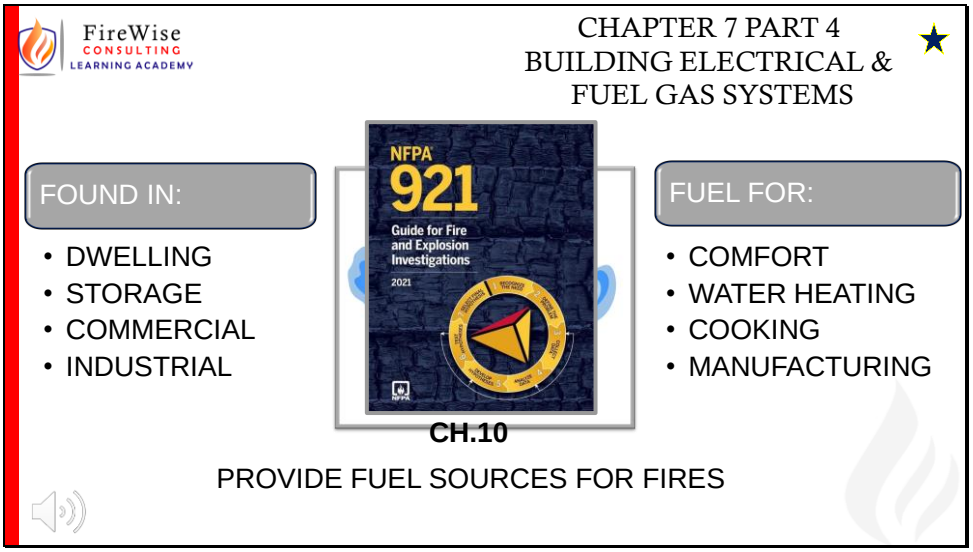
Slide 1



Welcome to **Part 4 of Chapter 7, Building Electrical & Fuel Gas Systems**. If you are following us in NFPA 921 we are covering Chapter 10.

Fuel gas systems are found in or near most dwelling, storage, commercial, or industrial use structures. These systems provide fuel for environmental comfort, water heating, cooking and manufacturing processes. They can also provide fuel sources for fires and explosions in structures.

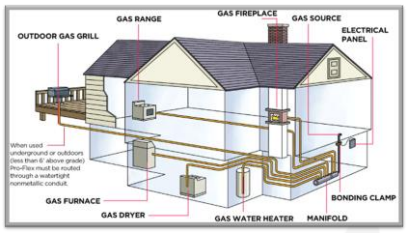
The fire investigator should have a basic understanding of fuel gases and the appliances and equipment that utilize them.

Slide 2

INTRODUCTION

IN THIS UNIT WE WILL EXPLAIN

THE IMPACT OF FUEL GASES
COMMON PIPING
CHARACTERISTICS
APPLIANCE & EQUIPMENT
REQUIREMENTS
COMMON **FUEL GAS SYSTEM**
COMPONENTS
UTILIZATION EQUIPMENT



In this unit we will:

- Explain the impact of fuel gases on fire and explosion investigations.
- Discuss fuel gas characteristics.
- Identify common fuel gas system components.
- Discuss common piping for fuel gas systems in buildings.
- Discuss common appliance and equipment requirements.
- Identify fuel gas utilization equipment.

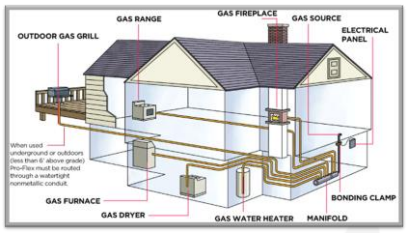
Slide 3

INTRODUCTION

IN THIS UNIT WE WILL EXPLAIN

HOW TO INVESTIGATE FUEL GAS SYSTEMS

CONDUCTING AN INVESTIGATION FOR FUEL GAS SYSTEMS



- Describe how to investigate fuel gas systems at a fire scene; and
- Describe how to conduct a fire and explosion investigation for fuel gas systems.

Slide 4

INTRODUCTION

PRESSURIZED GAS

ISOLATE & CAP

Photo courtesy NJ.com

Fuel gas systems are designed to retain moderately pressurized gas. The presence of leaks in the system can be determined by detecting a drop in pressure with-in the closed system. Before the piping is used for testing, the system must be inspected and any obviously damaged portions of the system should be isolated and capped.

Slide 5

FUEL SOURCES

ESCAPING FUEL GASES ARE **EASILY IGNITED**

FUGITIVE GASES

Fuel gases that escape from their piping, storage or utilization system can serve as easily ignited fuels for fires and explosions. The gases are commonly referred to as fugitive gases.

Slide 6

Ignition sources could include:

- Pilot lights and open flames from burners or appliances
- Static arcs
- Electrical arcs

Other competent Fuel Gas ignition sources could include:

- Arcs from switches or contacts in appliances
- Other electrical equipment
- Unknown sources outside of the building where the Fuel Gas may have migrated.

All potential ignition sources should be considered and confirmed that they would be competent.

Slide 7

During fire or explosion events, disrupted fuel gas systems can provide additional fuel and can greatly change or increase fire spread rates, or can spread fire to areas of the structure that would not normally be burned. The flames issuing from broken fuel gas lines, called flares, can spread fire and burn through the structure.

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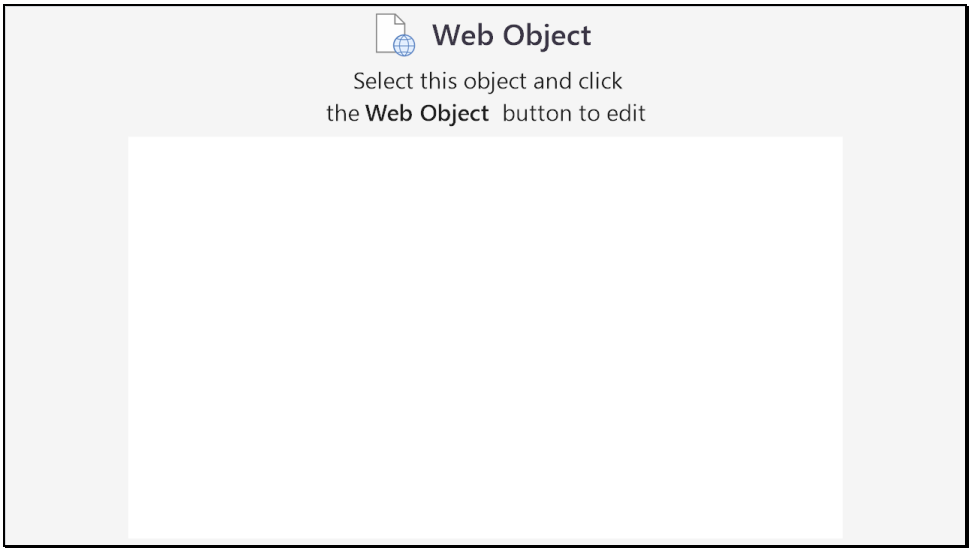
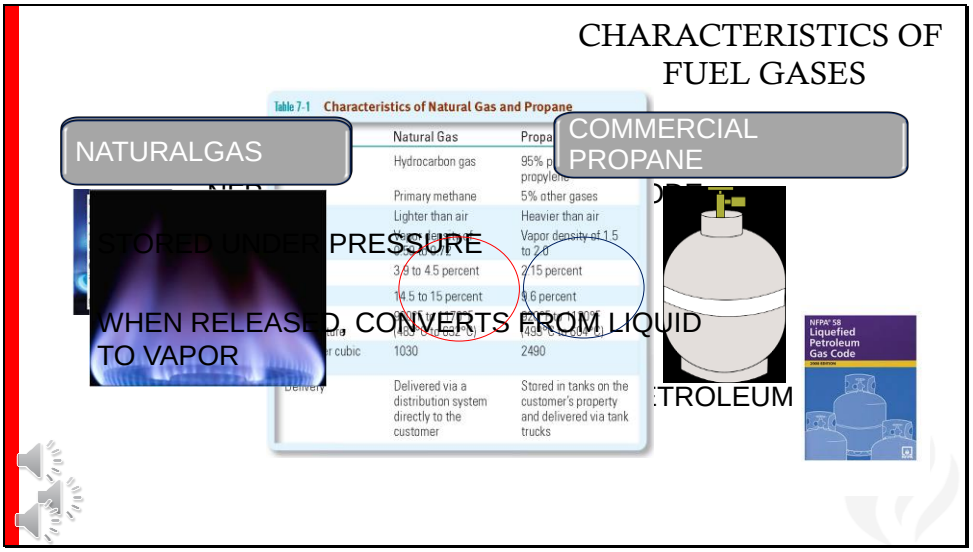


