & FOAM

INSTRUCTOR MANUAL

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Produced by Captain John Uitts

Responding to the Utility Emergency & Foam: Basic Level.

PREPARATION

Motivation: This Class is designed to be an awareness of the possible hazards associated with typical utility systems based on the products they transport. The class will explain the basic concepts of the various utility systems and what typical responder solutions may be used to common malfunctions. A discussion of firefighting foam and its applications round out the classroom presentation. The practical evolutions reinforce the tactics discussed in the classroom.

Prerequisites: The student will need an understanding of the ICS System, basic fire fighting concepts, and Hazardous Materials Operations

MATERIAL

Equipment: for Classroom:
Power point projector, laptop, and screen to accommodate presentation, CD of the video clips if not embedded in the program. Classroom delivery kit.

Equipment for Practical:
A flammable liquids pit or simulator, The Academy LP Props, foam equipment, attack engine with hose and nozzles,

PERSONNEL

Primary Instructor: One educator that has several years of field experience in response to all facets of non fire emergency responses and foam applications.

Secondary Instructor: One educator with some field experience in non fire emergency responses.

Psychomotor instructors: In addition to the primary instructors, safety officer, and prop operators, an additional instructor will be needed for each 6 students for all psychomotor skills.

RECOMMENDED TIME TO COMPLETE TRAINING:

Classroom presentation is to be about 8 hours including breaks. Practical evolutions comprise about 8 hours with breaks.

TERMINAL OBJECTIVE

This class is to prepare the student to an awareness level sufficient to insure that they are not placing themselves or others in a life threatening situation when encountering a utility emergency.

COGNITIVE OBJECTIVES

At the completion of this course, the student should be able to recognize the hazards of various utility systems and what steps they may take to protect themselves and the public. This may be as simple as evacuating the area and calling the proper utility personnel. The following is an expanded list of objectives.

1. Basic understanding of the operations of the following utilities:
    a. Electrical distribution
    b. Pipeline systems
    c. On site flammable containers and distribution methods
    d. Common transportation of flammable products

2. Basic understanding of the hazards of the following utilities:
    a. Electrical distribution
    b. Pipeline systems
    c. On site flammable containers and distribution
    d. Common transportation of flammable products

3. Basic understanding of the mitigation of malfunctions of the following utilities:
    a. Electrical distribution
    b. Pipeline systems
    c. On site flammable containers and distribution
    d. Common transportation of flammable products

4. Basic understanding of firefighting foam and its application

PSYCHOMOTOR OBJECTIVES

At the completion of this course, the student will be able to physically perform the following operations:

1 Set up foam equipment
    a. Set up a foam proportioner
        Skill Drill 16-44
        1 flow foam through a fog nozzle
        Skill Drill 16-46

        2 flow foam through a fog nozzle with an aerator tube attached

Skill Drill 16-45

b. Demonstrate high expansion foam equipment
   1 flow foam using a high expansion generator and fill an enclosed space
   Skill Drill 16-48

2 Deploy hand lines on a simulated flammable fuel spill
   Skill Drill 16-47A

3 Control the following situations

a. Control a simulated leaking gas line
   Skill Drills 32-9 & 21-13

b. Control a large propane grill fire

c. Control a 420 gal. propane tank which has flame impingement on the tank and is adjacent to a structure.
   Skill Drill 21-12

d. Control a simulated underground Propane tank breach

e. Control simulated propane, 500 gal. propane fill station fire.

PRESENTATION:

I. Introduction:

A. What are Utilities?
B. Where are Utilities found?
C. What dangers are associated with Utilities?

II. Standards and Codes which apply to Utilities:

A. Federal Regulations
B. Department of Transportation
C. Environmental Protection Agency
D. State and Local Utility Commissions
E. OSHA
F. Voluntary Consensus Standards
G. NFPA

III. Commodities Transported or Supplied by Utilities

A. Liquids
   1. Water
   2. Gasses

3. Fuels
4. Chemicals

B. Solids
1. Slurries
2. Powders

C. Power
1. Electricity

IV. Transportation and Storage Systems

A. Portable systems
1. Pressurized cylinders
2. Intermodal containers
3. Nonpressurized containers
4. Portable generators

B. Fixed on site systems
1. Pressurized tanks and cylinders
2. Nonpressurized containers
3. Fixed local generators

C. Multiple site consumer distribution systems
1. Pipelines
2. Unit transported
3. Electrical distribution

D. Multiple site wholesale distribution systems
1. Pipelines
2. Unit transported
3. Electrical transmission systems

V. Typical Utility System structure

A. Compare utility system to highways

B Detail an electric Utility
1. Generation
2. Transformation
3. Transmission
4. Transmission Substation
5. Distribution

C. Use MSDS Sheet to define Electricity

VI. Possible Common Problems of Utility Systems

A. Portable systems
   1. How transported
   2. How used
   3. How stored

B. Fixed on site systems
   1 Improper operation
   3. Improper application
   2. System malfunction

D. Multiple site consumer distribution systems
   1. Improper operation
   2. Improper application
   3. Outside intervention

E. Multiple site wholesale distribution systems
   1. Improper operation
   2. System malfunction
   3. Outside intervention

VII. Systematic Approach to Mitigation

a. Control Access
b. Identify Problem
c. Evaluate Hazards and Risks
d. Select Protective Measures
e. Assemble Resources and Manage them
f. Implement Control Measures
g. Decontamination
h. Termination

VIII. Properties of Transported Commodities

a. State
   1. Solid
   2. Liquid
   3. Gas
   4. Force phenomena

b. Weight (Use of MSDS Sheets and Demonstration)
   1 Vapor Density (gas)
   2 Specific Gravity (solid or liquid)

b. Reactivity
1. Will the product react with its surroundings?
2 What will vapors do?
3 Is it soluble in water?

d. Energy potential
1. What kind of damage can be expected?
2. How far is the damage likely to expand?

IX. Foam Properties and Application

a. Class "A"
b. Class "B"
1. Six types
2. Foam tetrahedron
4. How foam works (Demonstrations)
5. Foam proportioning
6. Portable eductor
7. Injection
8. Around the pump

F. High Expansion Foam
G. Compressed Air Foam Systems
H. Application
1. Sweep method
2. Bank-Down method
3. Seat of Fire method

APPLICATION:

I. Critical decision simulation:

a. Make an informed decision as to a plan of action or non action for several simulations. (Classroom simulations)

II. Suppression applications:

a. Deploy hand lines on a simulated flammable fuel spill with the use of foam equipment Skill Drills 16-44, 16-45,16-46,16-47A, & 16-48

b. Control a simulated leaking gas line Skill Drills 32-9 & 21-13

c. Control a large propane grill fire

d. Control a 420 gal. propane tank which has flame impingement on the tank and is adjacent to a structure. Skill Drill 21-12

e. Control a simulated underground propane tank breach

f. Control simulated propane, 500 gal. fill station fire.

EVALUATION:

I. COGNITIVE:

A true/false and or multiple choice quiz of 15 questions based on presentation material, textbook, and student manual.

II. PSYCHOMOTOR:

Psychomotor skills shall be developed and corrected with the listed evolutions.

SUMMARY AND REVIEW:

At the completion of this course, the student should recognize the hazards of various utility systems and what steps they may take to protect themselves and the public. This may be as simple as evacuating the area and calling the proper utility personnel. Make sure that the students understand the hazards associated with all utility systems. Make sure that the students understand that this is only an awareness level class and that without much more specialized education and special certified tools, that they cannot, in most cases, do anything themselves to the actual utility system! Point out that the foam introduction again is just basic, and the students need to concentrate on the systems they will actually use.

DELIVERY KIT

for

Responding to the Utility Emergency & Foam Application: Basic Level.

The following materials will be needed in the classroom to teach this program:

1. **Triplex wire,** Used at IG page 16
2. **Insulated high voltage cable**, Used at IG page 16
3. **Model generator,** Used at IG page 17
4. **Take apart circuit breaker,** Used at IG page 20
5. **ACSR line wire,** Used at IG page 24
6. **Cutaway propane cylinder,** Used at IG page 53
7. **30 Utility Emergencies & Foam Classroom MSDS Supplement**

   These are for classroom use only and need to be returned

   Used at IG pages 59, 60, 63, 65, & 67
8. **1# Propane gas cylinder,** Used at IG page 59
9. **1# Natural gas Cylinder,** Used at IG page 59
10. **Gas regulator with short hose,** Used at IG page 59
11. **Clear cylinder with mid connect gas hose nipple,** Used at IG page 59
12. **Baking sheet with clear cylinder rack,** Used at IG page 59
13. **Small candles (2),** Used at IG page 59
14. **Matches,** Used at IG page 59
15. **Bottle of clean water,** Used at IG page 59
16. **Corn syrup,** Used at IG page 59
17. **Vegetable oil,** Used at IG page 59
18. **AFFF mixed at 3% with red water, spray bottle: ¾ Oz. Foam concentrate to a 32 Oz,** Used at IG page 77
19. **AFFF-AR mixed at 6% in blue water, spray bottle: 1.5 Oz. foam concentrate to 32 Oz.,** Used at IG page 77
20. **K-1 in two separate 1 qt. jars. Fill about 1" deep,** Used at IG page 77
21. **Alcohol,** Used at IG page 77
22. **2 extra 1 qt. jars**

UTILITY EMERGENCIES

A BASIC LEVEL PROGRAM

Introduction Splash screen

Do all paperwork:

- Class attendance sheets
- Registration form or have students check preprinted registration print out

Introduce Yourself:

- Name
- What you do
- Your experiences that relate to the subject

State the purpose of the class:

- To give the responder a basic level of understanding of the dangers associated with utilities.
- This class ***does not*** give the responder any specialized training to perform operations on any utility.
- The majority of time will be spent explaining how each utility operates and pointing out products that could be problems to the responder.
- The last part of the program deals with the control of some specific utility problems.

INTRODUCTION

- **What are Utilities?**
  - **Something useful to the public**
  - **Commonly associated with energy or commodity distribution**
- **Where are Utilities found?**
  - **Above and below public property**
  - **Right-of-ways on any property**
  - **Private property**

Let's start by defining utilities.

Ask the question, "**What are utilities?"**

Guide student responses to cover at least the following:

Electric distribution systems:

<u>Piped systems</u>

Water
Sewer
Gas
Steam

<u>Transportation</u>

Land, water, air

Explain where utilities are found on public and private land.

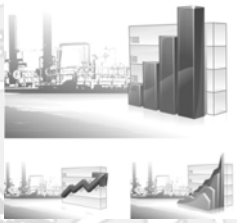
Under streets
Right-of-ways
Actual deeded rights to use another's land

Explain that all right-of-ways have restrictions to protect the utility infrastructure.

Mention the one call system (Dig Safe)

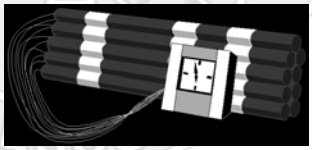
Are Utilities Controlled?

Public Interests
Photo by J Uitts



Fee Structures
MS ClipArt

Employee Safety
Drawing by FFWhy?



Protection from Attack
MS ClipArt

What controls are imposed on utilities?

Some answers:

- Protection of workers' health and safety.
- Protection from terrorist acts.
- Control of costs.
- Means to protect the public from dangers of fire, injury, or death.

STANDARDS and CODES

- Federal Laws
  - The Code of Federal Regulations(CFR)
  - DOT office of pipeline safety (OPS)
  - Department of Labor (OSHA)
    - 29 CFR 1910.120 aka SARA or (hazwoper)
  - Environmental Protection Agency
  - Department of Energy (DOE)
  - Department of Homeland Security

Explain that all utilities are regulated, just as responders are regulated, as to how they may operate as well as the levels of responsibility and training they must meet.

- Utilities are regulated and monitored by many government agencies.
- Construction, maintenance, operation, and cost structures are generally regulated and monitored in some way.
- Utilities may become terrorist targets because they are located in both remote and very congested locations.

Standards and Codes cont.

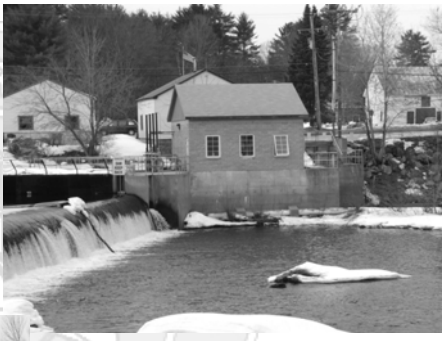
- **State Laws**
  - **Revised Statutes Annotated (RSA)**
    - **Health and safety**
    - **Environmental**
    - **Taxes**
    - **Labor**
  - **Public Utility Commission**
- **Consensus Standards**
  - **AGA -API -NFPA -NESC**

States have similar rules and regulations to those on the Federal level.

Most all utilities also follow standards set by consensus among their peers.
Examples are:

- American Gas Association
- American Petroleum Institute
- National Fire Protection Association
- National Electrical Safety Code (This is not the same as The National Electrical Code by NFPA!)

What products are represented?



Electrical Construction & Photo by J Uitts

Photo by J Uitts

This slide shows a pipeline distribution manifold.

What products could be in the pipelines?

- Gas
- Refined oil
- Crude oil

The second photo illustrates a 250 kW hydroelectric generating plant located in Contoocook Village. This is a relatively new plant completed in November of 1984.

What else is transported by wire / fiber?

- Data

More detailed lists follow on upcoming slides.

COMMODITIES DISTRIBUTED

- **Solids**
  - **Powders**
    - **Coal**
  - **Slurries**
    - **Coal**
    - **Clay**
  - **Capsule**
    - **Coal log**
    - **Pneumatic capsule**
    - **Hydraulic capsule**
- **Liquids**
  - **Water**
    - **Potable**
    - **waste**
  - **Fuels**
    - **JP4**
    - **Heavy oils**
    - **LNG**
    - **LPG**
  - **Chemicals**
    - **Anhydrous Ammonia**
    - **CO2**

Most of the items on this slide are transported by pipeline.

The **Solids and Slurries** are usually short run dedicated systems, as are most chemicals.

The **Capsule System** is in its infancy and may become a major player in 5 or more years. Products are either compressed into logs or placed in actual capsules and transported by air or water pressure to the exit locations.

Pipelines are most efficient in transporting liquids and gases.

Commodities Distributed Cont.

- Gasses
  - Natural Gas
  - LPG
  - Steam
  - Butane
  - Propylene
- Phenomena
  - Electrical Energy
- Other
  - Data
  - Some mass transit
- Commodities Note:
  - May be transported by methods other than a utility
  - Same control measures can be implemented

Pipelines are a utility.
The most common pipelines in New Hampshire are short petroleum pipelines and longer gas pipelines. Anything from potable water, sewerage, gas, and exotic chemicals travel via pipelines. Other than potable water and sewerage, the most common in our region are jet fuel, gasoline, home heating oil, natural gas, and liquid propane.

Electric distribution is a utility.
Electricity is a transported commodity even though it is not a solid, liquid, or gas. Data is also a form of energy transported by utilities and is either light or electricity energy at a very low level of potential. There are minimal hazards with data transport systems.

Air, land, and water transport systems may or may not be true utilities.
However, they carry the same products as utilities and may be mitigated in similar ways.

Public transportation may be utilities.
In some cases people are transported by a utility, but little time will be spent on emergencies based on mass transit as they are vehicle crashes with a mass casualty situation and are covered in other parts of responder training.

Problems of Utilities

- **What dangers are associated with Utilities?**
  - **Large amounts of product or energy**
  - **Special tools and skills may be needed to control discharges and spills**
  - **System may be controlled from remote locations**
  - **Large amounts of energy may be released in a fault or breach**

Explain that most utilities carry immense potential energy; while contained, they are relatively benign. However, if allowed to escape from the container, they may become deadly.

