Leak Detection in Natural Gas and Propane Commercial Motor Vehicles Course

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Federal Motor Carrier Safety Administration

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1. Leak Detection in Natural Gas and Propane Commercial Motor Vehicles Course

Sponsored by the Federal Motor Carrier Safety Administration Technology Division in partnership with the Commercial Vehicle Safety Alliance.

1.1 Introduction and Overview

1.2 Welcome

Welcome to the Leak Detection in Natural Gas and Propane Commercial Motor Vehicles Course. This training course is designed for commercial motor vehicle (CMV) inspectors to learn how to detect fuel leaks from vehicles powered by compressed natural gas (CNG), liquefied natural gas (LNG), and liquefied petroleum gas (LPG), also known as propane.

The fuel system is one of the 14 safety-critical systems of a CMV, and a defect in a safety-critical system is grounds for placing the vehicle out-of-service. Thus, just as the North American Standard (NAS) Inspection Procedures specifically identify a leaking diesel fuel system on a conventional CMV as grounds for placing that vehicle out-of-service during roadside inspections, leaking fuel from a natural gas or propane CMV should be grounds for placing a vehicle out-of-service.

This course is two hours in length and is comprised of two modules with content, graphic displays, and a video demonstration of selected detectors. There will be knowledge checks throughout the training.

1.3 Course Goal

Safety inspectors must understand the unique characteristics of natural gas (or propane) used as a fuel, and must be able to improve the overall safety of CMV operations by ensuring that CMVs powered by natural gas (or propane) meet appropriate safety criteria at all times while on public roads.

1.4 Training Outcomes

Safety inspectors must be able to:

- Improve the overall safety of CMV operations by ensuring that CMVs powered by natural gas or liquefied petroleum gas (LPG/propane) meet appropriate safety criteria at all times while operating on public roads.
- Identify the unique physical and chemical properties of natural gas and LPG, how these differ from the physical and chemical properties of diesel fuel, and the implications for detecting fuel leaks from CMVs powered by natural gas or LPG.
- Identify CMVs that are fueled by natural gas or LPG during an inspection.
- Determine during inspection of a CMV, using a hand held combustible gas detector, when a natural gas or LPG fuel system leak exists.
- Determine if a CMV should be placed out-of-service based on whether there is a leak in the natural gas or LPG fuel system of the CMV.

1.5 Training Outcomes (Continued)

Safety inspectors must be able to:

- Identify and be familiar with the Federal Motor Carrier Safety Regulation (FMCSR) sections that highlight regulations that are relevant to attributes of natural gas or LPG-powered vehicles. (49 CFR Part 393, Subpart E, as well as Inspection, Repair, and Maintenance requirements contained in 49 CFR Part 396, and minimum inspection standards and out-of-service criteria contained in 49 CFR Chapter III, Subchapter B, Appendix G).
- Identify and be familiar with the fuel system requirements in 49 CFR 393.65.
- Identify and be familiar with Inspection, Repair, and Maintenance Requirements contained in 49 CFR 396.
- Identify and be familiar with NAS Inspection Standards and out-of-service criteria contained in 49 CFR Chapter III, Subchapter B, Appendix G.

1.6 Course Objectives

After taking this course, CMV inspectors will be able to:

- Recognize when a CMV is fueled by CNG, LNG, or LPG.
- Identify the major components of a CNG, LNG, or LPG fuel system and their location on a CMV.
- Identify the physical and chemical properties of natural gas and LPG, how they differ from the properties of diesel fuel, and their implications for detecting fuel leaks from CMVs.
- Recognize how to use a combustible gas detector to search for leaks in a CNG, LNG, or LPG fuel system installed on a CMV.
- Identify the out-of-service criteria for CNG, LNG, or LPG fueled CMVs.

1.7 Course Topic Areas

- Identifying CMVs that use CNG, LNG, or LPG as a fuel.
- Physical and chemical properties of CNG, LNG, and LPG, and implications for detecting leaks.
- Description of the major components of a CNG, LNG, or LPG fuel system and the most likely locations for fuel leaks in these systems.
- Demonstration of how to conduct a leak check of a CNG, LNG, or LPG fuel system on a CMV using a combustible gas detector, and how to interpret the results.

1.8 Course Overview

This course will reinforce the perception that CNG, LNG, and LPG vehicles are safe if properly maintained, including taking prompt action to identify and correct any fuel system leaks.

Group of three pictures: Image 1 is a CNG fueling station; Image 2 is a public transportation bus; Image 3 is a refuse hauler. Caption says: Select each image to see more information. When user clicks each picture, the corresponding additional information comes up.