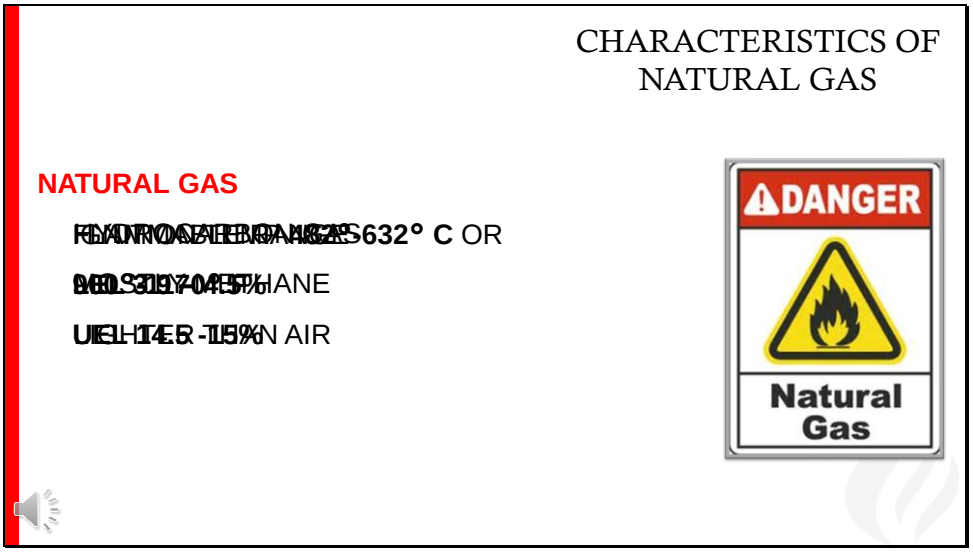
Dehaan Video #16

Slide 9



For more information on Fuel Gases, refer to NFPA 54, National **Fuel** Gas Code and NFPA 58, Liquefied Petroleum Gas Code.

Slide 10



Natural gas is a naturally occurring hydrocarbon gas product recovered by drilling wells into underground pockets, often in association with crude oil.
Natural gas is mostly methane, with lesser amounts of nitrogen, ethane, propane and traces of butane, hexane, carbon dioxide and oxygen.
It is lighter than air with a flammability range LEL (lower explosive limit) of 3.9 – 4.5% and an UEL (upper explosive limit) of 14.5 – 15%.
Its ignition temperature is 482 - 632° C or 900 – 1170° Fahrenheit.

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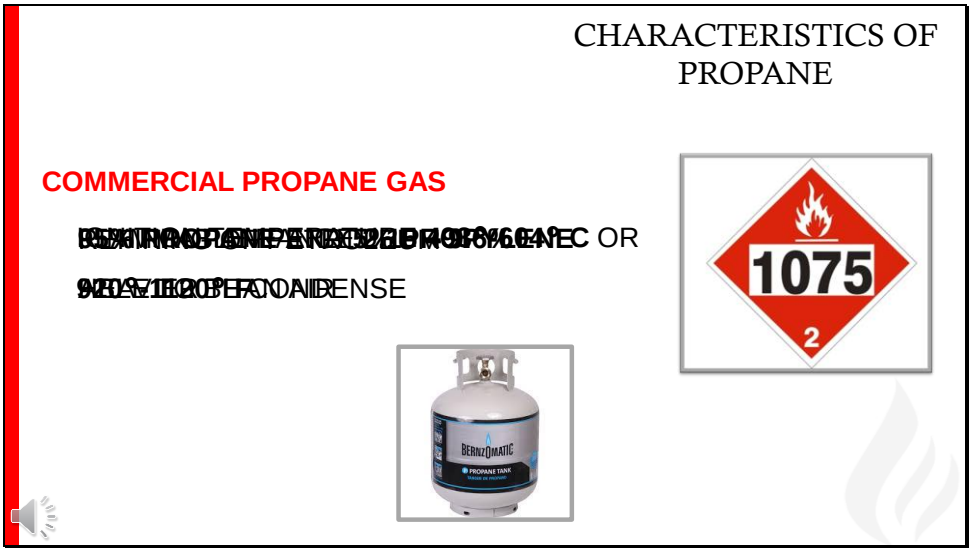

Commercial propane is derived from the refining of petroleum. Liquefied Petroleum gases or LP-Gases, can be liquefied under moderate pressure at normal temperatures. This ability to condense LP-Gases makes them more convenient to store and ship than natural gas making propane particularly suited for rural applications.
Propane is 95% propane and 5% propylene. Undiluted propane is 1.5 to 2 times heavier than air. Its lower explosive limit (LEL) is 2.15% and the upper explosive limit (UEL) is 9.6%.
The ignition temperature of propane is 493 – 604° C or 920 – 1120° Fahrenheit.