As a result of the large potential energy, special training and tools are required to maintain control of that energy. Federal Laws regulate who and what constitutes a trained person and the knowledge they must possess. In addition, the laws dictate what equipment a trained person must have to be properly protected. ***If you are not trained, do not touch or interfere with any utility components!***

Most utility systems are monitored from remote locations and may be stopped or started from these remote locations.

Most control systems do not have the capability to detect small leaks or breaches of the system.

Explain that a fault in a system will release large amounts of product, and depending on the properties of the product, may result in great harm.

OK, Now What?

Photo by Alice Wagner Longwood FL

* Photos by J Uitts

This slide shows that **not all utility incidents are life threatening**.

- In the case of the electrical fault in the modular furniture, the proper actions may be initiated by building personnel by merely opening the circuit breaker. **Note proper protective clothing and position!**
- However, the water main break will require skilled personnel with a knowledge of the water gate valve locations in order to isolate the problem.
- In both cases, the emergency is over at the opening of the circuit breaker and closure of the gate valves.
- Other control measures may or may not be needed after that point.
- This is what makes control of utilities case dependent.
- A prior relationship with local utility personnel will make any incident easier to manage!

We will start by looking at the most common utilities, what products they may involve, and some possible problems.

Towards the end of the program, we will go over the steps used to control utility incidents.

Finally, we will spend a day mitigating simulated utility emergencies**.**

TYPICAL UTILITY SYSTEMS

- **Electrical**
  - **Generation**
  - **Transmission**
  - **Distribution**
- **Communication**
  - **Generation**
  - **Transmission**
  - **Distribution**
- **Fuel**
  - **Gathering**
  - **Processing**
  - **Transmission**
  - **Distribution**
- **Transportation**
  - **Gathering**
  - **Transport**
  - **Distribution**

This slide demonstrates that most utility systems do the same job but with different infrastructures and products.

- The commonality is that they must gather or produce the product to be transported.
- In some cases, the product may be shipped in a raw state to a processing facility before entering a long distance transmission network.
- At the other end, the transmission system breaks out to smaller distribution networks for delivery to the end users.
- Common carrier systems of trucks, ships, and trains act in ways similar to the transmission and distribution portions of other utilities.

The student should be aware that <u>control measures are mainly based on the product, quantity, and any energy placed on the product by the system of transport.</u>

Ask students to place each major commodity category into a utility system.

- (That is, electricity in wires and fuels in pipelines and/or trucks.)

We will look at each type of system in following parts of the program.

Utility Systems as Highways

- The car builder is the source
- A single car is the product
- The road is the pipes or wires
- Traffic lights are valves or switches
- Intersections are connections or branch paths
- Traffic police are meters
- Parking places are tanks, batteries, or capacitors
- Your garage is the end user

In an effort to relate utility systems to something the student knows, **compare the highway system to a utility system. While there is no direct comparison, they are very similar in function**:

- The product of a car is sent over the roads (transmission system).
- Traffic lights are the stop valves or switching components.
- Intersections are distribution manifolds or switch yards where the product is redirected (distribution systems).
- Police are the enforcers or measuring devices.
- Temporary storage devices are like parking spots. The product only rests at these locations; they are not used.
- And lastly, the car arrives at the end user who pays for the car as well as the cost of transportation and distribution.

What is Electricity

- **Webster's**
  - **A form of energy generated by friction, induction, or chemical change, and having magnetic, chemical, and radiant effects.**
  - **Electric current supplied as a public utility for lighting, heating, etc.**
- **See the MSDS sheet**

In order to control a problem with an electrical system, we need to know what the product is and what it can do.

- **Mechanical energy** is used to force electrons to move through wires and other magnetic devices on to utilization devises such as heaters, motors, and lights.
- **Electric power** may be compared to the movement of water on the fire ground.
- While **commercial power systems** are very complex, we are looking only at the basic structure and possible hazards.
- Each situation will present a unique set of challenges that, in most cases, will need the assistance of trained power professionals.

In this class, students will be presented with some common occurrences and basic safety facts to insure their safety as responders as well as to protect the public they serve.

- Looking at the MSDS sheet indicates that electricity is sneaky and will jump out and kill.
- It only takes a small amount to do damage to responders and their equipment.

Electric Current & the Body

- **1 milliamp(mA) is just perceptible by most people.**
- **5 mA slight shock (0.5 watt LED lamp).**
  - **This is the threshold cutoff of a GFCI outlet.**
- **6-30 mA painful shock, loss of muscle control, may not be able to let go.**
- **50-150 mA extremely painful shock, respiratory arrest, severe muscle contractions, death is possible!**
- **1,000-4,300 mA (1-4.3 A) Ventricular fibrillation occurs. Muscles contract; nerve damage occurs. Death is likely.**
- **10,000 mA (10 A) Cardiac arrest & severe burns occur. Death is probable.**
- **15,000 mA (15 A) Smallest normal over current device.**

Note: This is typical for voltages below 600 V

Source: Electrical Safety-Safety & Health for Electrical Trades Student Manual (NIOSH)

This table shows current levels of voltages usually found in residential and commercial spaces and the expected effect on the average body:

We measure electron flow in units of Amps.

- A 150 watt light bulb uses 1.25 Amps at the normal household Voltage of 120.
- Muscle mass, fat, & water content will change the points up or down.
- The outlet into which it is plugged will be protected by a 15 or 20 Amp. over current device.
- The figures in the table are in milliamps which is 1,000 of an Amp.

The individual body, the level of voltage, the length of time the voltage is contacted, and many other factors will determine the extent of injuries.

While the external damage may seem small, the internal damage will be very large.

Very few people survive contact with voltages greater than 220 Volts.

There are cases where people have been killed by voltages as low as 49 volts.

Side effects of an Electric ARC

- **Flash Burns**
  - **Eyes and skin**
  - **Set clothing on fire**
    - **Melt into skin**
- **Impact Damage**
  - **An arc of 25,000 Amps will impose 480 pounds of force at 2 feet**
    - **Ear Damage**
    - **Concussion**
    - **Broken bones**

An electric arc produces temperatures as high as 35,000 degrees F.

- Molten particles of the equipment will be projected as far as 10 or 20 feet. This heat wave will melt synthetic clothing and burn the skin and respiratory tract.
- The intense ultraviolet light will burn the eyes at great distances.
- The sudden ionization of the air surrounding the arc will produce a shock wave similar to a blast of TNT.

- Most **residential electric services** are rated for an interrupting current of 10K, 22K, or 65K amps.
  - Even though it is only a residential service, there can still be enough energy available to do severe damage to a person, the structure, or the electrical equipment under fault conditions.
- A **remote rural electric service** could have an available short circuit current as high as 8,000 amps while a service in a densely populated area could have short circuit currents as high as 20,000 amps.
- **Commercial and industrial services** will be in the higher ranges of available current on a fault.

Typical Electric Utility Structure

- **Generation**
  - **Fuel boiler/steam turbine**
  - **Fuel/engine generator**
  - **Nuclear boiler/ steam turbine**
  - **Solar/cell**
  - **Chemical/battery**
  - **Fuel Cell**
  - **Water/generator**
  - **Wind/generator**
- **Transformation**
  - **Stepping up a low voltage high current to a high voltage lower current**
  - **metering**
- **Transmission**
  - **Moving large amounts of electricity long distances**

We will start with the electric utility.

A typical system starts with the generation of electrical energy. In New Hampshire this is principally done by **steam turbines** connected to generators. Steam is produced by coal, natural gas, trash, wood and nuclear energy. However, we also have some **small hydro (water) turbine** plants. The typical commercial power plant generators operate in the range of 2,400 to 13,800 Volts.

This power is then sent outside the power plant to a **switch yard** and stepped up to voltages in the range of 69,000 to 1,500,000 Volts (69kV to 1500kV in industry terms) for cross country transmission. The **transmission grid** is interconnected with all commercial power producers in the US and Canada. **Transmission lines** are generally operated by an entity other than the local serving utility company. However, the local utility will assist with incidents involving transmission lines to the extent of their training and available support equipment.

Typical Electric Utility Structure Continued

- **Transmission Substations**
  - **Reducing high voltage low current to lower voltage higher current**
  - **Switching**
  - **metering**
  - **Feed distribution lines**
- **Distribution**
  - **Wire lines to end user locations**
  - **switching**
  - **Transformation**
    - **To user voltage levels**
    - **metering**

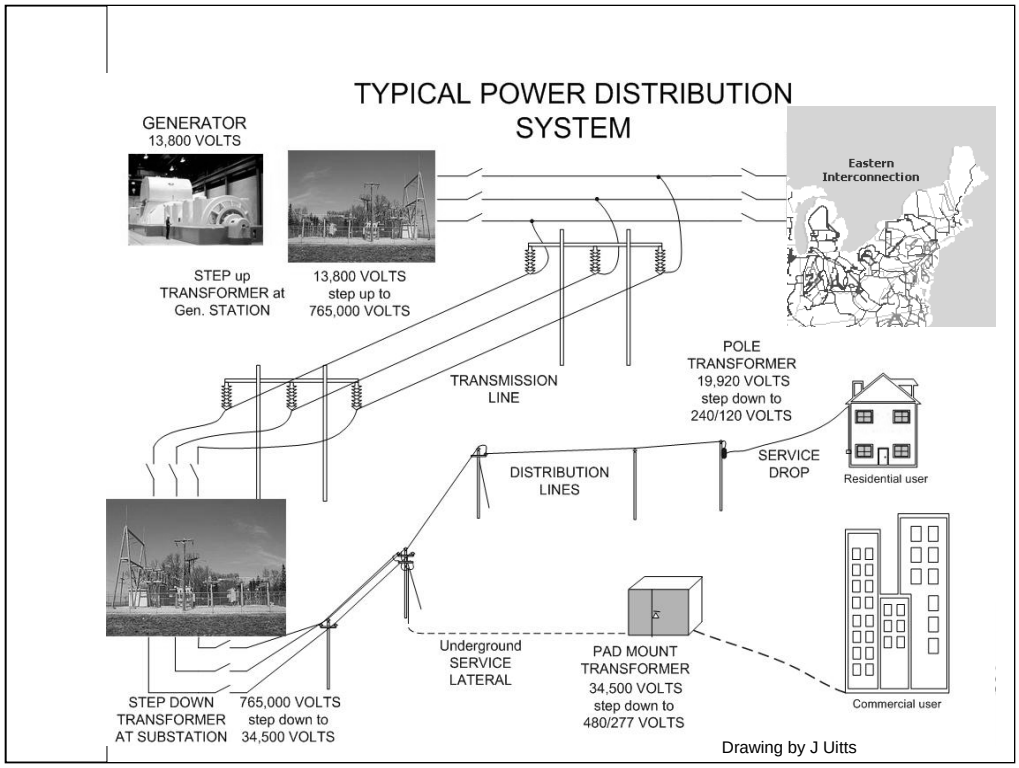
At the receiving end of the transmission line, substations are used to reduce the voltage to a level safe for local distribution in the ranges of 2,400 to 34,500 volts.

This is the voltage that may be on the poles of a typical city street or country road!
Additional distribution transformers are used at each user location to reduce this voltage to the level needed by the end user devices.

- This is typically 120/240 volts for a residence, while commercial and industrial users will have voltages of 120/208 or 277/480 V.
- Some large industries or small plants with large usage will have their own substations.

Some **industrial plants** will have internal distribution systems and substations operating at the same street voltages of 2,400 to 34,500 volts.

Small generators, wind turbines, and hydro plants are connected to the distribution system and “back feed” power back to the grid. There are strict controls imposed on these systems to prevent energized lines without utility knowledge.



This view puts all the pieces together:

- The generator and step-up transformer are just one of many power plants across the country.
- The power plant on the top right is just another example of the huge interconnected units in the national power grid. Note that there could be additional users connected to the transmission network.
- The substation on the lower left is also only one of many connected to the network. The distribution line, again, is only an example of the thousands connected to the network.
- The end user examples only cover a few examples of end use.
- The voltages are also just one example of the many possibilities that may be in a system in your service area.

NOTE: This drawing shows neither neutral nor grounding wires.

Enlarged Distribution Line

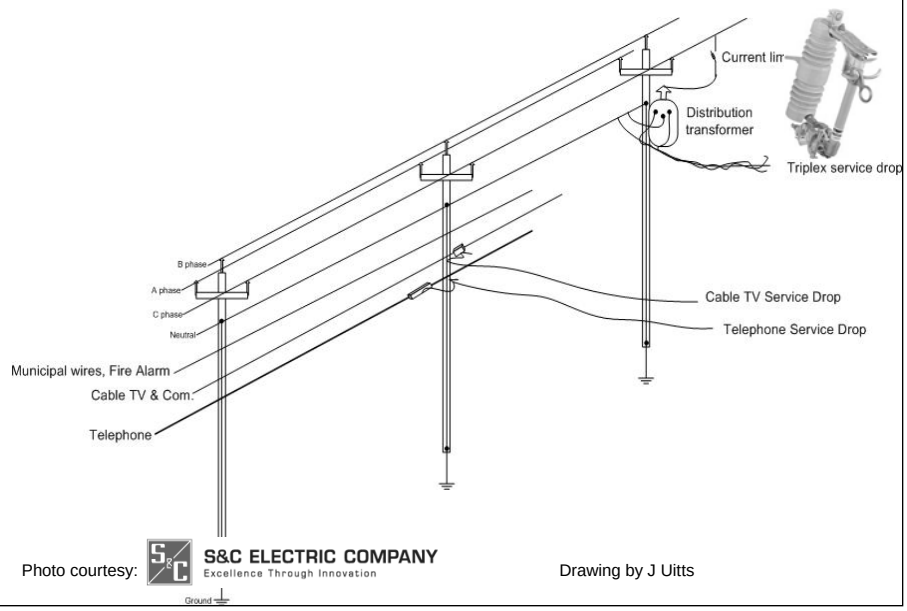


Photo courtesy: S&C ELECTRIC COMPANY Excellence Through Innovation

Drawing by J Uitts

This drawing shows a **<u>three phase</u>** distribution pole line, A, B, & C. Typical voltage would be 34,500 between the combinations of A & B, B & C, or C & A. Between A or B or C and the neutral, the voltage is only 19,920. These wires are the top most wires on the pole and have heavy insulators to which they are attached.

The bare wire below the cross arms is the **neutral wire** and is shared with both the primary top phases and the lower secondary service wires. This neutral wire is connected to a wire that goes down the pole to a copper plate attached at the base which acts as a connector to the earth. Thus the neutral is “GROUNDED” . Neutral conductors are grounded at all available locations in the system.

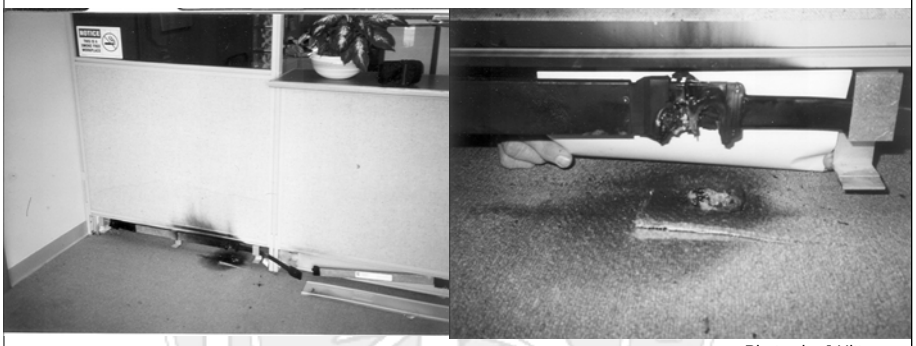
At a customer location one, two, or three transformers are attached to the pole. Each **primary wire** is connected to a transformer through a current limiting fuse. This fuse protects the distribution wires and not the transformer or load. It will provide some protection to the transformer if there is a fault on the primary side within the transformer.