Image 1: While CNG, LNG, and LPG vehicles currently comprise a small percentage of the commercial motor vehicle fleet, they have been in continuous use in the U.S. for more than 20 years, with a concentration in specific vocational uses such as transit buses and refuse haulers.

Image 2: In recent years, the advent of hydraulic fracturing and horizontal drilling has significantly increased the pace of U.S. natural gas development, with a consequent reduction in the cost of both natural gas and LPG. This has resulted in significant interest in natural gas and LPG as a transportation fuel, and in recent years sales of CNG, LNG, and LPG trucks have increased. In addition to being used as transportation fuels, both natural gas and LPG are also used extensively in the northern states for residential heating.

Image 3: Most commercial vehicle inspectors should have a general awareness of natural gas and LPG properties and safety considerations based on personal use of natural gas or LPG in their homes, or from hazardous materials training, which addresses safety issues related to bulk delivery of LPG and LNG fuel. If designed and maintained properly, CNG, LNG, and LPG vehicles are as safe as gasoline and diesel vehicles.

1.9 Module One: Overview of CNG, LNG, and LPG Fuel Properties and Commercial Motor Vehicle Fuel Systems

1.10 Module One Topics

- NAS Commercial Motor Vehicle (CMV) Inspections.
- Identifying CNG, LNG, and LPG-Powered Vehicles.
- Properties of CNG, LNG, and LPG.
- Summary of Fuel Properties and Leak Characteristics.
- Overview of CNG, LNG, and LPG Fuel Systems.
- Detecting CNG, LNG, and LPG Fuel Leaks.
- What to do if a Vehicle Has a Suspected Fuel Leak.

1.11 North American Standard (NAS) Commercial Motor Vehicle Inspections (Title Slide)

1.12 NAS CMV Inspections

- This training is intended to show you how to conduct a leak test using a combustible gas detector so that you can determine whether a CNG, LNG, or LPG vehicle should be declared out-of-service for a fuel leak.
- NAS out-of-service criteria for natural gas vehicles include any "fuel leak verified by a bubble test or combustible gas detector."

1.13 NAS Inspection Procedures

Graphic of the NAS Inspection Procedures: an aerial view of a commercial motor vehicle with locations of inspections, a list of inspections at each location and procedures and expansions of steps 16 (inspect the left saddle tank area) and 26 (inspect the right saddle tank area).

Group of graphics depicting the NAS inspection process: Locations on the vehicle for carrying out the inspections (15 through 37) on an aerial view of a commercial motor vehicle; list of inspections at each location (15 through 37) and two expansions of Step 16 (Inspect the left Saddle Tank area) and Step 26 (Inspect the right Saddle Tank area).

1.14 Knowledge Check

This slide shows images of a TPI-725 handheld combustible leak detector, a blow torch, bubble test solution, and an electric multi-tester. The following question appears at the top of the slide: NAS out-of-service criteria for natural gas vehicles include which of the following tools for detecting leaks? Rollover each image to check your response, or if visually impaired, move on to slide 1.15.

1.15 Knowledge Check: Which Options Can Be Used to Effectively Test for Natural Gas and Propane Leaks?

Which options can be used to effectively test for natural gas and propane leaks? (More than one answer can be correct).

1. Electrical Multi-Tester
2. Bubble-Test Solution
3. Combustible Gas Detector
4. Blow Torch

Answer: The correct response is Number 2 (Bubble Test) and Number 3 (Combustible Gas Detector). Number 4, blow torch, is incorrect. Never use a flame to detect a gas leak.

1.16 Identifying a Vehicle with a CNG, LNG, or LPG Fuel System (Title Slide)

1.17 Types of Commercial Motor Vehicles

- Many types of CMVs can use CNG, LNG, or LPG fuel systems.
- Larger vehicles (Class 6 to 8) will typically use CNG or LNG, while smaller vehicles (Class 3 to 5) could use CNG or LPG.
- It is not always obvious that a vehicle includes a CNG, LNG, or LPG fuel system - they often look similar or identical to diesel or gasoline vehicles.

Images of a variety of CMVs are displayed on the slide. Images include:

1. A white shuttle bus with red and blue stripes.
2. A yellow checkered mini-van taxi.
3. A blue king-cap pickup truck with "PROPANE" written on the side in large black letters. Grass and clouds painted on the side of the truck, with the blue as sky.
4. Bakery products delivery van.
5. Large green refuse hauler, with "Think Green, Think Clean" on the side of the truck in large light-green letters.
6. LNG-powered tractor with large "LNG" letters on cab door, and visible LNG tank immediately behind the cab.