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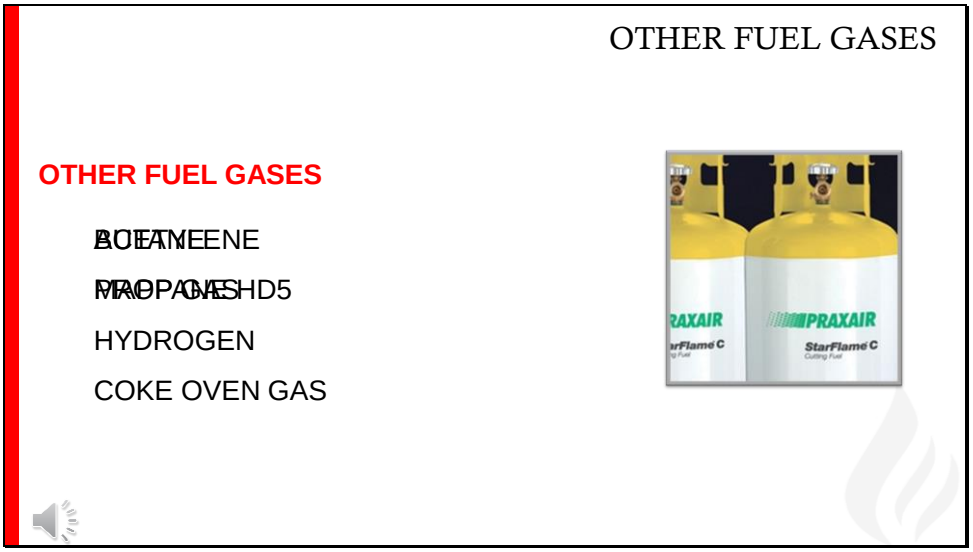
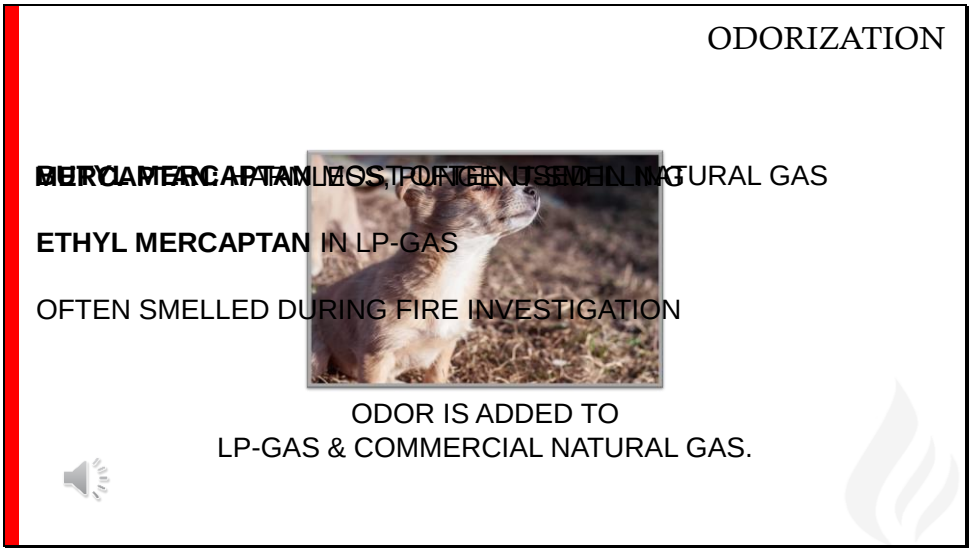


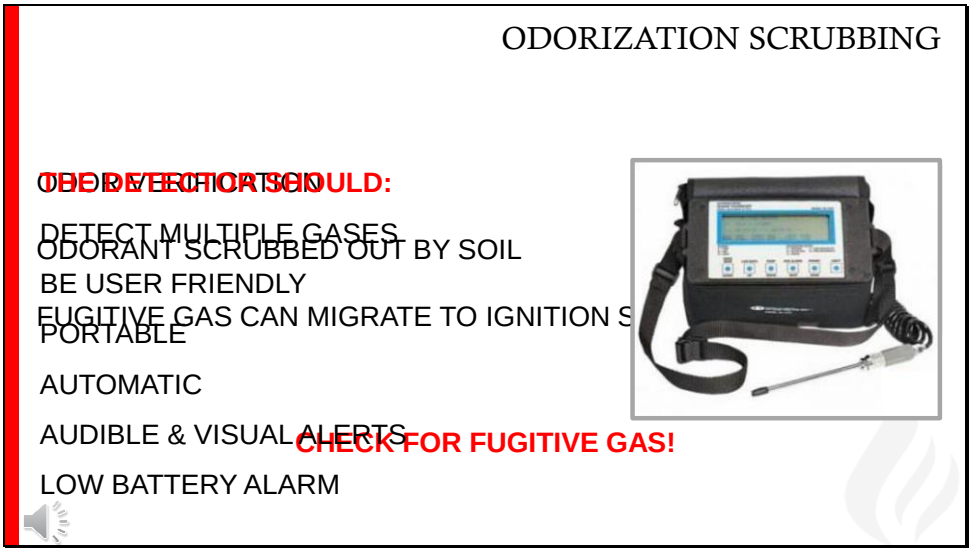
Other fuel gases that may be encountered by the fire investigator, particularly in commercial, industrial, or non-residential settings, include butane, propane HD5, and manufactured gases such as acetylene, Mapp gas, Hydrogen and coke oven gas.

Slide 13



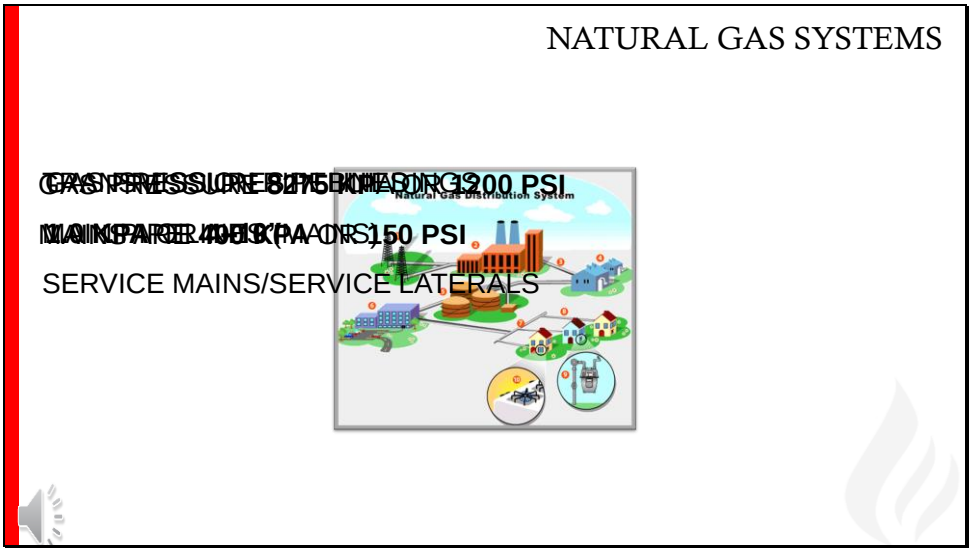
LP-Gas and commercial natural gas may not have a readily identifiable odor in their natural state. To increase the detectability of LP-Gas and Natural Gas, an odorant of blended mercaptan is added to the gases and this safety feature is required by law and is included in the fire code. Mercaptan is a harmless but pungent-smelling gas which is described as having the stench like rotting cabbages, rotten eggs or smelly socks.
Butyl mercaptan is most often used in natural gas. Ethyl mercaptan is added to LP-Gas. The mercaptan blend in these gases is easy to detect and is often smelled during fire investigations when the building or structure has a natural or LP-Gas fuel supply.