The secondary connections on the transformer feed the **service drop wire** to the customer. Most residential and small commercial service drops will be triplex or quad wire. This consists of a steel strand wrapped with aluminum conductors to make a bare neutral. Around this wire are wrapped insulated aluminum conductors to carry the energized or “hot” power. The neutral wire is connected to the earth through the primary neutral connection.

We will talk more about the “hot” wires later in the presentation. About 30” to 48” below the primary/secondary neutral is space on the pole for **municipal wires**. Usually these are Fire Alarm but could be traffic signal or other control circuits. In some cases the voltage could be lethal! About 12” below the municipal space is cable television, and 12” below that are telephone cables. If the cable has an orange outer sleeve it denotes a fiber optic assembly and carries light, not electricity. While the fiber cable cannot electrocute you, it can destroy your eyes by looking into the end of an open cable!

On some poles there could be multiples of any of these circuits. Be aware that guy wires are taking the side strain forces on the pole and opposing them with a connection to the earth as an anchor. If broken, the poles may shift, and the wires will whip when the tension is released.

WHAT CAN GO WRONG?



Photos by J Uitts

An example of an electrical fault within a structure.
This is a real call received by a Fire Department in NH.

The caller stated **“there is smoke coming from my wall!”**
911 Had the building occupants evacuate.
Dispatch sent a full structural fire response.

In this case, the responders were able to locate the circuit breaker panel and isolate the supply to the modular furniture wiring.

- You can see the intense char and molten copper imbedded in the carpet.
- The lower section of the furniture has been removed to locate the problem.
- It is possible that the entire modular furniture unit could have been energized by this fault.
- In this case, proper installation included properly grounding the units; therefore, the fault opened the over current device.
- If that had not been the case, responders would be the ones to open the circuit breaker.

Explain that a responder should have full PPE and use his/her non-dominate hand.

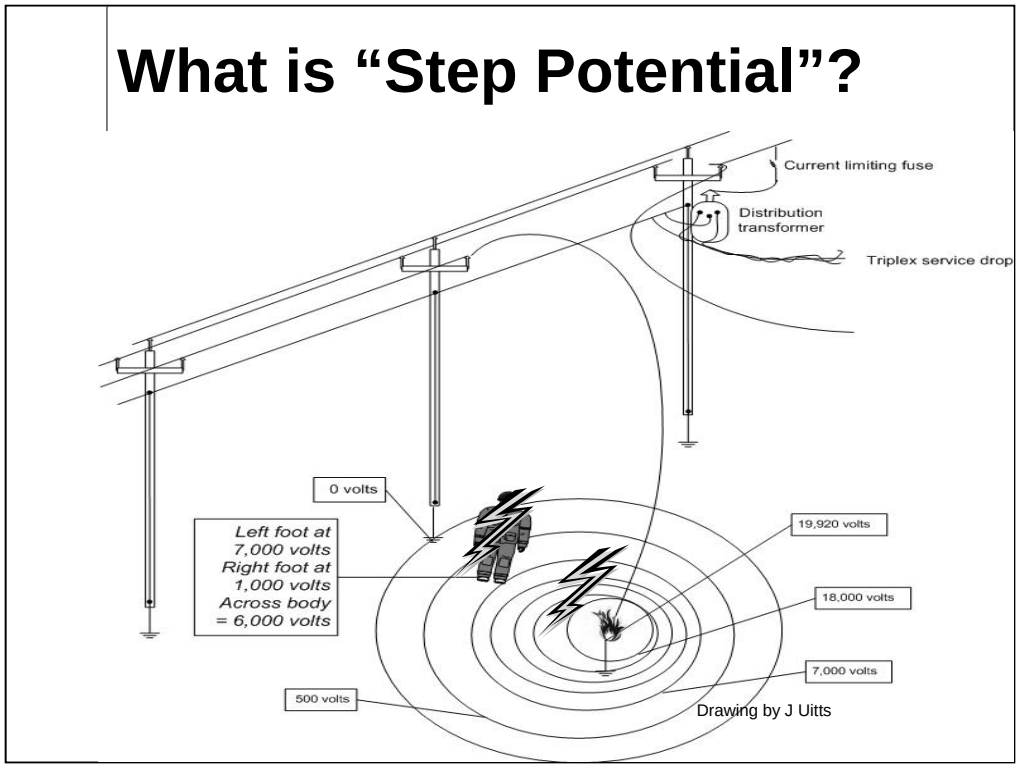
Face away from the unit and off to one side so that any arc blast will pass by the body.

A Common Winter Occurrence

Incidents like this attract lots of onlookers.

Emergency responders can do the following to help:

- Isolate the area.
- Have dispatch contact the utility for their expertise.
- Give the utility the geographical location and the pole numbers on either side of the problem.
- Do not go near the trees or pole that are affected as the ground could be energized. (By walking close to this energized earth one could be exposed to “step potential”.)



Because the earth has neither a uniform mass nor even moisture distribution, it is also not a uniform conductor. When a power line contacts the ground, the point of contact will be close to the same voltage as the wire. In an effort to equalize the voltage, electrons will try to follow the most direct route to the closest grounded connection.

As the electrons flow through the earth, they produce heat as in a lamp or toaster. This uses up voltage in the same way that friction loss in a fire hose reduces pressure. For each unit of distance the electrons travel, the voltage will decrease until the voltage is equal to the grounded conductor of the system.

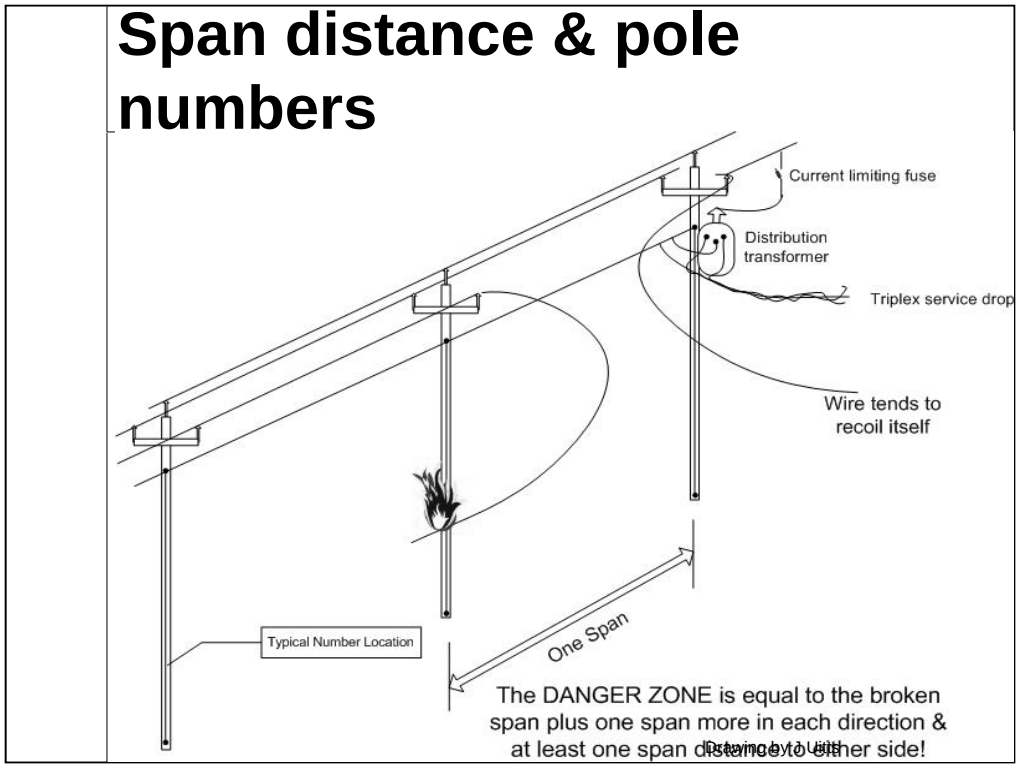
If a person steps between two adjacent areas of voltage change, there will be a difference that is bridged by the body and not the earth. Because the body is a better conductor than the earth, the current will flow through the body and do damage. If a tingling is felt near an electrical problem, slide the feet together. Exit the area by sliding one foot away, then the other, not passing the heel or toe of the other foot.

Wires in contact with trees, vehicles, and other objects will impose the same voltage on the object, and the same voltage dispersion gradients will be around the object and the earth where they make contact.

Another Common Problem

This is an incident that may occur when the tree limb finally arcs through the wire or from other mechanical damage to the system.

- Again, we need to **isolate the area**.
- In this case we have the possibility for step potential electrocution of personnel in the area.
- **The power company must be given a description of the trouble and the pole numbers on either side of the problem**.



With all instances of power line emergencies, one must maintain a safe distance from the problem.

- A rule of thumb is to **stay at least one pole span away from the problem** (Two span distances are even better.)
- In this case, stay in back of the pole marked with the tag indicator.
- Be aware that even if the wire is not broken and arcing, it could still separate and whip backwards or to the side within a span length.
- This action could cause other components to fail back along the line as the mechanical tension on the system is released by the break.

You Can’t Fix Inattention

This crane operator was not paying attention to where he was swinging the hoist cable! Once the cable contacted the power line, the entire crane truck was energized to the same voltage as the power line. In order to escape, the operator should jump free of the truck making sure to not touch the truck and the earth at the same time. If the operator had been on the truck at the same time the cable struck the power wire, he should have attempted to rotate the crane away to de-energize the unit before attempting to exit.

As one can see by the arcing at the jacks, a person would be incinerated if both the truck and the earth were touched. In jumping, one must attempt to land with both feet together, **not** on all fours, as there is a possibility of a large step potential around the vehicle; a wide stance of feet to hands would bridge a large area and result in the possibility of a greater voltage range. If the crane operator had been touching the ground and the truck, he would have been electrocuted.

Responders should resist the urge to go in and attempt to help.
Severe internal injuries could result not to mention the cardiac arrest incurred upon initial contact.

An uncommon incident

On an average, there is one transformer fire each day of the year.

- Most are the smaller pole type distribution units like this. However, tactics of response should be the same, regardless of size.
- The clearance distance will be greater for larger or higher voltage equipment.
- The utility will be scrapping the equipment, so any attempt to save that is a waste.
- A transformer similar in size to the one in the supplemental video could hold 50,000 gallons of mineral oil and have a weight of about 70 tons.
- Near the end there is a larger arc and a loud bang. This is the point where there is sufficient current flow to open a remote over current device to clear the fault from the remainder of the electric grid.
- In many cases this will not be the end as some protective devices will try to restore current flow multiple times before they lock out for human intervention.

Why you Shouldn't Remove a Meter

This video is of a test conducted on a handheld multimeter.

- It demonstrates what results when an electric watt-hour meter is removed under load.
- Many newer meter installations use remote current and voltage transformers to measure the actual usage and, if removed while under load, will produce very high voltages at the meter socket.

Communication Utilities

- Telephone
  - Voice
  - Data (DSL)
- Cable TV
  - Video
  - Data
  - IP voice
- Municipal
  - Fire Alarm
  - Traffic Signals
  - Video
  - Data
- May use metallic wire
- May use Optical Fiber
- Are supported with a steel strand attached to the poles
  - This may become energized by downed power conductors

Communication infrastructure shares the same poles with many power lines. However, there are instances where each system is carried on independent poles or underground. In general, the voltages found on communications lines will be low, and the current is limited; however, it still may be a danger. Municipal cables may have 120 volt circuits for traffic control systems.

Fiber optic conductors are the size of strands of hair but have an intense light source which, if viewed directly, will damage eyes. A fiber optic cable will have multiple strands, and the entire cable will have an outer jacket. At locations underground or at areas of contact with a pole, generally these cables will be within an orange protective sleeve. Many electric transmission lines now carry a steel jacketed fiber cable on the top most position in place of one of the static neutral. Where power lines are taken down by accidents or storms, there is a possibility that the communications support strands or metallic conductors could be energized at locations out of view from where the communication cables are down**.**

All wires should be considered energized!

At the end of this slide, show the PSNH video "YOUR SAFETY IS ON THE LINE". Explain that it will cover much of what has just been discussed in more detail along with what a first responder should do. (It is about 1/2 hour so plan breaks with that in mind.)

WARNING: This video is graphic and may not be suitable for all audiences!

Our Next Utility is Pipelines

- What products are carried in pipes in your community?

Photo by Mel Wooever

- Possible answers:
  - Water
  - Sewerage
  - Storm Water
  - Natural Gas
  - Propane
  - Steam
  - Jet Fuel

Before asking for answers explain:

We will now talk about the other primary utilities that are usually below us. The photo shows a large cross country pipeline. As with the electric utility, many of these systems are interconnected to far away points.

- They must have gathering or production locations (Generators),
- processing or treatment equipment (Power Plant step up transformer),
- transmission systems (High Tension Towers),
- break off points (Substations), and
- distribution networks to supply the end users.

Ask students the following:
Can you think of a system that is *reversed* in that it starts with the user and operates in the other direction?

- (Sanitary Sewers)

Have students fill in the answers.

- The list includes products transported by pipeline within New Hampshire.
- Pipelines are similar to railroads in that they may carry several different products in the same pipe.

10” Steam Pipe Rupture

A YouTube video from a security camera in New York City:

- A tow truck was crossing the intersection when this line ruptured.
- The driver was seriously burned and a passenger was injured by the 300 degree steam.

10” Steam Pipe Rupture

Another YouTube video view of the same leak showing the force of the escaping steam.

Boston, New York, Philadelphia, and Concord, NH have **public steam systems** while Durham and several other locations have **campus-wide steam systems**. These are just as dangerous as the public utility systems. The only difference is in ownership. The steam is used to both heat and cool buildings and is metered just like electricity or gas.

It took the steam company several hours to stop the flow, fearing the rupturing of more piping by a fast closure of the valves in the system.

Water

- **Starts at**
  - **Wells**
  - **River or stream**
  - **Reservoir**
- **Treatment plant**
- **Pumping Station**
- **Transmission Pipe**
- **Distribution Pipes**

Photo by J Uitts

Most potable water systems start with water from a well, river, or stream.

- The water is collected, filtered, and treated to remove biological hazards.
- Gravity or pumps move the product via transmission lines into the distribution piping.
  - The distribution piping is usually set up in a grid to make it easier to isolate a break and to assure adequate fire flows at a reasonable infrastructure cost.
  - Pipe sizes range from ¾” to as great as 60” with pressures of 20 to 125 PSI.

As with any emergency, larger volumes and pressures will cause greater risks and challenges.

A Large Water Line Repair

Photo courtesy of The City of Evanston (IL) water Division

Typical repair to a tap from a 24” high pressure water main:

- Note all the other piping within the excavation.
- Repairs to below grade systems can become very complicated and expensive as many different systems may be in close proximity.
- The failure of one may also affect others in unexpected ways.

Water Main rupture

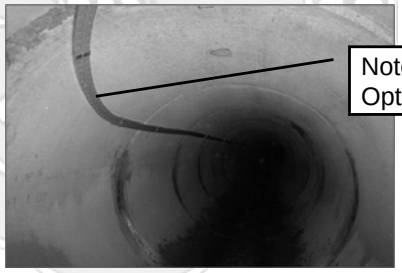
Another You Tube video showing the effects of construction equipment on underground utility piping:

It appears that the result was expected because the flow was stopped in short order.