1.18 Identify a CNG, LNG, or LPG Vehicle

- To identify a CNG or LNG vehicle look for a blue diamond label with the white letters: “CNG” or “LNG”.

- To identify a LPG vehicle, look for a black diamond label with the word “PROPANE” in silver or white.
- Use of these labels is NOT currently required by FMCSA, but is an industry best practice followed by most manufacturers.

Images of the CNG, LNG, and PROPANE diamond-shaped labels are displayed on the slide.

1.19 Potential Locations of Labels

Graphic depicting two generic box trucks with labels and arrows pointing to potential locations of labels:

- Label 1: .on lower rear or lower front.
- Label 2: on driver door.
- Label 3: on side or back of cab or sleeper berth.
- Label 4: on fuel tank and near fuel fill location.

1.20 Knowledge Check: Which Statements Are Correct about the Use of Diamond-Shaped Labels to Indicate Vehicles Powered by CNG, LNG, or LPG?

1. Mandatory according to the Federal law and the CFR.
2. NOT currently required by FMCSA, but is an industry best practice followed by most manufacturers.
3. An out-of-date practice not followed by many carriers.
4. Can be found in multiple locations on a given CMV.

Answer: The correct response is Number 2 (NOT currently required by FMCSA, but is an industry best practiced followed by most manufacturers) and Number 4 (can be found in multiple locations on a given CMV.

1.21 Properties of CNG (Title Slide)

1.22 Where Natural Gas Comes From

Natural gas is recovered from underground deposits, often in conjunction with petroleum or coal.

Graphic depicting both unconventional and conventional natural gas drilling in conjunction with petroleum or coal.

Rollover the picture to see more information.

When user rolls over the picture, more text comes up with the following content: Natural gas found in naturally occurring deposits is composed primarily of methane (CH4) but also includes varying amounts of ethane (C2H6), propane (C3H8), butane (C4H10), and pentane (C5H12). The non-methane C2+ hydrocarbons found in natural gas are typically called “natural gas liquids” because they condense from a gas to a liquid at modest pressure. Natural gas with a high percentage of natural gas liquids is referred to as “wet gas”.

Most of the natural gas liquids are typically removed during processing near the well head so that they will not condense in pipelines. The natural gas sold to customers by utility companies typically has 85+ percent methane and only small amounts of ethane, propane, and butane. It may also contain small amounts of nitrogen and/or carbon dioxide.

Natural gas is a gas under standard conditions and remains a gas even at very high pressures and very low temperatures - it is typically moved by pipeline under modest pressure (less than 500 psi).

1.23 Compressed Natural Gas

- Natural gas has very low energy density at atmospheric pressure ~1,000 British thermal units (BTU) per standard cubic foot (scf), compared to more than 17,000 BTU/scf for diesel fuel.
- To be used on a vehicle, natural gas is often compressed into tanks at pressures up to 3,600 pounds per square inch - this method of fuel storage on a vehicle is referred to as compressed natural gas or CNG.

Picture of compressed natural gas tanks along a truck's frame rail.

1.24 Equivalent Energy Content

Graphic of three boxes, one small, one medium and one large. Each box depicts equivalent energy content:

- Small box: 100 gallons diesel - 13.4 cubic feet .
- Medium box: CNG at 3,600 pounds per square inch - 53.5 cubic feet
- Large box: natural gas at atmospheric pressure - 227.3 cubic feet

Rollover to see more information about equivalent energy. The following text pops up: To hold as much fuel energy as a diesel fuel tank, CNG cylinders (at 3,600 psi) need to be almost four times as big. To hold an equivalent amount of energy at atmospheric pressure, a natural gas tank would need to be almost 17 times bigger than a diesel fuel tank.

1.25 CNG Leaks

- CNG leaks generally cannot be reliably detected using human senses alone.
- CNG is colorless - so leaks cannot be "seen."
- CNG is also naturally odorless.
- If a CNG leak is large enough, it may produce a high-pitched whistling sound.

Rollover to see more information about detecting leaks. The following text pops up:

- A sulfur-based compound (i.e., a mercaptan) with a distinct odor is usually added to pipeline natural gas to aid in leak detection.
- Some CNG used on vehicles may not be odorized, so smell will not always be a reliable method to detect leaks.
- Even if CNG is odorized, smell alone usually cannot reliably identify the exact location or relative size of a leak.