Slide 14



Odorant verification should be part of any fire or explosion investigation involving or potentially involving fuel gas if it appears that there were no indications of a leaking gas being detected by people present.
Explosions and fires have been caused by leaks in gas supply lines where no gas was detected by people present due to the odorant being scrubbed from the gas by the soil around the supply or distribution lines. In these particular events, the fugitive gas migrated into other pipes and voids until it found a suitable ignition source resulting in catastrophic explosions and fires.
Even after a fire as been extinguished, the investigator must ensure no fugitive gas is present. The best way to do that is with proper detection equipment which the investigator must be trained to competently use. The detector should detect multiple gases, be user friendly, portable, automatic,
have audible and visual alerts and a low battery alarm.

Slide 15

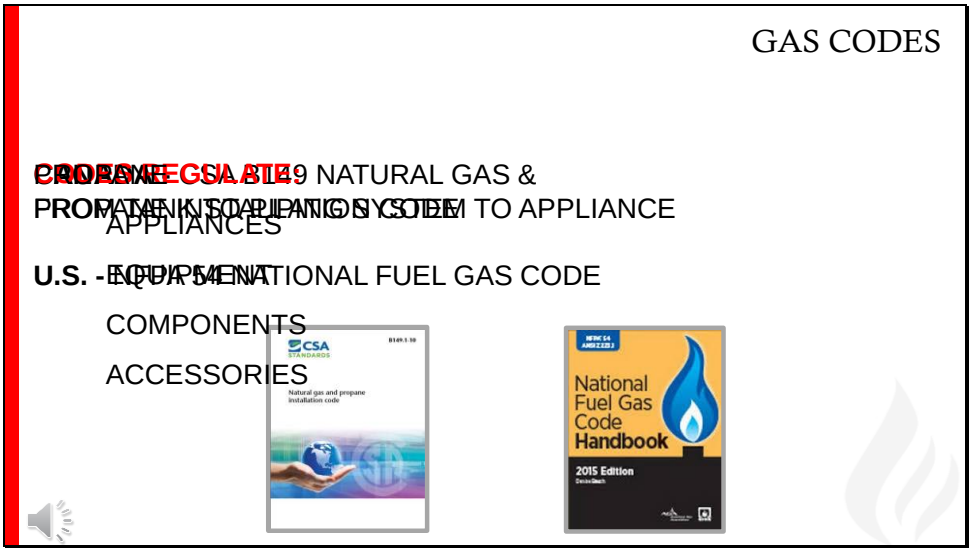


Natural gas systems are transmitted to customers' buildings from centralized production and storage facilities through:

- Transmission pipelines
- Main pipelines or mains
- Service mains or service laterals

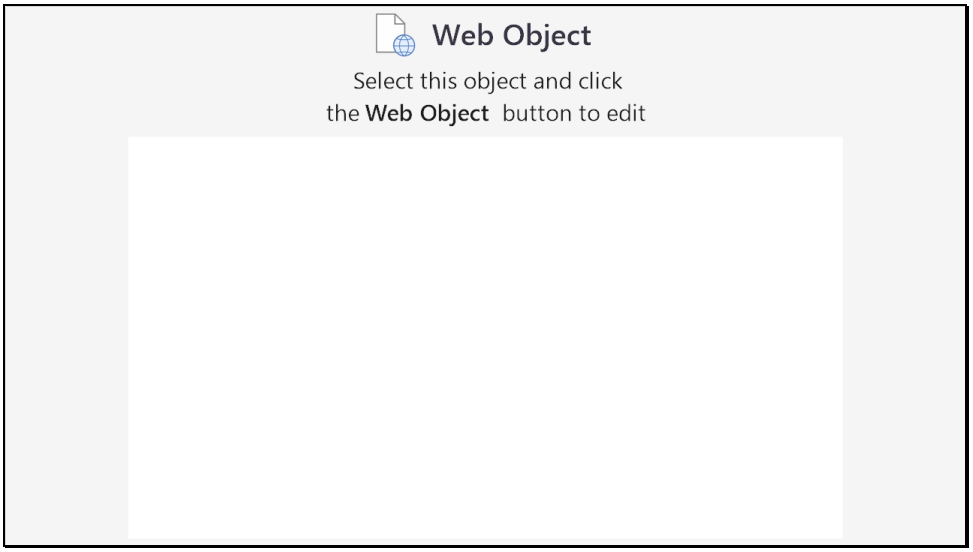
The distribution and piping systems that deliver natural gas to the customer are complex, with many intervening procedures and pressure changes from collection to ultimate use. Gas pressures in transmission pipes can be as high as 8275 kpa or 1200 psi. Main pipelines or mains, are reduced to 400 kpa or 150 psi. Gas line pressures in a building are generally in the range of 1.0 kpa or 4 inches to 10 inches in water column after passing through the gas meter and pressure regulator.

Slide 16



There are several different codes that regulate gas and propane depending on the jurisdiction. For example most Canadian jurisdictions use the CSA - B149.1, Natural Gas and Propane Installation Code while many jurisdictions in the US use the NFPA 54, National Fuel Gas Code. These codes normally regulate gas fired appliances, equipment, components, and accessories from the meter through the piping system and onward to the appliance. In the case of propane, regulations normally apply from the propane tank through the piping system to the appliance.

Slide 17



Dehaan video # 14

Slide 18

LP-Gas supply is often located at the consumer's site in tanks or cylinders.
Alternatively, the gas may be in bulk storage locations offsite and piped underground, similar to natural gas systems.
Tanks are larger than cylinders. Cargo tanks are permanently mounted on a chassis and are used for transporting LP-Gas. Portable tanks are used for transporting LP-Gas but are not mounted on a chassis with capacities in excess of 450 kg, 1000 lb water capacity or 100 imperial gallons.
Cargo and portable tanks are subject to DOT and ASME regulations typically designed with the working pressure of 1700 kpa or 250 psi.
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Slide 19

Cylinders are upright and tend to be smaller than tanks. They must conform to DOT requirements 49 CFR and CFR 178. Cylinders are refillable, however, cylinders below one pound capacity are non-refillable.

Cylinders are most frequently used in rural homes and businesses, mobile homes, recreational vehicles, and for outdoor barbeques and for motor fuel.

Container appurtenances are items connected to container openings. These items include, but are not limited to:

- Pressure relief valves
- Connections for flow control
- Liquid level gauging devices
- Pressure gauges
- Pressure regulators
- Vaporizers

Refer to NFPA 921 for more detailed information on each of the appurtenances found in propane systems.