Waste Water

- **Storm Water**
  - **Runoff from paved areas**
  - **Runoff from roof areas**
- **Sanitary Water**
  - **Gray water**
    - **Hand wash sinks**
    - **Showers**
    - **Washers**
  - **Black water**
    - **Urinals**
    - **Bidets**
    - **Water Closets**

Firefightersclosecalls.com



Note: Fiber Optic cables

CableRunner North America, LLC

Waste water systems range in size between 2” to 20’ depending on the expected flow.
Most systems flow by gravity, but there are both large and small force mains (pumped) in both rural and urban locations.

<u>Waste water breaks cause more concern than fresh water breaks because of the health risks</u>:
As you can see by the photo, <u>they can also be a rescue challenge</u>.

- With water pipeline emergencies, the tasks will normally be **isolation, rescue, and property conservation**.
- Flooding of structures will also cause problems with other utility systems and the potential of structural collapse.
- Four LA City Firefighters just barely escaped as they were backing away from a depression in the roadway just as it opened into a giant sink hole.
- The lower photo shows the emerging technology of deploying fiber optic cables through existing sewers:
- The pipe shown is 6’ in diameter but cable can be placed in pipes as small as 8”.
- Several major cities have had this infrastructure added so as to complete the most difficult task of construction called “last mile”.

Result of Storm Water

This YouTube video shows the effects of storm water infiltration into a waste water system:

- The only recourse in this situation is to restrict access to the area and wait for nature to take its course.

Chemical Pipelines

- **In New Hampshire there are few or no pipelines that transport chemicals off site of specific manufactures.**

While there are pipelines that transport various chemicals in other parts of the country, in NH, we do not have such risks, save for a selected few manufacturing facilities. The semiconductor industry uses some very toxic gases in their production facilities; these pipelines, while small, are a great internal utility risk within the facility. In the midwest, there are large bore ammonia pipelines similar to our natural gas pipelines.

Our biggest risk is from the trucking of dangerous chemicals over our state roads. The trucking industry is regulated and required to conform to regulations in the task of transporting dangerous goods. The same applies to air, rail, and water shipments. Hazardous materials training and the firefighting and mitigation skills presented in the following sections may be used to control incidents involving chemicals.

It is most important to follow the 8 step control process.
The first three are very important to a first responder:

1. secure the area,
2. determine what is broken and leaking, and
3. the function of whatever is broken and/or leaking.

- **Do no more without proper training, knowledge, and tools to do the job correctly on the first try!**
- **An incorrect move may be your last or cause the problem to become much larger.**

Petroleum Pipelines

- **Most Petroleum pipelines in New Hampshire are captive with individual industrial sites or very short distance feeders to major users.**
  - **One exception runs from Lancaster to Shelburne (crude oil)**
- **Examples**
  - **Jet Fuel**
    - **Pease Airport**
    - **Manchester Airport**
  - **Crude Oil**
    - 18" & 24" Pipeline in service of about 69 mi. total
    - 35 miles of 12" pipe cleaned and nitrogen charged out of service

Again, we have few pipelines that carry refined petroleum.

Most of these serve our airports with jet aviation fuel.

- The one exception is an oil pipeline system owned by Portland Pipe Corp. that runs east to west and connects to other lines in the distribution grid. This system takes crude oil from the port of Portland to Montreal and Ontario.
- At peak throughput, the system is capable of transporting 525,000 barrels a day.
- In addition to the actual pipelines, there are pump stations located in Lancaster and Shelburne, NH.
- This pipeline was first constructed in 1941.

Gas Pipelines

- **The predominate pipelines in New England transport natural gas.**
- **New Hampshire has four transmission pipelines**(About 274 Mi.)
  - **Pelham to Concord**
  - **Two from Plaistow to Newington**
  - **Pittsburg to Gorham**

Photo by J Uitts

Transmission of natural gas is increasing in our region. Other regions also have liquid Propane (LP) or liquid Natural Gas (LNG) pipelines. Many upgrades and enhancements have been made in the last ten years to the grid in the southeastern corner of New Hampshire.
All of these transmission lines operate at about 1000 Psi.

- The **Pittsburg Gorham Line** is 24 " in diameter.
- A second 30" line runs from **Plaistow to Newington and on into Me**.
- Both these lines are owned or shared by *Portland Natural Gas Transmission System*. The other co operator of the southern line is *Maritimes & Northeast Pipeline LLC.*
- The **second Plaistow to Newington line** is operated by *Granite State Gas Transportation Co.*
- At least one of the Newington lines is bidirectional. Without talking to the operator, one would have no idea as to the direction of the gas flow.
- The **Pelham to Concord line** is operated by *The El Paso Pipeline Group, Northern Division* a part of *Tennessee Gas Pipeline an El Paso company.*

None of these lines have had any reportable incidents since 1998. (That is the earliest reporting period on file to the present.) However, an incident with any one of these lines would be a major challenge. A quick search of reported accidents in the US will provide an understanding of the extensive damage that may result from a failure of one of these pipelines.

Note the markers may not be above the pipe but just in the general area!

Gas Pipeline Incident

These photos show the destruction that results from the rupture of a large high pressure pipeline.

- Most occurrences are from external damage by excavation equipment.
- Several incidents have also been from fatigue failures of the pipe itself.
- One massive failure in Carlsbad, New Mexico was a result of corrosion within the pipe from lack of proper treatment of the gas transported as well as from lack of the ability to internally inspect the section of pipeline that failed.
- This failure killed 12 people and cost millions in fines, repairs, and settlements with families.

An Incident You May Control

While most incidents are not as destructive as the previous photos indicate, care must still be used when controlling small incidents.

- Do not extinguish a fire fed by a gas or by a liquid that changes to a gas under normal atmospheric conditions.
- Because escaping gases cannot be seen, it is better to let them burn in a controlled location in place of flowing to an unknown ignition source.
- This flash back effect will be demonstrated in the practical evolutions.
- This example is a relatively low pressure distribution line which makes the escape easier to control.
- The location away from any structures also makes the control less of a problem.

Other Petroleum Transit

- **While not true public utilities, there are other means of petroleum transport within our area.**
- **Examples**
  - **Air**
  - **Rail**
  - **Ship**
  - **Truck**

Photo Courtesy of Craig walker

Photo J Uitts

Our definition of a utility is "something useful to the public".

- By that definition we can include many services normally thought of as transportation.
- We will stay with those commodities that may be of concern to one's health or safety.
- While electricity is not transported in large quantities by truck, rail, or ship, it is utilized in those types of transport conveyances.
- The same precautions apply to safety as in the fixed world. Just because something has low voltage does not mean it cannot cause extensive damages or even kill. Large and hybrid vehicles have higher voltage systems than the average 12 volt car battery.

Other "Utilities"

- Fuels
  - Gasoline
  - Heating Oils
  - Diesel Fuels
  - Propane (LPG)
  - LNG
- Transportation
  - Truck
  - Rail
  - Ship
- All Transported as a Liquid
- All need to be "vaporized to burn"
  - Must burn to produce energy
- Some require pressurization to remain a liquid.

Most other commodities transported are chemicals and fuels.

- It is important to know that some fuels such as LPG must be maintained under pressure in order to stay a liquid.
- Once the pressure is released, the liquid will vaporize at normal atmospheric conditions.

The transport and storage of the fuels listed will be our main focus.

Basic Distribution

- **Regional Terminal**
  - **Receives product**
    - **Ship**
    - **Rail**
  - **Stores product**
    - **May mix in additives**
      - **Ethanol**
      - **Ethyl Mercaptan**
  - **Loads product**
    - **Marketer trucks**
    - **Transport trucks**
- **Marketer**
  - **May store**
  - **May place in portable containers**
  - **Delivers to end user**
    - **Direct use tank**
    - **Resale tanks**
- **End User**
  - **places in equipment or uses as fuel**

Petroleum products for New Hampshire originate at terminals in the Portsmouth, Rochester, Claremont, Boston, Portland, and the Albany areas:

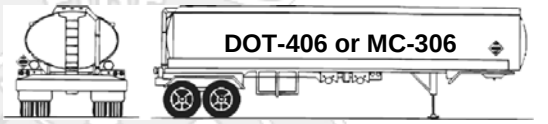
- These terminals may receive the bulk product by pipeline, ship, rail, or in some cases, by truck.
- At the terminal the product is stored in giant tanks and pumped into trucks that ship the product to local distributors.
- In the case of gasoline, the ethanol is added at this stage as it causes problems when shipped by pipeline.
- In the case of LPG, the odorant is introduced at this time. At this point, LPG has no noticeable odor.

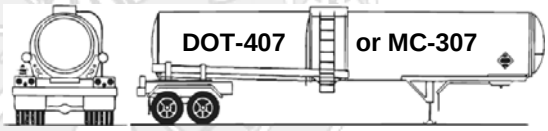
The distributor then takes the product to a storage tank or directly to the consumer.

- Most of the gasoline and diesel fuel goes to local filling stations and is stored in underground tanks.
  - These tanks use either pumps located within the dispenser, or in most cases, pumps within the tank to push the product through the meter and the filling hose to the consumer tank.
    1. These dispensers have special “break away couplings” at grade level to seal off the product pipe if the dispenser is knocked over or pulled off its base.
    2. Because the dispenser also has electric power, usually the product that is trapped within the open piping or spilled on the ground is ignited if the unit is dislodged from the base.
  - The shear valve prohibits the fire and product in the below grade piping from meeting.
    1. These valves also have a thermal latch to close the valve if involved in fire but not sheared.

Non-pressurized Liquids

- Gasoline
- Diesel fuels
- Heating oils
- Jet Fuel
- Road oils (HOT)
- All commonly transported and used in our area





Drawings from http:/chemresponsetool.noaa.gov/containers-guide/truck.htm

Let's look at the commodities that do not require pressure to remain a liquid.

- Most are received by ship at a local terminal or transported by rail or truck from remote processing facilities.
- The silhouette drawings depict the type of tanker that would be used to transport these items.
- Most commodities are stored in tanks above and below ground that are vented to the atmosphere.
    - The majority of below grade tanks must consist of a double wall design to protect the environment.
- The products are moved from various containers by a system of pipes, hoses, and pumps.
    - These may be at fixed land based facilities or mounted to transport vehicles.
- The collection, processing, and distribution system utilized with pipelines is also utilized for containers on water, rails, and roads.
- Incidents within a terminal or large distribution facility require a large response. In most cases, the facility will have been preplanned by a department, the operator and, in some cases, with mutual aid companies.
- Incidents within rail cars or ships have special challenges that will not be covered in this program.

A Tanker Crash!

This video illustrates the result of a tank truck crash on I-95 at Rt-128 on July 12, 2008:

- The truck was carrying 11,000 gallons of gasoline.
- The driver escaped with minor injuries while the highways were closed for over 4 hours.
- This shows the intensity of a large quantity of flammable liquid.
- Two circumstances could result in a “BLEVE”:
    - if any of the tank compartments are **not** breached and
    - If they are heated by the fire so as to boil the contents which would over pressurize the tank, resulting in failure.
- At that point the escaping liquid would rapidly vaporize and flash into a large fireball. We will talk about a BLEVE later.
- This incident is located within the distribution chain between the terminal and the retail distributor.

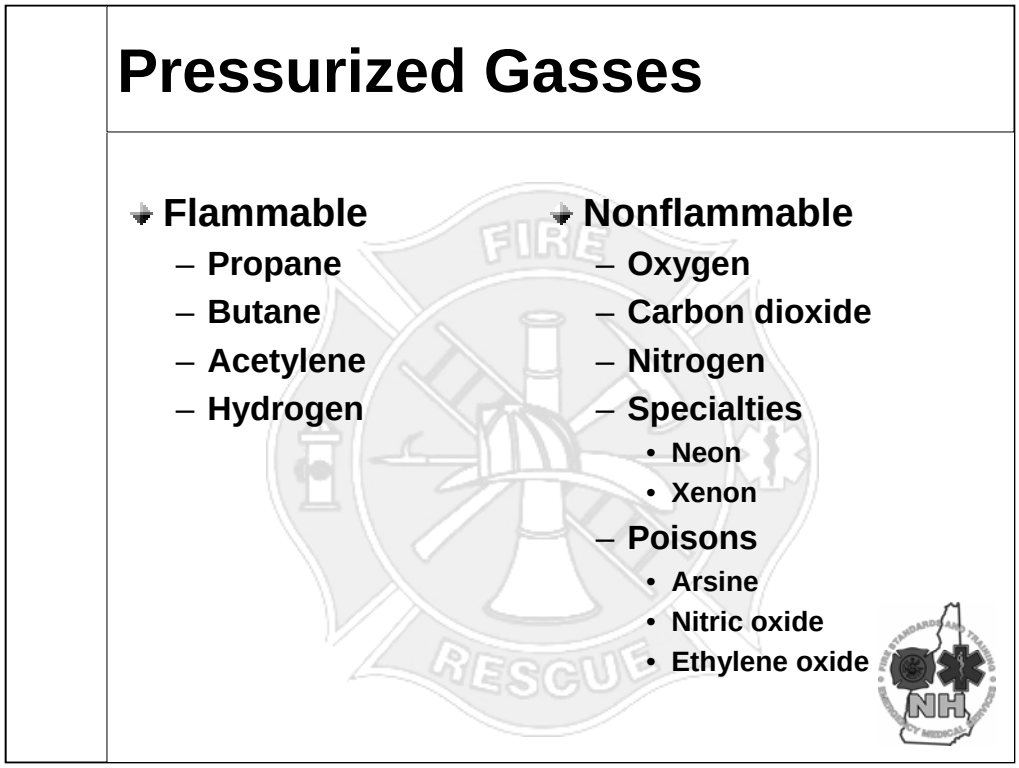
A Gasoline Pump Fire

This is a very common incident at the end retail distribution point.

- This illustrates the importance of motor fuel dispensers having “shear couplings”.
  - The product that is burning was contained between the coupling and the fill hose.
  - The product from the underground piping is isolated by the closed “shear coupling”.

Have the students predict what problems and fire growth can be expected in this incident.

- The heat of the pump fire could reduce the structural strength of the overhead canopy or melt the plastic tank of the adjacent auto.
- While not causing an explosion, rapid fire growth near explosive intensity could occur.



While the two previous videos were about gasoline incidents, they could have been examples of any flammable liquid fire or spill. The resulting fire is still of a high intensity with similar actions of the fuel and necessary attack.

This list shows just a few of the common gases that are transported and used in industry and research facilities.

- Quantities may be in **small cylinders or large transport trucks**.
- The properties and quantity of the material will play a key role in determining how the incident is handled.
- Each of these needs to be contained within a tank under some amount of pressure.
- The <u>second difference</u> in these is that **some are transported as a gas and others are transported as a liquid.**

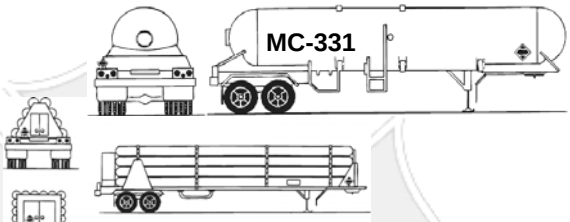
Of concern to most responders is any vapor cloud emanating from any cylinder or transport vehicle.

In the case of **Liquid Nitrogen and Liquid Oxygen transport systems**, a small vapor cloud is normal. The reason for this is that the transport system uses a small quantity of the gas to be expelled through a special heat exchanger in order to keep the transport vessel cold.

In this program we will concentrate only on the flammable gases. Your Haz-Mat training will guide you with most of the others.