- The nose (olfactory senses) “fatigues” (i.e., loses its sensitivity to the odor) after a certain period of time (minutes) of exposure to the odor.

1.26 Natural Gas Is Lighter Than Air

- Natural gas is lighter than air, with a specific gravity relative to air of 0.6 to 0.7.
- Natural gas leaking from a CNG fuel system will therefore rise vertically from the leak point.

Graphic depicting natural gas floating up into a cloud above a commercial vehicle. The graphic has a legend: red color signifies flammable gas concentrations and a purple color signifies non-flammable gas concentrations.

Rollover to see more information. The following text pops up:

- If leaking into open air, NG will quickly dissipate to non-flammable levels as it rises.
- If leaking into an enclosed space (vehicle cab, engine compartment, or building) a flammable mixture of natural gas can collect in the space, starting at ceiling level, and pose a significant fire or explosion hazard.

1.27 Flammability Range

Natural gas has a flammability range of 5–15 percent volume concentration in air. (This compares with diesel fuel, which has a flammability range of 0.6–5.5 percent.)

- Five percent (50,000 parts per million [ppm]) of natural gas is the “lower flammable limit” (LFL)—below 5 percent concentration, a mixture of natural gas and air is too lean to sustain a flame.
- Fifteen percent (150,000 ppm) is the “upper flammable limit” (UFL)—above 15 percent concentration, a mixture of natural gas and air is too rich to sustain a flame.

1.28 Lower Flammable Limit (LFL)

The percent of the LFL is often used to determine the severity of a natural gas leak based on relative hazard level.

Graphic depicting the lower flammability limits of a natural gas leak based on the relative hazard level.

Roll over the flame to see more about the percent of lower flammable limit and overall concentrations of methane. The following text pops up:

- A measured concentration of natural gas in an enclosed space that is less than 12,500 ppm (< 25 percent of the LFL) (< 1.25 percent overall concentration) is not considered hazardous, and requires no action.
- A measured concentration of natural gas in an enclosed space that is between 12,500 and 25,000 ppm (25 percent and 50 percent of the LFL)(1.25–2.50 percent overall concentration) is considered hazardous, and at a minimum occupants should be warned.
- A measured concentration of natural gas in an enclosed space that is greater than 25,000 ppm (> 50 percent of the LFL (> 2.50 percent overall concentration) is considered extremely hazardous, and occupants should evacuate.

1.29 Knowledge Check: Which Statements Correctly Represent Common Properties of CNG?

Which statements correctly represent common properties of CNG? (Select all that apply.)

1. Natural gas is recovered from underground deposits, often in conjunction with petroleum or coal.
2. Natural gas has a higher energy density at atmospheric pressure (BTU/scf) than that of diesel fuel.
3. A smaller CNG cylinder can hold as much fuel energy as a larger diesel fuel tank.
4. CNG leaks are always easily detected because of the odor.

Answer: The correct response is Number 1 (natural gas is recovered from underground deposits, often in conjunction with petroleum or coal).

1.30 Knowledge Check: Which Statements Are Correct About Common Properties of CNG?

Which statements are correct about common properties of CNG? (Select all that apply.)

1. Natural gas leaking from a CNG fuel system will pool at ground level.
2. The flammability range for CNG is between 5 percent and 15 percent volume concentration in air.
3. A measured concentration of natural gas in an enclosed space that is less than 12,500 ppm (< 25 percent of the LFL, < 1.25 percent overall concentration) is hazardous and requires action.
4. A measured concentration of natural gas in an enclosed space that is 5,000 to 10,000 ppm (25–50 percent of the LFL, 1.25–2.50 percent overall concentration) is hazardous and requires action.

Answer: The correct response is Number 2 (the flammability range for CNG is between 5 percent and 15 percent volume concentration in air) and Number 4 (a measured concentration of natural gas in an enclosed space that is 5,000 to 10,000 ppm [25–50 percent of the LFL, 1.25–2.50 percent overall concentration] is hazardous and requires action).

1.31 Properties of LNG (Title Slide)

1.32 Critical Temperatures

When the temperature of natural gas is reduced below −260 degrees F (−162 degrees C) it condenses to a liquid at atmospheric pressure; natural gas held in this state is referred to as “liquefied natural gas” or “LNG”.

Graphic of temperature scale from −460 degrees F to 212 degrees F with various points marked: absolute zero (−460 degrees F), LNG temp (−260 degrees F), water freezing point (32 degrees F), room temperature (68 degrees F), water boiling point (212 degrees F).