Slide 20

LP-GAS SYSTEMS

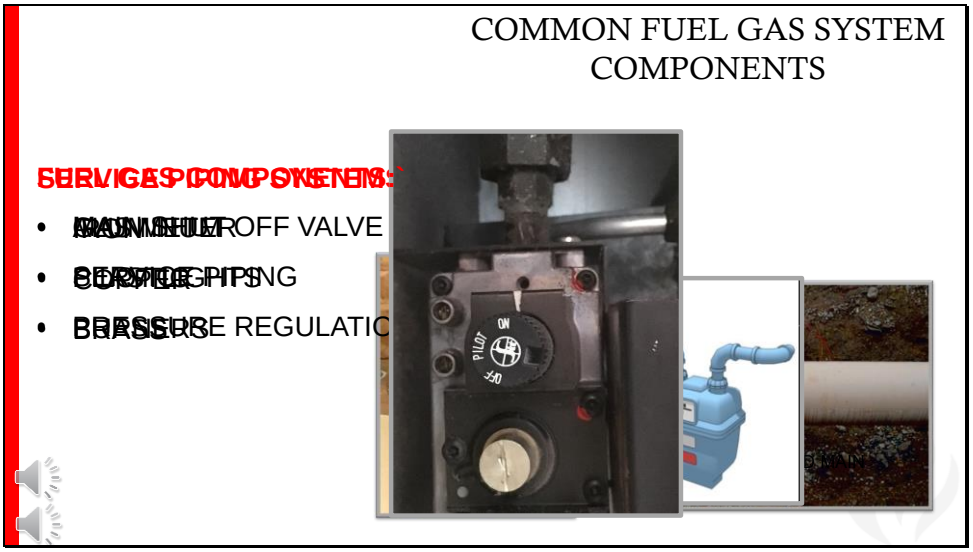
VAPORIZER IS USED TO CONVERT LIQUID PROPANE TO GAS

VAPORIZES AT **-42°C** OR **-44° F**

270 TIMES BY VOLUME

A vaporizer is used to warm the liquefied propane converting it to a vapor gas when there is a demand for large quantities of the vaporized gas. Remember, propane starts to vaporize at -42°C or -44° F and expands at 270 times by volume.

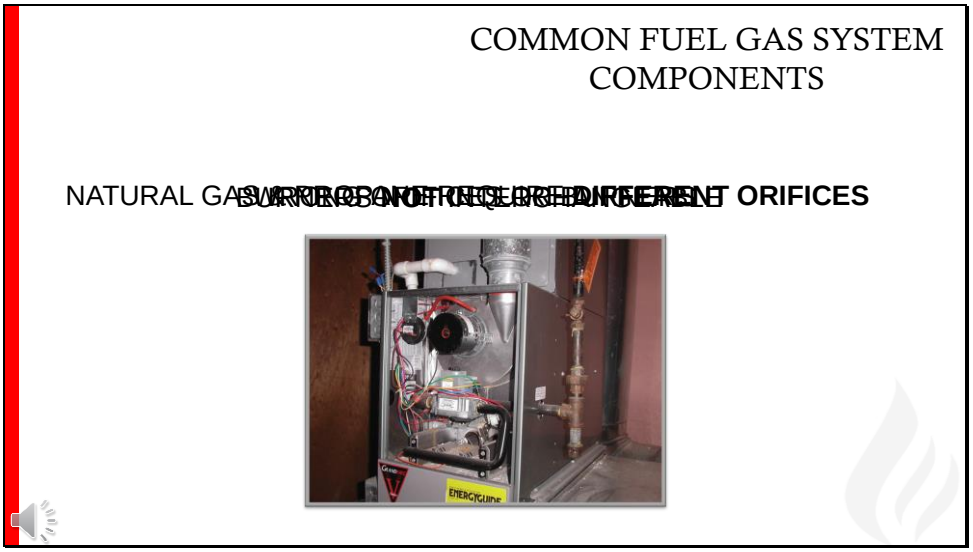
Slide 21



Common fuel gas system components start with the piping systems. They may be made from; Iron, copper, brass, aluminum alloy or plastic - as long as the piping material used with the gases, is not corrosive to them.
Unapproved tubing or piping materials in “not-to-code”, homemade applications may lead to leaks and the release of fugitive gas.

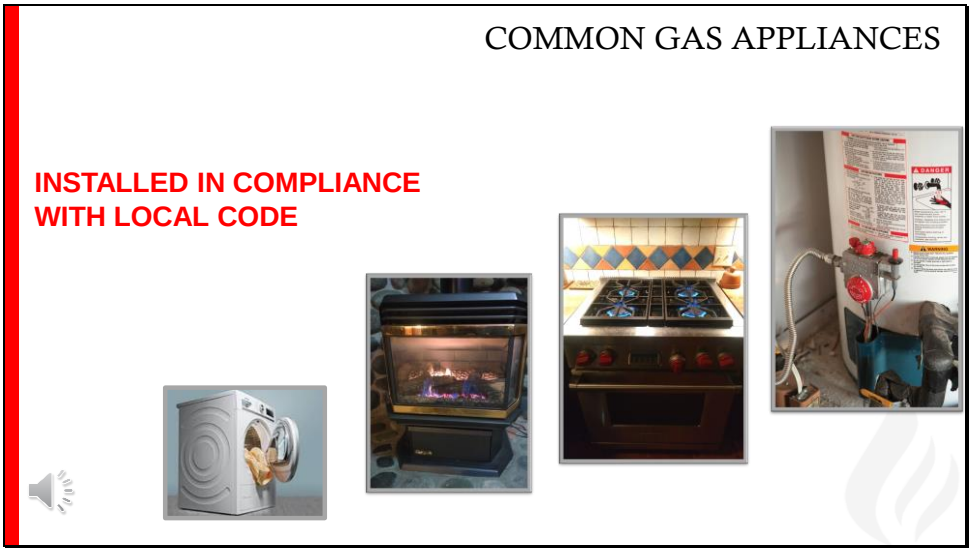
Other common fuel gas components include; the main shut off valve in place to shut off fuel gas to the system inside the building.
From the meter and shut off valve is the service piping, pressure regulation, gas meter, pilot lights and burners.
There are a variety of pilot lights including manual ignition, pilot burner flame and pilotless igniters which produce a small arc or use a heating element or glow plug to ignite the burner in an appliance.

Slide 22



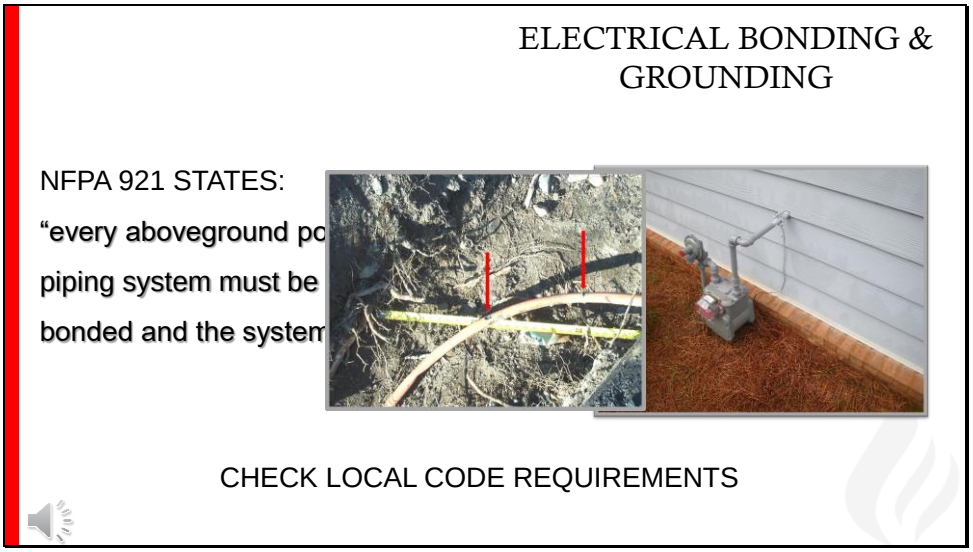
Problems with fuel gas systems, including fires, are often caused by the use of inappropriate orifices or burners for natural gas or propane. Gas burners are devices for the final conveyance of the fuel gas, or a mixture of gas and air to be burned. Although the several types of burners in common use are essentially the same in general design for both natural gas or propane, they may not be interchangeable from one gas usage to another. Physical differences between natural gas and propane require different-sized burner orifices.