Pressurized Gas Transports

- **Tank Trucks**
- **Tube Trucks**
- **Rail Cars**
- **Ships & Barges**



Drawings from http:/chemresponsetool.noaa.gov/containers-guide/truck.htm

Photo Courtesy of Doug Stark

Photo Courtesy of Craig walker

Photo Courtesy of FERC

Students may use the knowledge from their Haz-Mat class to identify the various types of tank trucks.

•**The <u>most important</u> visual point is to identify if the truck is normally pressurized.**

•Tank pressures may range from 0 to 5,000 psi.

- DOT-406 or MC-306 tanks are rated to hold up to 3psi. These are the **normal gasoline and oil tankers** which are not considered pressure tanks.
- **Tube trailers** are designed to hold gases at 5,000 psi. and normally carry gases rather than liquids.
- DOT-407, 412 and MC-307, 312 are **chemical and corrosive tankers** and may have pressures of up to 50 psi. (The DOT-407 MC-307 tankers may be insulated and heated in the same way as road oil tankers originating out of Newington.)

•The second most common tanker we see is the MC-331 **liquefied gas trailer** carrying propane.

- These typically originate in the Newington, Boston, Rochester, Claremont, or Albany, NY areas.
- These tankers have relief valves set to relieve in the 350 psi range.
- Each of these tank trucks has a number of safety features designed to contain the product in an emergency.

Tank truck safety Features

- Internal valves
- Excess flow valves
- Protected piping & fittings
- Remote valve closure devices
- Pressure relief valves
- Fusible plugs

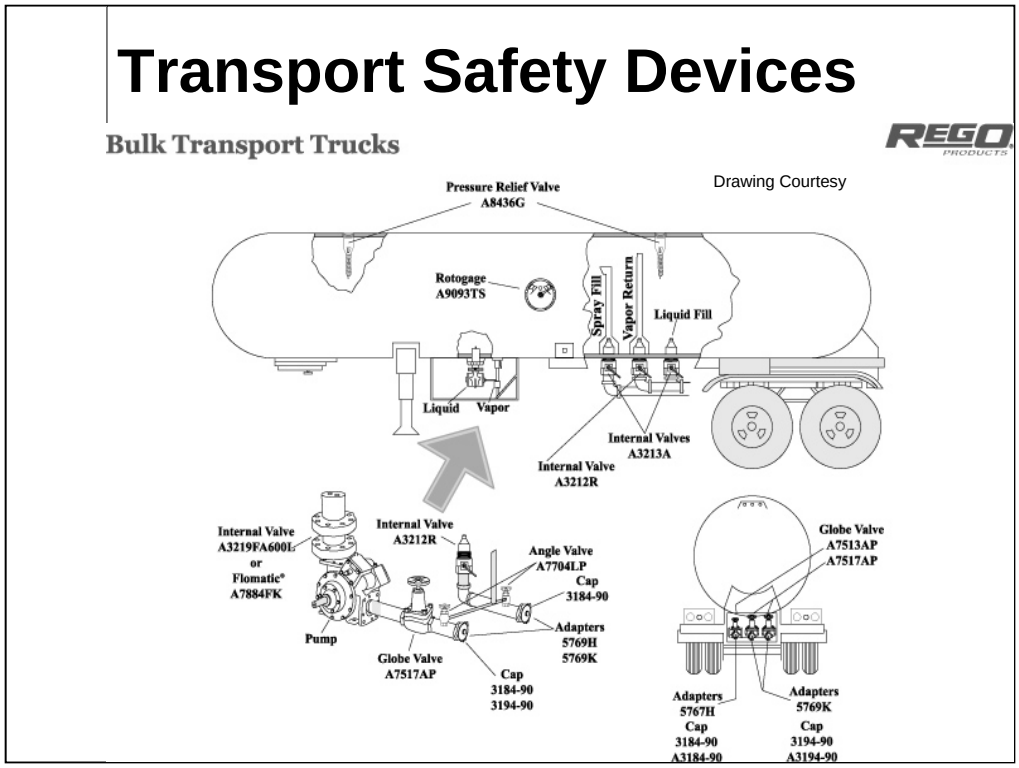
- AND THE MOST IMPORTANT!

Drawing by FFWhy?

Driver Training and Experience!

Most transport and delivery trucks are required to have certain safety devices.

- These are designed to **limit outflow of product** if a pipe or hose is broken, or if the piping is broken from the opening of the tank.
- Just as in gasoline dispensers, these valves are designed to **shear on impact** but leave the actual closed valve within the container.
- The outlet valves also must **self-close if subjected to high heat**, as in a fire, *and* have **remote closure operators** on the vehicle.
- Normally, these remote controls are on the driver front and the curb rear of the tank frame.
- Additionally, all pressure vessels must have approved pressure relief valves to vent product if the tank pressure rises above a safe level.
    - If such a valve is operating and product is escaping, most likely it is from an external fire which will also ignite the escaping product.
    - If the sound of that escaping product increases in pitch and intensity, it is a good indication that the tank relief is approaching the point at which it cannot release enough product to keep the tank at a safe pressure.
- **If the tank cannot be cooled rapidly to reduce the sound, *it is time to retreat*!**
- Smaller tanks may have fusible plugs that serve the same purpose.



Point out the recessed pressure relief valves in the top of the tank.

- At the bottom of the tank are 4 internal valves to protect from loss of product if the piping should be sheared away by some accident.
- The level indicator on the side is protected by a heavy steel shroud.
- The piping and valves in the rear are protected by their placement and by the internal valves.

Note the expansion ration of Propane is 270 cubic feet of gas to each gallon of product.

Problems may be reduced by 270 times by changing the orientation of a tank from expelling liquid to vapor.

BLEVE

This YouTube video shows the result of heating a large rail car containing LPG.

- The reporter notices that the sound is increasing as the tank car is heated.
- Also, the steel of the car side that is not in contact with the liquid is being heated above its solid state and finally ruptures violently.
- The liquid in the car is being heated and vaporizing at a rate that exceeds the release rate of the safety valves.
- The rapid escape of the liquid remaining allows it to immediately boil into an expanding gas and explode.
- This is called a **BLEVE, or Boiling Liquid Expanding Vapor Explosion**.
- Any flammable liquid can be forced into this condition by external fires on the container of any size!

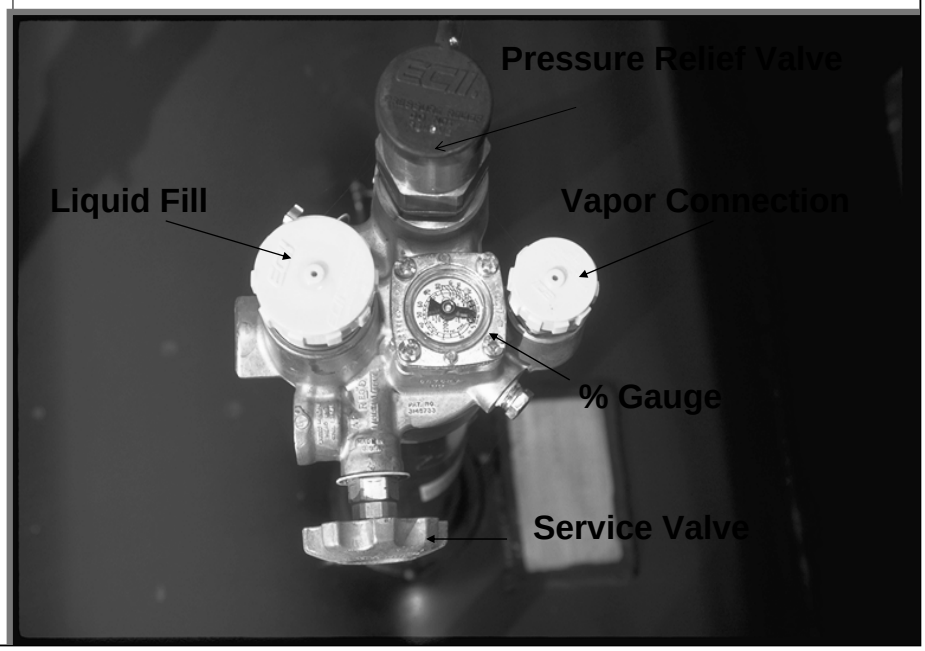
Fixed & Portable Containers

- **All Gas Containers Have**
  - **Basic Container**
  - **Service connection**
    - **To Fill/empty**
  - **Relief Valve**
    - **Fusible plugs**
- **May Have**
  - **Level indicator**
  - **Other Valves**
  - **Pressure Gauge**

Smaller containers used for consumer storage have similar features and will act the same as the rail car depicted in the previous video.

- They must have some means of controlling the filling and removal of the product.
- They will have either a pressure relief valve or fusible/frangible relief plugs.
- They may have pressure or temperature gauges, other valves, and liquid level indicators.
- A section of pipeline with the block valves closed at each side becomes a fixed container.

Typical UG Propane Tank



This is the service assembly affixed to the top of a pipe riser on a below grade tank.

- It has all the required devices combined into one compact assembly.
- This assembly is located in a riser housing placed over the tank before it is backfilled.
- It extends just above the finished grade to allow access to the valve.
- The only other opening in the tank has a fitting arranged to extract the liquid from the tank if this assembly is compromised.

(Show *Pipeline Emergencies* DVD, 45 min.)
Explain to students that as they watch the video they should think not only about pipelines but also consider the other utilities that have been discussed. The control principles are the same.

Systematic Approach

- Control Access
  - Keep yourself & others safe
- Identify the Problem
  - What is broken and what is escaping
- Evaluate Hazards and Risks
  - What can it do
- Select Protective Measures
- Assemble resources and manage them!
  - What is needed
- Implement Control Measures
  - Stop EMERGENCY
- Decontamination and Regrouping
- Termination

While the last video was based on pipelines, **all emergencies should be controlled by a methodical and logical method.**

- Responders make use of the National Incident Command System used to control emergency situations.
- Most utility crews also operate with the ICS or a similar format and thus, will work well with the fire department at an incident.
- Like the fire department, they want to have the same outcome, which is to minimize life and property hazards.
- A major component needed to make this as seamless as possible is to have prior dialog with local utilities.

This slide shows the 8 steps needed to mitigate a utility emergency. They should be very close to the steps used for any other incident.

Control Access (step one)

- May be as simple as placing some fire line tape
- May require lots of manpower to evacuate a hospital
- You may have lots of time or be pressed to act fast
- You may have to write off equipment, buildings, or people that can not be saved without

UNREASONABLE RISK to YOU

The first task is to control access to the incident.

- This may also involve the evacuation of a single building or a large area of buildings.
- The area could include a few people or a large quantity of people located in a hospital or arena, for example.
- The nature of the incident will also dictate how fast this task must be accomplished.

The most important point is to protect you and your crew.

Do not try to save people that are not viable or equipment or buildings that can be replaced.

DO NOT GET TUNNEL VISION!

Identify Problem (step 2)

- Do I know what is broken?
  - Use your knowledge of the system
  - Ask knowledgeable people for assistance
- Is there a product escape?
  - Do I know the properties of the product
- Do I know the quantity of product
- What area does the potential for risk include
  - Are there possible secondary risks

After site management we need to access the problem.

- Do we know what is broken and what is being released, if anything?
- If there is a release, what is the material and what can it do?
- The rate and quantity of the release will set some time elements as to the potential dangers.
- Look for secondary problems like environmental contamination or flooding.

Point out that this is looking like a class in ICS and Haz-Mat awareness!

We will use information from those classes to control a utility incident.

Hazard & Risk Eval. (Step 3)

- **Must know product information**
  - **Use ERG**
  - **Use MSDS sheets**
  - **Use local knowledge**
  - **Use the UTILITY personnel**
- **What are possible dangers?**
  - **Quantity = Potential**
- **What is the life threat?**
  - **Fire, explosion, flood, asphyxiation, or poisoning.**
- **Infrastructure threat?**
- **Environmental threat?**

We will use all the tools of our previous classes and some new information to evaluate the potential dangers and perform a risk analysis.

These tools may be MSDS sheets and local knowledge.
This knowledge may be what the local utility has given a fire dept. in preplanning sessions or by direct interface at the incident.

- **First, the most important risk evaluation will be life safety.**
- **Second**, evaluate the threat to buildings or equipment.
- **Third**, assess what threats may be presented to the environment.
- Always re-evaluate conditions after each action.

Usually the bigger the infrastructure that is defective, the more potential there is for more extensive damage.

- The same holds true for the force imposed on the escaping material.
- The larger the force, the more potential there is for more and wider areas of damage.
- A pipe that has 0.25 pounds of force on the gas is far less dangerous than a pipe that has 1000.0 pounds of force on the gas.
- Local knowledge will help you with information before you have an incident.

PHYSICAL PROPERTIES

- State
  - Solid
  - Liquid
  - Gas
  - Force Phenomena
- Weight
  - Specific gravity
    - Solid
    - Liquid
  - Vapor Density
    - Gases
- Boiling point
  - Liquid to gas
- Volatility
  - Rate of evaporation
- Expansion ratio
  - Liquid to gas ratio
- Vapor pressure
  - Pressure in container
- Viscosity
  - Ability to flow
- Color & odor

Before we may control a release of material from a utility, we must understand the properties of the released materials.

The FF1 text on page 129 explains the differences between solids, liquids and gases. Explain that while electricity is none of these, it ***is*** a potent energy force produced by forcing electrons to flow from one point to another. We do not manufacture electrons but only make them move in a loop from the source through the utilization device and back to the source. This process always needs a return path and in most cases that path is connected to the earth. This is where we get the term ground; most electrical systems have one conductor connected to the earth (grounded).

Begin the student use of an MSDS sheet with this live demonstration:

- We will use a cylinder with a small amount of corn syrup, colored water and vegetable oil to demonstrate specific gravity.
- Have the students use the MSDS sheets in the manual to predict the layers <u>before</u> you pour the materials into the cylinder.
- They have a MSDS for each of the above substances.
- This demonstration also may cover color, odor and viscosity properties

Our second demonstration will show vapor density using common materials the student may encounter:

- We will use the cylinder with the center hose fitting with a candle flame adjacent to the top and bottom to show the vapor density of Natural Gas and Propane.
- Again, have the students use the MSDS sheets to predict which flame will flare with each product.
- Refer students to pages 141-142 & 789-792 of the FF1 text for more information on these properties.
- We will look at the remaining properties with a specific material after a few more slides.

CHEMICAL PROPERTIES

- **Flash point**
  - **Temp. vapors will flash**
- **Fire point**
  - **Temp. vapors burn**
- **Ignition temperature**
  - **Temp. for auto ignition**
- **Flammable limits**
  - **% of product to air to burn or explode**
- **Boiling point**
  - **Temp. to change from liquid to gas**
- **Reactivity**
  - **Does it play well with other materials?**
- **Expansion ratio**
  - **Ratio liquid to gas**
- **Solubility**
  - **Mix with water?**
- **Reactivity**
  Activity when mixed
- **Health hazard**
  - **Asphyxiate**

Use the Propane MSDS sheets to help explain the listed terms and how they affect the scene control of an escaping product.

- Again, these should be familiar to the students from the Haz-Mat section of FF 1 and from pages 787 to 794 of the FF1 text.

There is no need to go into great depth!

ENERGY POTENTIAL

- **Product**
  - **Inherent energy**
  - **Quantity**
  - **Rate**
- **How Transported**
  - **Container**
  - **Pipe**
  - **Wire**
- **Size**
  - **Container**
  - **Pipe**
    - **Size**
    - **Pressure**
    - **Flow rate**
  - **Wire**
    - **Size**
    - **Voltage**
    - **Current**

This information will be used in controlling a product release and is based on the following:

- **the size of the transport system,**
- **the rate of release,**
- **the pressure behind the release, and**
- **the information found on the MSDS sheets.**

- This is a good opportunity to reinforce the concept that <u>wire size is the same as a pipe or fire hose size.</u>
- Pressure in liquids is measured in pounds per square inch, and electricity is measured in volts.
- Volume in liquids is measured in gallons, and in electricity it is amps (current flow).
- In electricity and in liquids, there must be movement of the product in order to have GPM or Current(A) measurements.
  - In other words, you must have an open nozzle or faucet or, in the case of electricity, a path through something to ground.
  - This path may be a wire touching the ground, a person that is grounded, or through a device such as a lamp.
- A high pressure or voltage in a small size pipe or wire can still possess an extreme amount of energy and therefore, more risk.

Incident Application

Photo by E. Uitts

OH #%@*^What Do I DO

Drawing by FFWhy?

PS: This is time for students to THINK
and to discuss their ideas!
Use the information you have been given
In this and other classes.

Tank is about 5' high and 3' in diameter
with a label "John's GAS keeps you warm"

Scenario:
We will use a simple 100 gallon propane tank that has been struck by a riding lawn mower. The tank is intact, but the supply line from the tank to the structure is broken at grade adjacent to the tank. The ground has also caught fire around the tank. The relief valve opens, and the escaping gas ignites as you arrive with your engine and crew. You have a 3000 gallon tanker enroute and should be on scene in 2 minutes.

Is time on your side?
(Answer: NO!)
Using the 8 step process what is step 1?
(Answer: Site management and control. Clear people away by at least 300'.)
Your second step is?
(Answer: Identify Problem & Materials Burning. Problem is broken supply line to house. Materials burning are ground cover and escaping gas.)
Step 3 is what?
(Answer: Hazard & Risk evaluation. Hazards are expansion of fire into structure, continued heating of tank, and possible expansion of ground fire. Risks are that continued heating of a tank may cause a BLEVE!)
Step 4 is?
(Answer: selection of PPE. Come on folks; this is a structure fire! We will use all our PPE. As we can see where the gas is escaping and it is outside, we may forego the use of gas meters at this time.)
Step 5 is?
(Answer: Develop a plan and assemble resources to implement the plan. Do we go defensive or offensive? In this case you have every thing you need and should go offensive!)
AND OUR NEXT STEP IS?
(Answer: Put the plan into action. That should be an immediate cooling of the tank in the vapor space area, and the closure of the tank outlet valve. Then and only then do we worry about the structure fire and ground fire.)
Step 7 is what?
(Answer: Decontamination and continue to check structure for residual gas or fire. Now is the time to use your gas meter within the building.)
Step 8 should be?
(Answer: Termination and return to service. You may all wish to pat yourselves on the back for a job well done……. and change your shorts!)

Let's examine the Product

- **Product on fire = LPG**
  - **Propane**
  - **UN # 1075**
- **Physical Properties**
  - **State**
  - **Weight (sg/vd)**
  - **Boiling point**
  - **Volatility**
  - **Expansion ratio**
  - **Vapor pressure**
  - **Viscosity**
  - **Color & odor**
- **Chemical Properties**
  - **Flash point**
  - **Ignition temperature**
  - **Boiling point**
  - **Flammable range**
  - **Expansion ratio**
  - **Reactivity**
  - **Solubility**
  - **Health risk**
- **Energy Potential**
  - **Quantity**
  - **Release rate**
  - **External forces**

In order to be more prepared for other incidents that may involve propane, let's look at the material and what it can do.

Have the students use the ERG and/or the MSDS sheet for this product to predict what the product will do when released.

What state is the product in?
(Answer: Liquid and gas)

Continue down the list of questions getting the answers from the MSDS sheet (GAS INNOVATIONS MSDS is preferred for this exercise).

As you reference each property, ask what it means in terms of controlling the incident.

Are some properties more important to incident control than others? Why or why not?

Pose the question, "What response could be made if the tank had been on its side?"
(Answer: By uprighting the tank, if the valves could not be closed, the problem is reduced by 270 times because it has gone from a liquid release to a gas release.

What response would be appropriate if the relief valve had been operating for some time before arrival and the sound of the escaping gas was increasing in intensity and pitch?

Odor Investigation

Let's look at a new incident and build on the knowledge we used in the last incident.

Scenario:
We have received a call of a strong gas odor in the area of this building. Upon arrival, you are told that the area was flooded the day before, and now there is a strong odor and hissing sound by the gas meter.

- Let students formulate a plan based on the information they have to this point.
- Guide them through the 8 step process.
- **Do not tell them that this is a natural gas installation.**
- Let them build their plan based on either propane or natural gas.
    - Unless you have local knowledge, it could be either.
    - In this case, the solution to the problem is to use a fog stream to protect the crewmember that will close the main gas valve.
    - Then finish dispersing the vapor and meter check the building.

Let's examine the Product

- **Product = NG**
  - **Natural Gas**
  - **UN # 1971**
- **Physical Properties**
  - **State**
  - **Weight (s.g. / v.d.)**
  - **Boiling point**
  - **Volatility**
  - **Expansion ratio**
  - **Vapor pressure**
  - **Viscosity**
  - **Color & odor**
- **Chemical Properties**
  - **Flash point**
  - **Ignition temperature**
  - **Boiling point**
  - **Flammable range**
  - **Expansion ratio**
  - **Reactivity**
  - **Solubility**
  - **Health risk**
- **Energy Potential**
  - **Quantity**
  - **Release rate**
  - **External forces**

Have the students use the MSDS for natural gas.

- Point out the differences between propane and natural gas.
- Will any of the differences change your plan of attack on incidents based on this product?
  - Most natural gas service people will not be happy if you fill up the excavation around a broken pipe with water.
  - How would you like wallowing in the mud to repair a broken pipe?
- You may disperse the rising vapors with a fog stream with care.
- In either case, let the product burn so that you know where it is.
- Protect the exposures.
- The size of the pipe and the pressure of the product will determine the size of the incident.
- Natural gas is also stored and transported as CNG (compressed natural gas).
- It is used as a motor fuel just as propane is used for vehicles.
- Propane mixed with air is injected in city gas lines in the colder months when the pipeline cannot supply the desired flow rates into the city gate.
- Propane will behave just like natural gas.

Product Spill & Fire

Scenario:
You have been dispatched to the local mini-mart for a gasoline spill. Upon your arrival this is what you see!

- The method of extinguishment deployed by the bystanders appeared to produce the desired result.
- Had this only been a small fuel spill with no nutcase and no bystander intervention, what would you do?
- If it had become a large (more than 5 gallon) spill, what would be your plan of action?
- If a large spill had been ignited, what would be the new plan of attack?
- Will the shear/fire valve within the dispenser be of any help?

Let the students do most of the planning.
Guide in the proper direction only when necessary.

Let's examine the Product

- **Product = Gasoline**
  - **UN # 1203**
- **Physical Properties**
  - **State**
  - **Weight (s.g. / v.d.)**
  - **Boiling point**
  - **Volatility**
  - **Expansion ratio**
  - **Vapor pressure**
  - **Viscosity**
  - **Color & odor**
- **Chemical Properties**
  - **Flash point**
  - **Ignition temperature**
  - **Boiling point**
  - **Flammable range**
  - **Expansion ratio**
  - **Reactivity**
  - **Solubility**
  - **Health risk**
- **Energy Potential**
  - **Quantity**
  - **Release rate**
  - **External forces**

At this point, the students are being led into flammable liquids and the use of foams.

Use the MSDS for Premium Unleaded Gasoline (no Alcohol).

The use of absorbent materials is the normal practice on small spills. However, most of the time little regard is given to the disposal of the materials that may still be emitting vapors. As long as there are vapors present, we have a concern for possible ignition. On larger spills it may be wise to lay a foam blanket over the spill to prevent vapors from traveling to an ignition source. We must use care to prevent the product or foam water from entering sewers or drainage basins. We will get into the properties and use of fire foams as we discuss this incident.

Ask what is now added to most gasoline to increase the cleaner burns to protect the environment?

- You may get MTBE, which is an ether derivative and highly polluting to water.
- MTBE has been replaced with denatured alcohol.
  - This may be added in quantities up to 80%.
  - Have the students compare the MSDS for straight gasoline and that which has alcohol added.
  - Note in particular that alcohol mixes with water.
- We also have the MSDS for straight alcohol which also indicates the affinity for water.
- While great quantities of water will suppress a flaming liquid fuel fire, fighting foams will do the job more easily as well as more safely.

We will look at these foams next.

Extinguishing Agents

- **Water**
  - **Cheap**
  - **Abundant**
  - **High heat absorption**
  - **High expansion steam conversion inside a closed space (up to 1700:1) without adequate ventilation will cause burns**
- **Foams**
  - **Supplemental to water**
  - **Add additional properties**
- **Auxiliary Agents**
  - **Dry chemical**
  - **Halons,**
  - **Halon replacements**
  - **More expensive**
  - **More specialized**

In order to be most successful in extinguishing utility fires, we may wish to use materials other than just plain water.

- We have touched on the properties of both water and auxiliary agents in our fire extinguisher classes.
- In industrial & special situations, these materials may be used with built-in protection systems to protect from the event of fire.
- In the utility industries, these systems will be in places of high risk or value.
  - Examples would be:
    - large switch yards and switching stations of electric and communication utilities,
    - tank farms, and
    - loading racks of petroleum distributors.
- Keep in mind that, as we learned with extinguishers, an electrical fire reverts to a class “A” or “B” fire after the power is disconnected.

Foams

- Foams must match the fuel
- Class A foams do not work on Class B fires
- Class B fuels are divided into two categories
  - Hydrocarbons
    - crude oil, fuel oil, gasoline, benzene, naphtha, jet fuel and kerosene
    - Standard fire fighting foam is an effective extinguishing agent and vapor suppressant because it can float on the surface
  - Polar solvents
    - alcohol, acetone, lacquer thinner, ketones, and esters, which are miscible
    - special alcohol-resistant foam must be used

Point out that there are many types of foams designed for specific tasks.

We will break them down into some general categories and explain their use and application.

Class “A” Foam

- Mixed with water in the range of 0.1% to 3.0%
- Can be applied with a wide range of nozzles
- Reduces surface tension of water
- 0.1% “wet” foam has good penetration
- 3.0% “dry” foam is great for application to structures to protect from adjacent radiant heat

The first major class would be “Class A” foams originally designed for wildland fires.

- They are now common for any type of class “A” materials.
- They are mixed with water, in the range of 0.1% to 3.0%.
- The more concentrate that is added to the water, the “dryer” the finished foam.
- This “dry” foam will stick to structures and brush providing an insulating blanket from adjacent radiant heat.
- Dry foam may be used to protect structures from utility fed fires.

WARNING

Class A Foam

WARNING: Use Class A foam only on Class A fuels.

It is not specifically formulated for fighting Class B fires and will not provide the extinguishing and vapor-suppression capabilities of Class B foams

Class "B" Foams

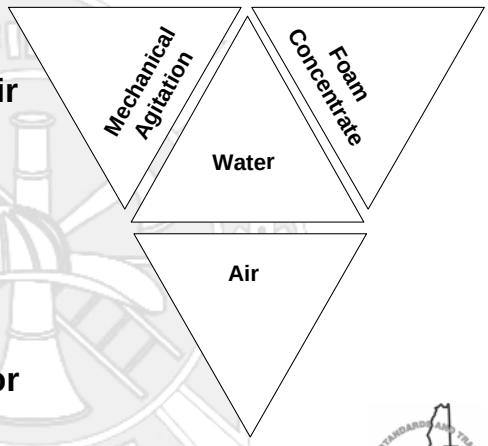
- Specific Foam Concentrates
  - Some foams produce a vapor sealing film
  - Others, such as medium and high expansion foams are used in large volumes to flood surfaces and fill cavities
- Aqueous Film Forming Foam (AFFF)
- Regular Protein Foam (PF)
- Fluoroprotein Foam (FPF)
- Film Forming Fluoroprotein Foam (FFFP)
- High-Expansion Foams (HX)

There are several different types of class "B" foams.

- (AFFF) **A triple F** is the most common and has wide use. It is a liquid concentrate that is made from fluorochemical and hydrocarbon surfactants combined with high boiling point solvent and water with suitable foam stabilizers.
- (PT) **Regular Protein Foam** was used for almost all aircraft fire fighting before the 1970's. Due to its corrosiveness, no self-sealing ability, and other limitations PF is no longer widely used. It may still be used in some special industrial applications.
- (FPF) is widely used in protecting fuel tanks and petroleum facilities because its unique fuel shedding qualities make it highly desirable in sub surface injection applications.
- (FFFP) Fluoroprotein foam technology with aqueous film forming foam capabilities providing the benefits of AFFF with long lasting heat resistance of FPF.
- (HX) **High Expansion foams** have applications in concealed spaces, fire extinguishing systems for specific industries such as aircraft hangars, rolled or bulk paper storage, etc.. High expansion foams have expansion ratios of 200:1 to 1,000:1. HX is usable on class "A" materials.

Elements of Foam

- **To produce a quality foam blanket foam concentrate, water, air and mechanical aeration must be present and blended in correct ratios**
- **Removal of any element will result in no foam production or poor quality foam**



We need four items to come together to produce usable foam.

Just like the Fire Tetrahedron we have a Foam Tetrahedron.

Definitions of Foam

- **Foam concentrate**
  - **Raw foam liquid before it's introduced to water and air**
- **Foam proportioner**
  - **Device that introduces foam concentrate into water stream to make foam solution**
- **Foam solution**
  - **Mixture of foam concentrate and water before the introduction of air**
- **Foam**
  - **Complete product after air is introduced into foam solution (also known as finished foam)**

This list of definitions is necessary in order to be able to talk about **how we make and use the end product.**

How Foam Works

- **Separating**
  - **Creating a barrier between the fuel and the fire**
- **Cooling**
  - **Lowering the temperature of the fuel and adjacent surfaces**
- **Suppressing (smothering)**
  - **Preventing the release of flammable vapors and reducing the possibility of ignition or re-ignition**

Review the principles of foam suppression.

- It is important that the foam is compatible with the product that is on fire.
  - Incompatible foams will be destroyed by the product and will not be effective.
- Point out that a foam blanket is very thin, and any incursion will allow vapors to escape with the possibility of ignition.
- The smothering process will only come into play if the product to be controlled is on a single plane.
- If the product is flowing from an elevated area, it now becomes a three-dimensional fire.
- By introducing a dry agent into the foam stream, we may control this part of the fire.
- Most aircraft attack equipment will have this ability.
- The only way to produce this affect with normal structural equipment is to attempt to add dry agent into the stream with a portable extinguisher.

Foam Proportioning

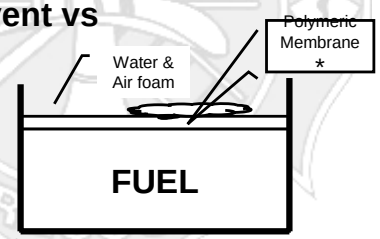
- Most concentrates are intended to be mixed with 94 to 99.9 percent water
  - May be fresh or salt
- For example 3% foam concentrate is 97 parts water, 3 parts foam concentrate
  - Ranges 0.1 to 6.0%
- Four methods by which foam may be proportioned; induction, injection,
  - Batch mixing, and pre-mixing

Foam concentrates are designed to be most efficient at a specified ratio of concentrate to water.

- That may be as low as 0.1% for type “A” concentrate to 6.0% for AFFF.
- <u>The correct mix is very important!</u>
- Some means of mechanical proportioning is the best method, but in dire circumstances, concentrate may be added to the booster tank in the proper ratio in order to achieve acceptable results. Premixing is normally how portable foam fire extinguishers are charged.