Slide 23



Other common fuel system appliances are water heaters, cooking stoves, fireplaces and clothes dryers. Each will have some type of ignition system and a gas control valve.
Approved appliances, accessories and equipment must meet gas code requirements.
Each appliance must be used with the type of gas for which it was designed and installed according to local code requirements.

Slide 24



Electrical Bonding and grounding is a local code issue. Some jurisdictions insist on it while others prohibit it.

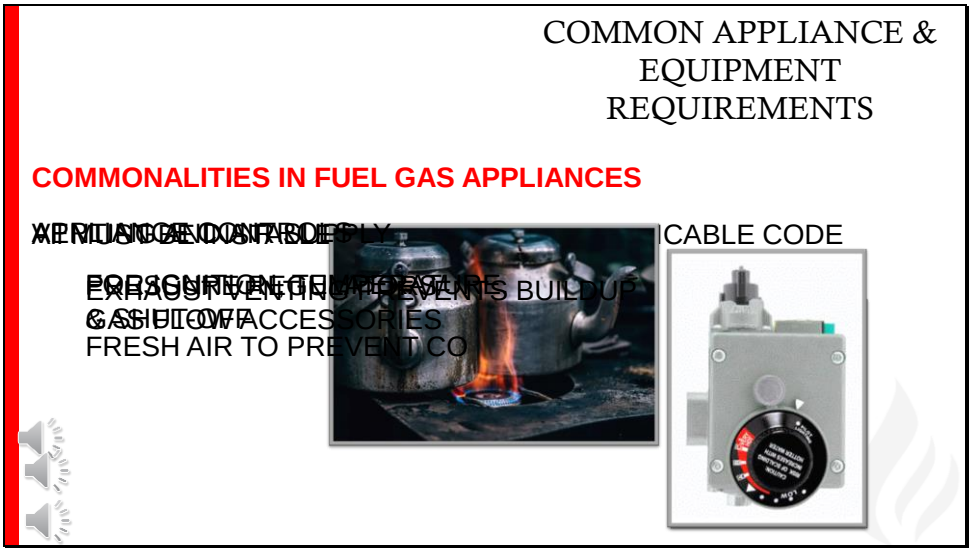
NFPA 921 states: “Every aboveground portion of the piping system must be electrically bonded and the system grounded”.

One of the reasons for this is to ensure arcs do not occur if lightning strikes the ground and the charge is conducted through the system. Lighting has been known to cause leaks in underground plastic pipe which was not grounded or the grounding wire was not installed properly.

This photograph shows a piece of plastic natural gas line that was damaged during a lightning storm. The plastic pipe had a copper trace wire taped to the gas line so it could be detected. At each location where the trace wire was taped to the plastic gas line electricity burned a whole through the gas line. The result was an explosion in a house and two people were killed. The odorant was probably scrubbed out as the gas migrated through the soil.

When doing your investigation, check your local code to determine the local requirements.

Slide 25

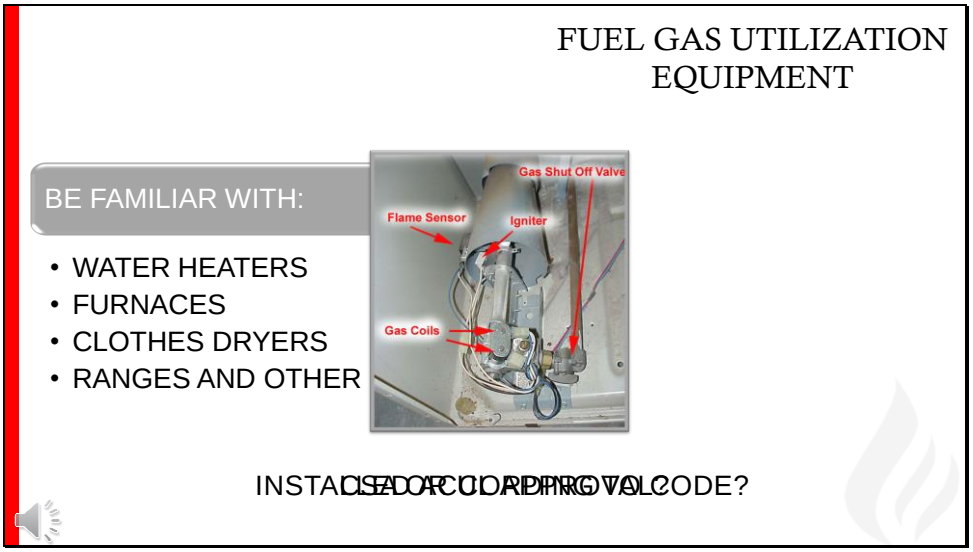


There are several considerations or requirements for the installation and use of fuel gas appliances that are common, no matter which fuel gases are used in the appliances
All fuel gas appliances must be installed and comply with local codes such as NFPA 54, National Fuel Gas Code.

Other common appliance and equipment requirements include venting and air supply. Exhaust venting prevents buildup of combustion products and evacuates heat and exhaust gases from the burner to the outside.
Fresh or combustion air from outside is often necessary to prevent buildup of carbon monoxide inside the building.

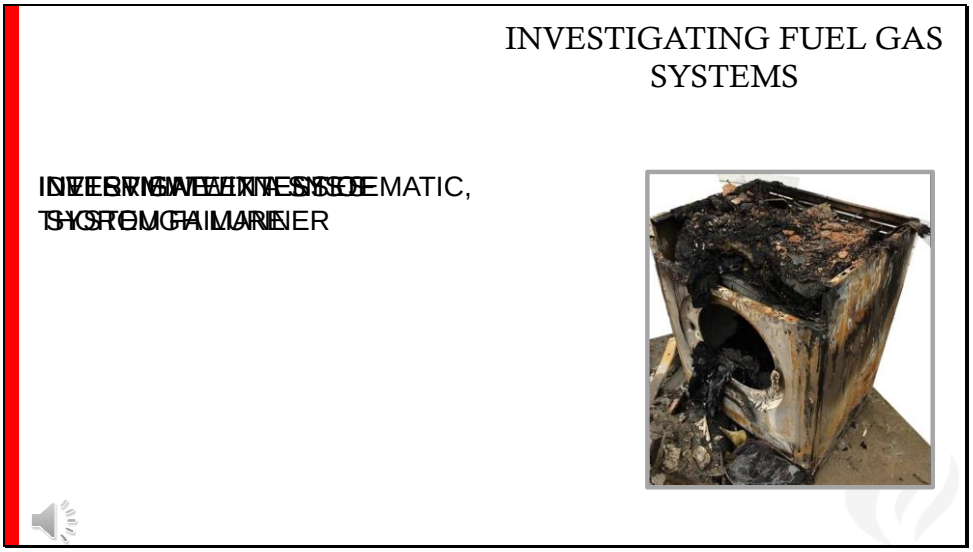
Appliance controls are required for ignition, to regulate temperature and to shut-off the appliance. Some gas appliances may require pressure regulators or gas flow accessories.