Demonstration of Properties

- Suppression of vapor
- ¼ Life & need for reapplication
- Chemical resistance
  - Non polar solvent vs polar solvent



* In AFFF-AR concentrate only Polymeric layer does not self heal!

Drawing J Uitts

Demonstration:
The classroom kit will contain 3 jars with a small quantity of K-1 fuel.
There will be two spray bottles, one labeled “Non AR Foam” and the other labeled “AR Foam”.
Gently swirl each spray bottle before using to mix concentrate and water.
<u>When the demonstration is complete, replace the jar lids and return the kit for product disposal and cleaning.</u>

<u>Demo 1:</u>
- You should now open the jar labeled “K-1”.
- Observe the presence of vapor in the form of an odor coming from the open jar.

<u>Demo 2:</u>
- Spray the surface of the K-1 with non AR foam and set aside.
- Observe the foam breakdown and the water migrating to the bottom of the container.

<u>Demo 3:</u>
- Prepare a second K-1 sample and spray with non AR foam.
- Now add a small amount of alcohol and observe the failure of the foam blanket.
- (Note: this will have to sit motionless until you finish the next demonstration.)

<u>Demo 4:</u>
- Prepare a third K-1 sample and spray with alcohol resistant foam, and <u>again</u> add a small amount of alcohol.
- Note that the foam blanket still remains.

Foam Proportioning

- **Induction method uses pressure energy in the water stream to induct (draft) foam concentrate into the fire stream**
  - **Achieved by passing the stream of water through an eductor that has a restricted diameter**

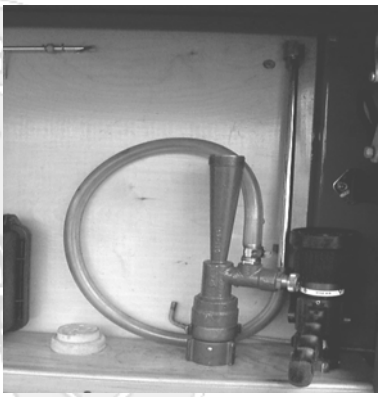
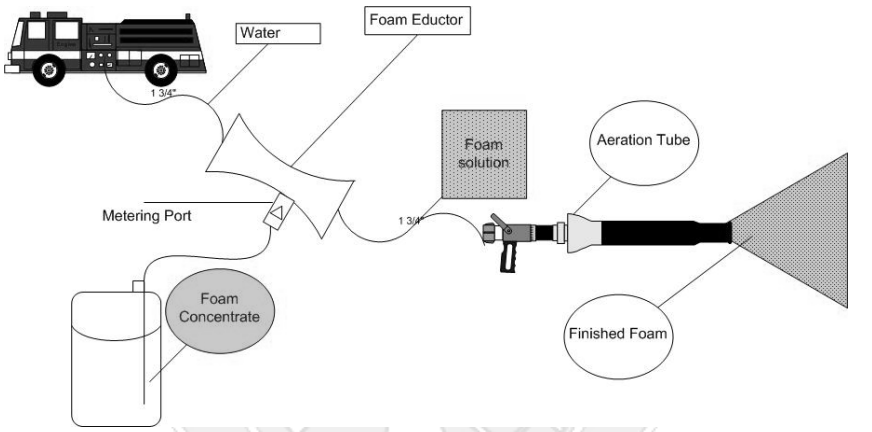


Photo by Deputy Chief Shutts
Portland ME FD

If possible, bring an eductor into the classroom and show how it operates.

Portable Eductor



Drawing J Uitts

It is important to match the eductor and the nozzle flow and pressure rates to get proper operation.

- One must also match the required inlet pressure and the maximum outflow hose length as these are critical to maintaining the correct mixtures.
- In this example, we need 200 PSI at the inlet of the eductor and a maximum of 250’ of 1 3/4” hose to a 100 psi, 95 GPM fog nozzle on the outlet.
- This rating is for a pickup tube setting of 3 to 6%.
- Settings of 1% and below will allow an additional 100’ of discharge hose.
- Reduced inlet pressure will effect nozzle pressure and will result in an increase in foam to water ratio.
- The eductor manufacturer’s information should be consulted for each different eductor nozzle combination you use.

Portable Eductor Location

Photos J Uitts

The location of the eductor will be determined by the distance of the pump to the fire and the amount of hose that must be deployed.

- The manufacturer's recommendations need to be followed or the mix ratio will be inaccurate.
- In general, 200 PSI will be needed at the eductor inlet to provide 100 PSI at tip of a fog nozzle 100' away from the eductor outlet.

Foam Injection

- **An external pump or head pressure is used to force foam concentrate into the fire stream at the correct ratio in comparison to the flow**
  - **These systems are commonly used in apparatus mounted or fixed fire protection system applications**

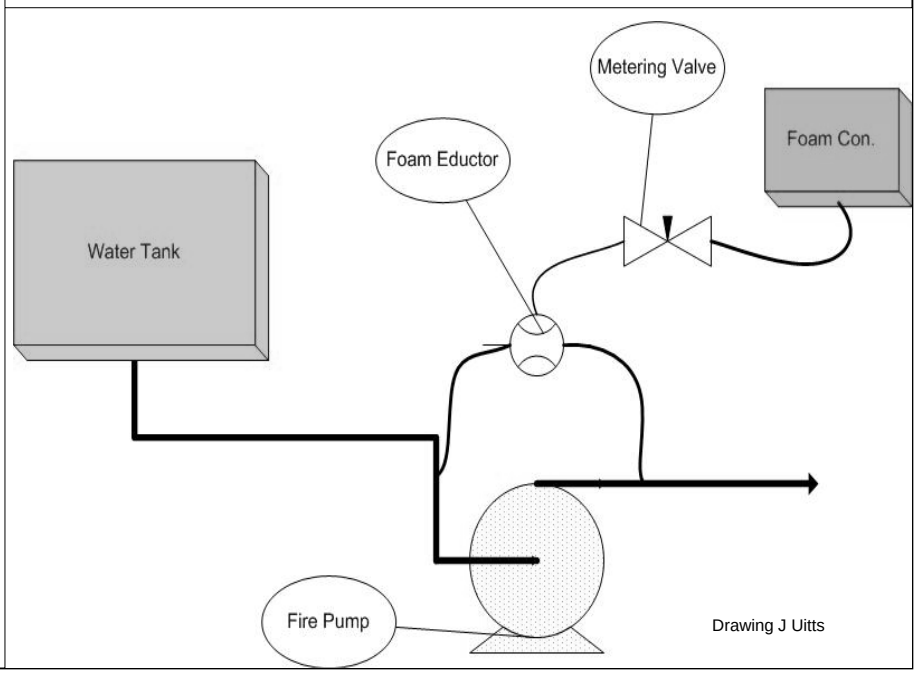
Photo by NHFA

Foam concentrate injection is controlled by monitoring the water flow and controlling the speed of a positive displacement foam concentrate pump, thus injecting concentrate at the desired ratio.

Advantages include the following:

- accurate proportioning of foam concentrate at any flow rate or pressure within design limits,
- automatic adjustment is made in relation to changes in water flow when nozzles are opened or closed,
- may be used with high energy foam systems.

Around-the-Pump Proportioners



A small return (bypass) water line connected from the discharge side of the pump back to the intake side of the pump with an in-line eductor positioned on the bypass line allows for foam pick up.

A valve just off the pump discharge piping controls the flow of water through the bypass line.

When open, a small amount of water (10 to 40 GPM) discharged through the pump creates a venturi effect and draws foam from the concentrate tank.

The foam solution is then supplied back to the intake side of the pump and discharged into a hoseline.

A pump can only supply water or foam, not both at the same time.

Portable Foam Application

- **Once the foam concentrate is mixed to form a foam solution, the solution must then be aerated and delivered**
  - **With low energy foam systems , the aeration and discharge of the foam are accomplished by the foam nozzle**
- **Standard fire fighting nozzles can be used for some foams**
- **Air-Aspiration foam nozzle**
  - **May be an air aspiration tube attached to a standard fog nozzle**

Standard fog nozzles will allow enough air to be entrained in the solution at the nozzle tip to produce usable AFFF foam blankets.

- The addition of a foam tube designed for the nozzle will enhance the finished foam.
- Fog nozzles that produce non-aspirated foam are best suited for fire attacks on Class B fires. They provide maximum penetration power and rapid extinguishment.

Air-aspiration foam nozzles are best suited for applying a foam blanket to un-ignited or recently extinguished pools of fuel.

- The foam produced by these nozzles forms a more effective blanket for long term vapor suppression.
- The added tube increases the aspiration up to a ratio of 12:1.
- Some dedicated foam nozzles will have expansion ratios up to 50:1 for medium expansion foams.

High Expansion Foam

- **Requires**
  - **High Expansion Concentrate**
  - **Proper Foam Generator**
    - **Either an adaptor to mount to a normal smoke ejector**
    - **Or a dedicated fan foam generator unit**
- **Used to fill large spaces**
  - **Low water content**
  - **Large bubbles**
  - **More air**

Photo by J Uitts

High expansion foam is used to fill spaces where a firefighter cannot be placed or to flood spaces with high value equipment or products.

Examples are:

- aircraft hangers and
- rolled paper storage.

These are generally **fixed systems**.

Portable systems may be used for basement or attic fires where access is a concern.
The large volume of foam both cools and smothers a fire within the filled space.

CAFS

- **Compressed Air Foam Systems**
  - **Same general educton process**
  - **Add a large amount of compressed air into the foam concentrate/water mix**
- **Features**
  - **Greater reach**
  - **Lighter hose line**
    - **May be more prone to kinking**
  - **High expansion**
  - **Use smooth bore nozzle**

CAFS has been used in structural attack situations with mixed results.

- Advantages:
  - The ability to change the foam concentrate level and the uniform bubble production
  - Lighter attack line weight
- Some people would never go back to normal water operations while others do not feel that the advantages outweigh the disadvantages, which include more likelihood of kinked hoses.

Application

- Do not start a foam operation unless you have enough concentrate to finish the task!
- Know how to set up your equipment
- Know which nozzles and components are matched to the foam you are to use
- Do not mix class “A” and class “B” foam concentrates.
  - They will jell
- Do not mix differing brands of concentrate
  - Ok if both are the same Mil. Speck. #

It is important to have enough foam concentrate on hand or on the road before operations are started.

- Though beginning with water is okay, finishing with water will undo all of the foam protection.
- Not all equipment is compatible, so be sure to use equipment (nozzles, proportioner) that match in flow ratings.
- Mixing class “A” and class “B” foam concentrates will gum up the tanks, lines, and valves they contact.
- Not all foam concentrates mix well with other like-labeled concentrates unless labeled to military specifications.
- If equipment is properly set up and foam is not produced, the most likely problem is a plugged orifice in the proportioner.

Aspirating Versus Nonaspirating Nozzles

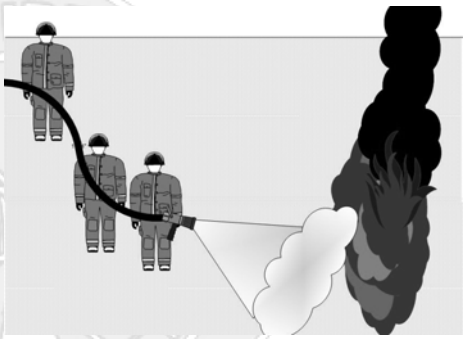
- Only film forming foams are suitable for non-aspirating application
- Application of protein foams requires air-aspirating nozzles
- AFFF can be applied with either
- Non-aspirating
  - farther reach, larger areas may be covered
- Aspirating
  - Designed to produce good quality foam, reduced burnback and restricts re-ignition

The foam concentrate selection will dictate the use of an aspirating or non-aspirating nozzle.

- Most structural trucks will be equipped with either or have the ability to deploy class “A” or “B” foam.
- Common fog nozzles will normally be the choice of applicator.
- Possessing the add-on foam tube for these fog nozzles gives one the advantage of making a selection in the field based on the need.
  - Example: a flaming fuel spill can be attacked with class “B” foam and the standard fog nozzle.
- After the fire is extinguished, the air tube may be added to lay a vapor suppressing blanket over the remaining fuel.

Sweep Application

- **Directs foam stream on the ground near the front edge of a burning liquid pool**
- **Foam then rolls across surface of fuel**
- **Used only on pool of liquid fuel (ignited or un-ignited on open ground)**



In the sweep or roll on method of application, the foam stream is directed at the ground in front of the flaming fuel spill, and the foam blanket is pushed or rolled onto the spill.

- We must be very careful not to push the fuel or to break the foam blanket as more foam is applied.
- Slow, steady, horizontal motion is needed.
- The application location will have to be relocated so as to prevent movement of the fuel and provide full coverage.

Sweep Application

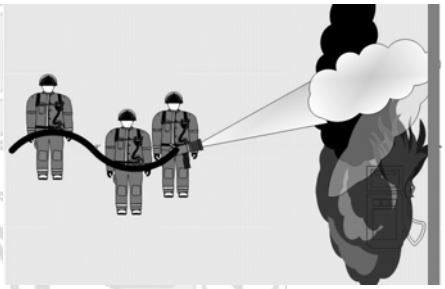
Photo J Uitts

This photo shows the application by the sweep method to a leaking drum.

•Note the foam is applied well in back of the spilled product and is swept onto it.
•The goal is to not disturb or move the leaking product.

Bank-Down Application

- **Employed when an elevated object is near (fuselage, wall, tank shell, etc.)**
- **Foam stream is directed at the object, foam runs down onto the surface of the fuel**
- **Used primarily in dike fires and fires involving spills around damaged or overturned transports vehicles**



Drawing J Uitts

The bank down or bounce method is best when you have an object against which you may direct the stream.

- This will break the stream into a fine mist that settles on the flaming fuel.
- Again, we do not wish to push the fuel nor do we wish to break any foam blanket we have built over the fuel.

Bank-Down Application

Photo J Uitts

Again, in this application the goal is to aim the foam stream against an object above the spill; doing so will ensure that the rain and run off will cover the spill without moving the spilled product.

Seat of the Fire Method

- **Set fog nozzle to 10 degree fog position.**
- **Slowly sweep stream parallel to the ground.**
- **Build foam blanket on fuel before advancing.**

Photo by E Uitts

The seat of the fire method of application has replaced the older wasteful rain down method.

- Again, inefficiency in suppression time of as much as 70% is achieved by this method of application.
- In the rain down method where the stream is elevated at about a 45 degree angle above horizontal, much of the agent is lost in the thermal column.
- With any method, fuel must not be agitated or pushed. Doing so produces more vapors that increase the fire which in turn requires more agent and work to suppress.
- Attempt to attack from uphill and upwind.
- Try to avoid walking through spilled product and foam as this will open a void in the foam blanket and allow vapors to escape.
- There is also the possibility of protective clothing absorbing the product and acting like a lamp wick!

Summary

- Utilities transport products
  - Electricity
  - Fuels as liquids
  - Fuels as Gases
- Dangers of an escape
  - Large quantity
  - Lots of energy
  - Special tools
  - Specialized training
- Control
  - Secure incident area
  - Evaluate risk & hazards
    - Think long term
  - Select protective actions
  - Assemble recourses
  - Implement plan
  - Decon & clean-up
  - Termination

Utilities add special risks in:

- the great amounts of potential energy,
- remote controlled systems,
- specialized training and equipment needs, and
- large fire loads they may have.

Recap the 8 step control process which we use for most any incident.
Remind students that we only enter into calculated risk to save what is savable!