Slide 26



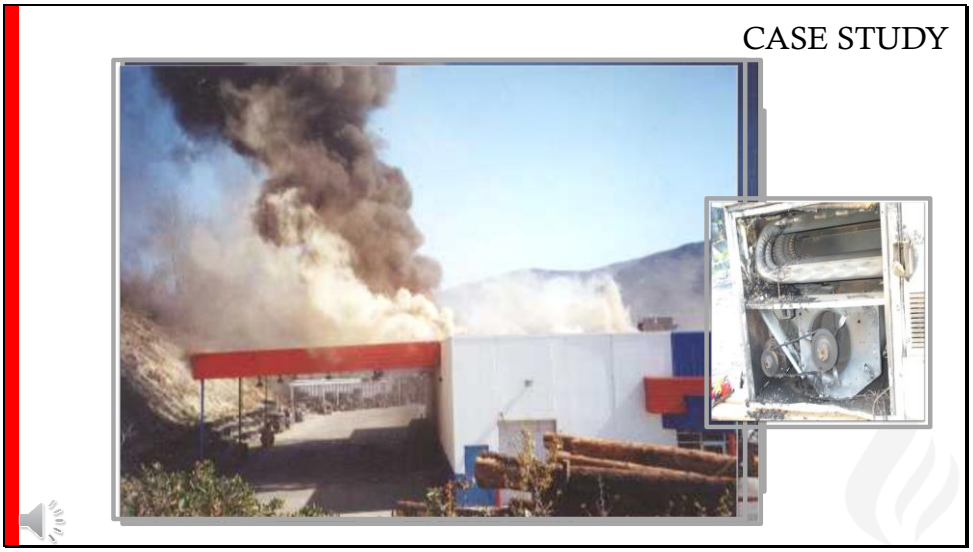
A fire investigator should be familiar with the design and operation of water heaters, furnaces, clothes dryers, ranges and any other gas fired appliance. Expert advice may need to be sought for complicated equipment that a fire investigator may not have intricate knowledge about or of if it was working properly at the time of the fire. Did the equipment have CSA or UL approvals and was it installed according to code? Any deviations from the codes or standards discovered in your investigation should be noted.

Slide 27



Investigating fuel gas systems requires some planning and should be done in a systematic, thorough manner. If a gas appliance or part of a fuel gas system is believed to be at fault, the investigator must determine whether and to what extent. Interviews with witnesses should touch on fuel gas systems as part of the investigation process.

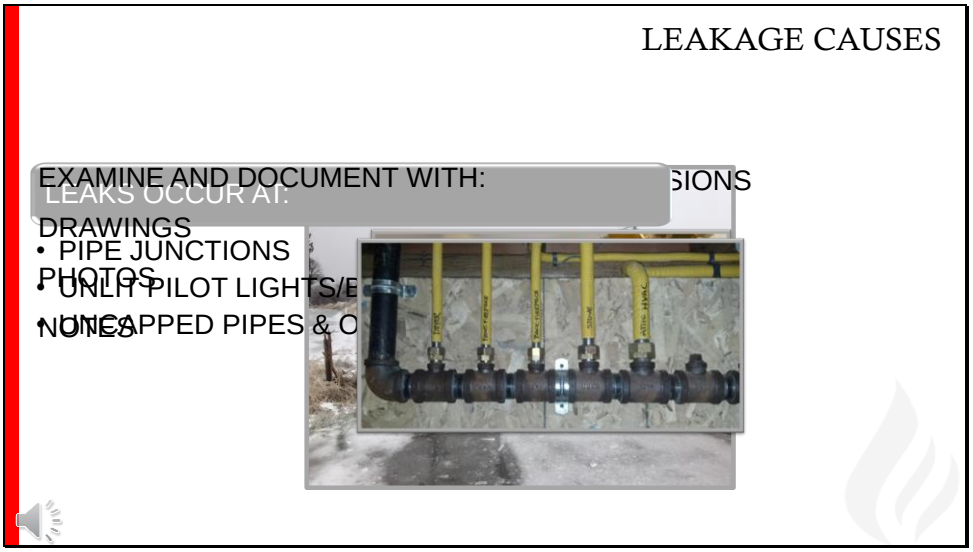
Slide 28



In this case a fire occurred at a tire shop around 10:00 hours on a warm spring day. The fire was discovered by one of the technicians when he drove a vehicle out from under the canopy at the rear of the shop and saw the fire on the roof. When the fire investigator interviewed witnesses he was told that the fire started on the roof of the building and spread to the inside of the structure. He was also told that there was an HVAC system on the roof that was serviced a couple of days prior to the fire.

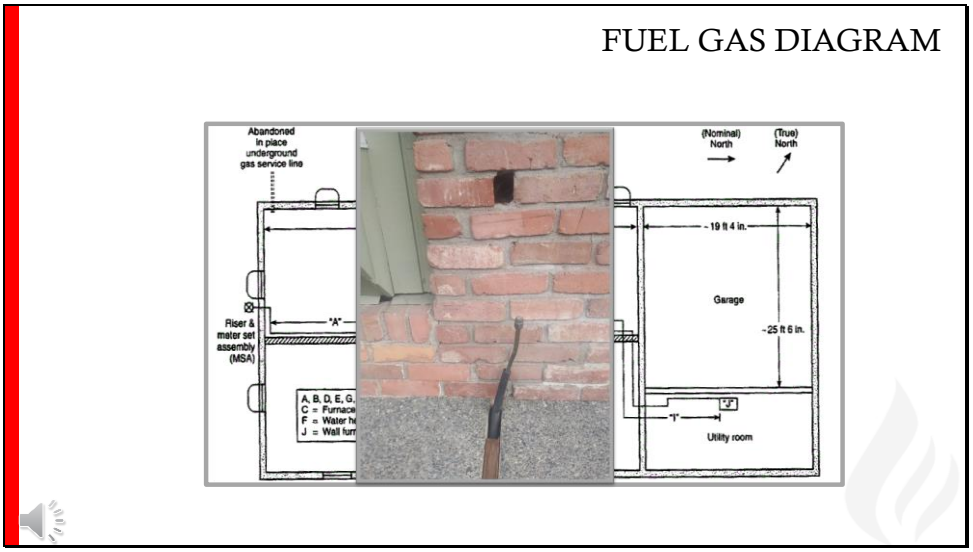
The witnesses were convinced that the fire started in the HVAC unit. On examination, the investigator determined that the HVAC system was comprised of an electric air conditioner and a natural gas fired forced air heater. Often when a fire starts in a forced air heating unit the fan motor and/or fan would be seized and the belt drive would be burned completely. In this case the fan turned freely and the belt drive was still intact. In addition, it was a warm day and the furnace was turned off. Further investigation revealed that a new air compressor had been installed in a room on the mezzanine floor directly below the HVAC system about a week prior to the fire. After a thorough investigation the fire was determined to be accidental resulting from a mechanical failure of the air compressor. It is important for the fire investigator to keep an open mind when conducting their investigation. It is easy to jump to conclusions based on information provided by witnesses but the conclusion must be supported by physical evidence which in this case did not support the witness information.

Slide 29



Leakage from piping and equipment is the main cause of gas-fueled fires and explosions. Commonly, leaks occur at pipe junctions, at unlit pilot lights or burners, and at uncapped pipes and outlets. Leaks can be caused by corrosion and by physical damage to a gas line. Electrical energy from downed powerlines or lightning strikes can damage metal or non-metallic gas lines. Piping joints and connections are the most common locations for leaks. Improper connections between piping elements and appliance controls such as improper threads, not enough threads, or too much or not enough joint compound can cause leaks. Each connection in the entire system should be thoroughly examined and documented using drawings, photographs and notes.

Slide 30



As part of your investigation, a fuel gas system diagram should be created showing all elements of the system including old fuel gas lines no longer in service. The location of each appliance, valve, vent, cap or other system element should be included in the diagram. Each component of the fuel gas system should be examined and evaluated to determine whether, and to what extent, it operated or failed, and to what extent it contributed to the fire or explosion.

Slide 31

PRESSURE TESTING

LEAKS CAN BE DETERMINED BY A DROP IN PRESSURE

IF NO LEAK DETECTED

INSPECT, ISOLATE & CAP

REPEAT WITH A DOWNSTREAM BURNER OPEN & INGITED

Fuel gas systems are designed to retain moderately pressurized gas. The presence of leaks in the system can be determined by detecting a drop in pressure within the closed system. Before the piping is used for testing, the system must be inspected and any obviously damaged portions of the system should be isolated and capped. Sometimes it may be necessary to test the piping in multiple sections due to physical damage to the system.

This testing should be done by a qualified gas fitter or gas inspector.

If it is decided it is safe to use the actual fuel gas of the system, the gas meter itself can be used to detect a flow of gas. After first checking that the meter is working properly and has not been damaged by the explosion or fire, or has not been bypassed, gas may be reintroduced into the system through the meter, and the dials observed to determine if gas is escaping somewhere downstream. NFPA 54 recommends that if no leak is detected by observing the meter dials, the test should be repeated with a downstream burner open and ignited to ensure the meter is working properly.

Slide 32

LOCATING LEAKS

LEAKS CAN BE DETECTED BY SOAP BUBBLE TEST

AFTER TESTING, RINSE WITH WATER

Leaks at pipe junctions, fittings, and appliance connections can be detected by applying soap bubble solutions to the suspected leaking area. If the system is pressurized, the production of bubbles in the solution will disclose the leak.

After testing, the area should be rinsed with water to prevent possible corrosion or stress cracking.

Slide 33

TESTING FLOW RATES & PRESSURES

REGULATORS SHOULD BE TESTED

TESTING IN THE FIELD OR AT A LAB

BY QUALIFIED PERSONNEL

If regulators or other gas appliance and service components have not been severely damaged by fire, they can be tested to see if they are functioning correctly. These tests can be done in the field or in a laboratory. The tests should only be done by qualified, trained personnel.

Slide 34

LEAK TESTING

This is an example of an explosion and fire where the piping system was suspected of leaking resulting in an explosion. As can be seen in these photographs, the roof of the mobile home has been lifted and the rear panel of the unit has been blown out. The authority having jurisdiction for gas safety did not have an inspector available to participate in the investigation so the fire investigator used a technician from the utility company that supplied the gas to conduct a system leak test. No leaks were detected and the source of the gas and cause of this explosion/fire was undetermined.

It can be argued that this is like sending the fox to guard the hen house. The inference could be drawn that the technician from the utility company had a vested interest in the outcome of the investigation and therefore should not have participated. In hindsight, an independent expert should have been used for testing the system to avoid the potential conflict of interest or the investigator should have insisted on, and waited for, an inspector from the regulatory authority to be available.

If there is a perception of a possible conflict of interest any findings of the investigator will likely be negated.

Slide 35

TESTING FLOW RATES & PRESSURES

TEST FOR THE TYPE GAS
THEY WERE DESIGNED FOR

Testing flow rates and pressures of gas system components must be done for the type of fuel gas for which they were designed.

Slide 36

Dehaan Video #13 Dr. DeHaan: Combustible Gas Detector

Slide 37

UNIT REVIEW

NATURAL GAS OR LP-GAS IN VAPOR FORM ONLY

NG SYSTEMS SUPPLIED VIA UNDERGROUND MAINS

LP-GAS IS SUPPLIED BY A CONSUMER TANK

In this unit we saw:

Fuel gas systems will likely be either natural gas or lp-gas in vapor form only

Natural gas systems are generally supplied via underground mains

Lp-gas is usually supplied by a consumer tank located on the site

Slide 38

UNIT REVIEW

FUGITIVE GASES

ESCAPED

CAN EASILY BE IGNITED

Fuel gases that escape from their piping, storage or utilization systems are referred to as fugitive gases. Fugitive gases can serve as easily ignited fuels for fires and explosions.

Slide 39

UNIT REVIEW

BOTH GASES SUPPLY FUEL TO APPLIANCES

MERCAPTAN IS ADDED AS AN ODORANT

Both types of fuel gases will supply fuel to various appliances that may heat water and the environment and be used for cooking or various other services.

Mercaptan is added as an odorant to fuel gases

Slide 40

UNIT REVIEW

ODORANT CAN BE SCRUBBED OUT

DAMAGED GAS SYSTEMS – ALLOW GASES TO ESCAPE

Fuel gases escaping underground can have the odorant scrubbed as the gas migrates through the soil.

Fuel gas systems are often damaged as a result of other activities occurring in the structure, allowing fuel gas to escape from the system.

Slide 41

UNIT REVIEW

TESTS BY TRAINED LABORATORY TECHNICIANS

TEST FOR THE FUEL TYPE DESIGNED FOR

Fuel gas system tests should be conducted by trained laboratory technicians

Fuel gas system tests should be conducted using the specific characteristics of the fuel for which they were designed.

Slide 42

END OF CHAPTER 7 PART 4

CONTACT
TRAINING@FIREWISECONSULTING.COM

That's the end of **Part 4 of Chapter 7, Building Electrical & Fuel Gas Systems**. You are now ready to move on to Chapter **8** which deals with **Examining the Fire Scene**, but please complete the quiz for Chapter **7 Part 4** first.

If you have any questions now is a good time to contact your teacher.