Thank You

- **Please complete a class evaluation form.**

Photo by E Uitts

CREF#_____ Primary Instructor_____ Date_____

New Hampshire Fire Standards and Training and Emergency Medical Services

Utility Emergencies & Foam

P - Pass, F - Fail, I - Incomplete

Last	First	16-44 Place a Foam line in service	16-45 Apply Foam by Sweep method	16-46 Apply Foam by the Bankshot Method	16-47A Apply Foam by the Seat of Fire Method	16-48 DEMO Applying High Expansion foam	32-9 Dispersion of Gas Vapor	21-13 Shutting off Gas Utilities	21-12 Controlling a Gas Cylinder Fire

Candidate: _____ Date: _____

ID#: _____

Skill Drill 16-47A
Fire Fighter II, 6.3.1

Applying Foam with the Seat of the Fire

Evaluator Instructions: The candidate shall be provided with a foam line, air aspirating nozzle, and full personal protective equipment.

Task: Seat of the Fire method of applying foam.

Performance Outcome: The candidate shall use the Seat of the Fire method to apply foam.

Candidate Directive: "Properly use Seat of the Fire method to apply foam."

No.	Task Steps	First Test		Retest	
		P	F	P	F
1.	Opens nozzle to ensure foam is produced & set nozzle to 10 degree fog.				
2.	Moves into safe range and opens nozzle.				
3.	Directs foam horizontally above the product so foam is not agitating the product.				
4.	Allows foam to pool until product is completely covered.				

Retest Approved By:	Retest Evaluator:

Evaluator Comments: _____ Candidate Comments: _____

Evaluator	Date	Candidate	Date
Retest Evaluator	Date	Retest Candidate	Date

Candidate: _____ Date: _____

ID#: _____

Skill Drill 16-48
Fire Fighter II

Applying High Expansion Foam (Use As DEMONSTRATION

Evaluator Instructions: The candidate shall be provided with a foam line, High Ex. Generator, and full personal protective equipment.

Task: Applying High Expansion Foam as part of a team.

Performance Outcome: The candidate shall fill a space with high expansion foam.

Candidate Directive: "Properly Apply High Expansion Foam into X space."

No.	Task Steps	First Test		Retest	
		P	F	P	F
1.	Assembles foam equipment properly.				
2.	Moves into safe range and sets up equipment to introduce foam into a space.				
3.	Starts foam generation.				
4.	Allows foam to completely fill the intended space.				

Retest Approved By:	Retest Evaluator:

Evaluator Comments: _____ Candidate Comments: _____

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Evaluator	Date	Candidate	Date
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Retest Evaluator	Date	Retest Candidate	Date

Candidate: _____ Date: _____

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Skill Drill 21-12
Fire Fighter II, 6.3.3

Suppressing a Flammable Gas Cylinder Fire

Evaluator Instructions: The candidate shall be provided with full personal protective equipment (PPE), self-contained breathing apparatus (SCBA), and 1¾“ hose lines.

Task: Suppressing a flammable gas cylinder fire.

Performance Outcome: With a team, the candidate shall demonstrate how to safely suppress a flammable gas cylinder fire.

Candidate Directive: “With a team, safely suppress a flammable gas cylinder fire.”

No.	Task Steps	First Test		Retest	
		P	F	P	F
1.	Cools the tank from a distance until the relief valve resets.				
2.	Wearing full PPE, two teams advance with hose lines using an interlocking 90º-wide fog pattern. Teams do not approach cylinder from the ends. Team leader is located between the two nozzle persons and coordinates and directs the advance upon the cylinder.				
3.	When cylinder is reached, nozzle teams isolate shut-off valve with their fog streams while leader closes tank valve.				
4.	After burning gas is extinguished, nozzle teams continue to apply water to the cylinder to cool the metal so as to prevent tank failure resulting in a BLEVE.				
5.	As cooling continues, teams slowly back away from the cylinder, never turning their backs to it.				

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Retest Evaluator	Date	Retest Candidate	Date

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Candidate:_____ Date:_____

ID#:_____

Skill Drill 21-13
Fire Fighter I, 5.3.18

Shutting Off Gas Utilities

Evaluator Instructions: The candidate shall be provided with PPE, SCBA, portable radio, hand tools, fully equipped apparatus, an external gas shut off valve, lockout/tagout system, and an assignment to control gas utilities at a structure fire. Instructor should follow the recommendations of NFPA 1403, *Standard on Live Fire Training Evolutions*, to minimize risks during live fire training. Controlling utilities is often a task assigned to ladder companies.

Task: Controlling gas utilities.

Performance Outcome: The candidate as part of a coordinated structural fire attack shall recognize and manage hazards, identify utility control devices, and operate control valves or switches.

Candidate Directive: "Safely control gas utilities."

No.	Task Steps	First Test		Retest	
		P	F	P	F
1.	Dons PPE and SCBA.				
2.	Enters accountability system.				
3.	Acknowledges assignment.				
4.	Locates exterior gas shut-off valve.				
5.	Shuts gas valve.				
6.	Attaches tag and lock (if required).				
7.	Notifies command that gas is shut off.				

Retest Approved By:	Retest Evaluator:

Evaluator Comments: _____ Candidate Comments: _____

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Evaluator	Date	Candidate	Date

Retest Evaluator	Date	Retest Candidate	Date

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Candidate:_____ Date:_____

ID#:_____

Skill Drill 32-9
Fire Fighter I, NFPA 472, 2008 6.6.4.1 (3) (i)

Using Vapor Dispersion to Manage a Hazardous Materials Incident

Evaluator Instructions: The candidate shall use vapor dispersion as a product control solution.

Task: Correctly utilize vapor dispersion as a product control solution.

Performance Outcome: The candidate shall be able to correctly use vapor dispersion for product control.

Candidate Directive: "Correctly control a product release using vapor dispersion."

No.	Task Steps	First Test		Retest	
		P	F	P	F
1.	The candidate shall identify the product, its physical and chemical properties, and the technique necessary for dispersion.				
2.	The candidate shall survey the area and environment, taking in to account structures, topography, and weather conditions for direction that dispersion will move.				
3.	The candidate shall use four-gas monitor to determine safe work area.				
4.	The candidate shall ensure that all sources of ignition have been removed in the case of a flammable vapor.				
5.	The candidate shall set up, from an effective and safe distance, and disperse vapors utilizing hose streams with fog spray, large displacement fans, HVAC systems, or other available methods.				
6.	The candidate shall continue to monitor the environment until vapors have been dispersed.				

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Candidate: _____ Date: _____

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Skill Drill 16-44
Fire Fighter II, 6.3.1

Placing a Foam Line in Service

Evaluator Instructions: The candidate shall be provided with an attack line, air aspirating nozzle, foam concentrate, foam eductor, and gloves.

Task: Placing foam line in service.

Performance Outcome: The candidate shall demonstrate the ability to place a foam line in service.

Candidate Directive: "Properly place a foam line into service."

No.	Task Steps	First Test		Retest	
		P	F	P	F
1.	Attack lines need to be procured. Removes nozzle and replaces with air aspirating nozzle.				
2.	Places in-line eductor in line no more than 150' from nozzle.				
3.	Places foam concentrate container next to eductor. Checks percentage of concentrate; sets metering device on eductor.				
4.	Places pick-up tube from eductor into concentrate; keeps both items at similar elevations.				
5.	Charges hose line, flows water through nozzle until foam appears.				
6.	Applies foam using application methods.				

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Retest Evaluator	Date	Retest Candidate	Date

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Candidate: _____ Date: _____

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Skill Drill 16-45
Fire Fighter II, 6.3.1

Performing the Sweep Method of Applying Foam

Evaluator Instructions: The candidate shall be provided with a foam line, air aspirating nozzle, and full personal protective equipment.

Task: Sweeping method of applying foam.

Performance Outcome: The candidate shall use sweep method to apply foam.

Candidate Directive: "Properly use sweep method to apply foam."

No.	Task Steps	First Test		Retest	
		P	F	P	F
1.	Opens nozzle to ensure foam is produced.				
2.	Moves into safe range and opens nozzle.				
3.	Directs foam onto ground in front of pool of product.				
4.	Allows foam to roll across top of pool until completely covered.				

Retest Approved By:	Retest Evaluator:

Evaluator Comments: _____ Candidate Comments: _____

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Candidate: _____ Date: _____

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Skill Drill 16-46
Fire Fighter II, 6.3.1

Applying Foam with the Bankshot Method

Evaluator Instructions: The candidate shall be provided with a foam line, air aspirating nozzle, and full personal protective equipment.

Task: Bankshot method of applying foam.

Performance Outcome: The candidate shall use the bankshot method to apply foam.

Candidate Directive: "Properly use bankshot method to apply foam."

No.	Task Steps	First Test		Retest	
		P	F	P	F
1.	Opens nozzle to ensure foam is produced.				
2.	Moves into safe range and opens nozzle.				
3.	Directs foam onto solid structure so foam is directed off object and onto pool of product.				
4.	Allows foam to roll across pool until completely covered.				

Retest Approved By:	Retest Evaluator:

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Name: _____ Utility Emergencies Quiz 1

Form: 0

Version: 0

1. UNTITLED 001

If you respond to a utility emergency and do not know how the system operates. You should?

A. Rush in and do something
B. Study the system and operate valves
C.✔ Do not touch or interfere
D. Feed with water

SM 1& IG 9

2. UNTITLED 007

Electrical wires that operate at voltages in the ranges of 69,000 to 1,500,00 are called

A.✔ Transmission lines
B. Distribution lines
C. Feeder lines
D. Secondary lines

SM 5 & IG 13-14

3. UNTITLED 012

An electric arc produces all of the following **except**

A. Light
B. Infrared energy
C.✔ Cold waves
D. A blast wave

SM 11 & IG 19

4. UNTITLED 015

A downed power line produces radiating energy fields on the ground that if walked on

A.✔ allow for a step potential situation
B. allow for us to jump over them
C. allow for us to see the power waves
D. allow for us to move objects near the wire

SM 12 & IG 22

5. UNTITLED 016

T F✔ All communications wires that are on the ground are safe to move

SM 14 & IG 28

6. UNTITLED 022

Some communities have potable water pipelines. The largest danger from them is

A.✔ Flooding & structural collapse
B. EColi and electrocution
C. Muscle contractions and defibrillation
D. Flooding and blindness

SM 15 & IG 35

7. UNTITLED 026

T F✔ Crude oil pipelines are common in the southwestern USA but we do not have any in New Hampshire.

SM 15 & IG 38

8. UNTITLED 031

A fire that includes leaking flammable gas should always

A. extinguished as soon as we are able
B.✔ let burn and protect exposures
C. covered with foam
D. covered with earth

SM 16 & IG 41

9. UNTITLED 033

Gasoline and Diesel dispensers have

A.✔ thermal and shear valves to contain a leak if dislodged
B. spring valves to contain a leak if dislodged
C. flutter valves to contain a leak if dislodged
D. sputter valves to contain a leak if dislodged

SM 17 & IG 44

10. UNTITLED 038

Liquid Propane gas is transported in large quantities in New Hampshire. When released, it will form a gas that is

A. 40 times greater than the liquid volume
B. 120 times greater than the liquid volume
C.✔ 270 times greater than the liquid volume
D. 320 times greater than the liquid volume

SM 18 & IG 63

11. UNTITLED 040

If a pressurized tank truck has fire impinging on the tank and you notice an increasing higher, whistle type, sound from the tank, you should

A. be aware of a possible spill of product
B.✔ be aware of a possible BLEVE situation
C. be aware of a possible BEVEE situation
D. be aware that it means nothing

SM 19 & IG 50, 52

12. UNTITLED 043

The first step of our control process is

A. to rush in and save everyone
B. to call for more resources
C. to inform the utility operator
D.✔ to limit access to the effected area

SM 21 & IG 56

13. UNTITLED 044

We evaluate risks and hazards as step

A. one
B. two
C.✔ three
D. four

SM 21 & IG 58

14. UNTITLED 048

Portable foam eductors must be matched to

A. the nozzle
B. the hose size and length
C. the supply pressure
D.✔ All of the Above

SM 25 & 79

15. UNTITLED 050

Finished foam may be applied by

A. Seat of the Fire
B. Sweep
C. Bank down
D.✔ All of the Above

SM 26 & IG 87-89

You have completed the test!

Name: _____

Utility Emergencies Quiz 2

Form: 0

Version: 0

1. UNTITLED 005

Utility systems are dangerous because?

A. They cover large areas
B.✔ They transport large amounts of energy
C. They connect intrastate
D. They connect interstate

SM 3 & IG 9

2. UNTITLED 008

The typical home in the USA has voltages in the range of

A. 277 / 480
B. 120 / 208
C. 4,160 / 7,200
D.✔ 120 / 240

SM 5 & IG 14

3. UNTITLED 014

A downed power line that is arcing and stops indicates

A. it is safe to touch it
B. it must cool before you touch it
C.✔ it is never safe to touch it
D. a fuse has opened

SM 12 & IG 21

4. UNTITLED 017

If a power wire is on a vehicle you should have the operator

A. if they are able, move the vehicle away from the wire
B. do not touch the vehicle or the ground at the same time
C. as a last resort jump from the vehicle without touching it
D.✔ all of the above
E. None of the Above

SM 12 & IG 25

5. UNTITLED 020

Communications cables that are within an orange sleeve have the potential to

A. burn your hands if touched
B. spring back to the pole if moved
C. leak poisonous fluid if cut
D.✔ destroy your eyes if viewed from the cut ends

SM 8 & IG 28

6. UNTITLED 023
Sewage pipelines present the same challenges as for water pipelines but have the added danger of
A. having grater pressures
B. generally are smaller
C. always have pumps
D.✔ have health risks
SM 15 & IG 35

7. UNTITLED 027
The most common petroleum product in New Hampshire pipelines is
A. LNG
B. LPG
C.✔ Natural Gas
D. Gasoline
SM 15 & IG 39

8. UNTITLED 030
A large gas pipeline failure most likely involves
A. a fire in a small area
B. several small fires
C. several small explosions and no fire
D.✔ a fire that covers a large area
SM 16 & IG 39-40

9. UNTITLED 032
T✔ F Gasoline dispensers may have internal pumps or they may be in the product storage tank.
SM 17 & IG 44

10. UNTITLED 039
Transport and delivery trucks carrying fuels will have safety valve closure controls located
A. at the rear of the truck
B. at the curb side both front and back of the truck
C.✔ at the drivers side front and the curb side rear of the tank
D. at the front of the cab on the drivers side
SM 18 & IG 51

11. UNTITLED 041
If a pressurized tank truck has fire impinging on the tank, we must concentrate on
A.✔ cooling the entire tank with large amounts of water
B. extinguishing the fire with large amounts of foam
C. extinguishing the fire with foam washed down with water
D. extinguishing the fire with dry powder
SM 19 & IG 50, 63

12. UNTITLED 042

We use

A. a 4 step process to control utility incidents
B. a 7 step process to control utility incidents
C.✔ an 8 step process to control utility incidents
D. a 6 step process to control utility incidents

SM 21 & IG 55

13. UNTITLED 045

As we implement our plan of action, our most important task is to continuously

A. replace operating personnel
B. replenish air cylinders
C.✔ reevaluate our results and reassess risks
D. reevaluate our risks

SM 21 & IG 58

14. UNTITLED 047

To make finished foam we need which of the following

A. Aeration/Agitation
B. Foam concentrate
C. Water
D.✔ All of the Above

SM 24 & IG 73

15. UNTITLED 049

Using Class “A” foam concentrate in a 3% mix will

A.✔ produce dry sticky foam
B. produce wet foam
C. produce slippery foam
D. will waste foam concentrate

SM 23 & IG 70

You have completed the test!