1.33 Specially Insulated Containers

LNG is stored in specially insulated containers to maintain it at a low temperature, and is typically moved by ship or tanker truck.

- LNG has higher energy density than CNG—approximately 10,000 BTU/scf compared to approximately 4,000 BTU/scf for CNG at 3,600 pounds per square inch.
- Vehicles sometimes use LNG fuel systems instead of CNG fuel systems to increase vehicle range between fueling events.
- CNG trucks can typically travel less than 300 miles before needing to refuel, while some LNG trucks can go as far as 600 miles.

Image of a white LNG tanker truck.

1.34 LNG Leak

- LNG leaking from a fuel system may form a puddle of liquid on the ground, but as it warms the LNG will vaporize to a colorless gas.
- The vaporized LNG may form a cold, dense area of gas that can move horizontally near ground level a short distance before beginning to rise vertically as it warms further.
- Water vapor may condense in the vicinity of the liquid LNG puddle and/or the cold natural gas vapor, producing a visible white cloud.
- Vapor clouds can form around cold components of an LNG fuel system under normal operating conditions, so the presence of a vapor cloud alone cannot be used to identify LNG fuel leaks.

Graphic of a vehicle, with a puddle of LNG on ground covered by a cloud of LNG extending horizontally and then rising.

Rollover truck to see more information. The following text pops up: LNG vapors dissipate to non-flammable level as they rise but can collect to flammable level in an enclosed space.

1.35 Odor Not Used to Identify LNG Leaks

- Odorants cannot be added to LNG because they would freeze and solidify, so natural gas leaking from an LNG fuel system will always be odorless.
- Odor can never be used to identify LNG fuel leaks.

Graphic depicting that odor can never be used to identify LNG fuel leaks.

1.36 Leaking LNG

- Leaking LNG poses the same potential hazard as leaking CNG—leaks in open air will eventually dissipate to non-flammable levels, while leaks into an enclosed space can accumulate into a flammable mixture, posing a fire or explosion hazard.
- Leaking LNG has the same lower flammable limit as leaking CNG—5 percent volume concentration in air after the LNG has vaporized to a gas.

Graphic of a truck with an LNG fuel leak showing the gas floating upward into a cloud above the truck, and accumulating at the ceiling of the enclosure.

1.37 Knowledge Check: What Are the Advantages of LNG?

What are advantages of LNG? (Select all that apply.)

1. LNG makes it possible to travel longer distances than CNG trucks.
2. LNG containers can be smaller than CNG containers, because LNG requires less space than CNG.
3. LNG can be odorized.
4. Keeping LNG at a low temperature prevents danger of explosion.

Answer: The correct response is Number 1 (LNG makes it possible to travel longer distances than CNG trucks) and Number 2 (LNG containers can be smaller than CNG containers, because LNG requires less space than CNG).

1.38 Properties of Liquefied Petroleum Gas (LPG) (Title Slide)

1.39 Liquefied Petroleum Gas

- Liquefied Petroleum Gas (LPG) may also be referred to as "LP Gas" or "Propane." It is a mixture of compressible hydrocarbon gases—in the United States, LPG is typically mostly propane (C3H8), with smaller amounts of butane (C4H10) and propylene (C3H6).
- LPG is created as a by-product of oil refining and by removing much of the propane and butane from "wet" natural gas during processing.
- In the United States, most suppliers sell LPG meeting the HD-5 specification, which mandates at least 90 percent propane content and no more than 5 percent propylene content.

1.40 LPG Tank Pressures

- The boiling point of propane at atmospheric pressure is -44 degrees Fahrenheit, and of butane is 32 degrees Fahrenheit, so LPG is a gas at atmospheric pressure over the normal ambient temperature range.
- LPG condenses to a liquid at modest pressure even at elevated temperatures, so it is stored and moved in bulk as a liquid, in pressurized containers. LPG fuel is also stored on vehicles as a pressurized liquid.
- LPG containers are typically designed to handle up to approximately 300 pounds per square inch internal pressure, but the actual pressure inside an LPG tank will vary depending on composition (percent propane vs. butane) and ambient temperature.

Picture of a propane tanker truck.

Picture of LPG tanks mounted behind the cab on a commercial vehicle.

Rollover to see LPG tank pressures. A pop-up of a vapor pressure table is displayed.

Pop-up table titled: Vapor Pressure (pounds per square inch). Row 1: propane at 20 degrees F is 41; propane at 70 degrees F is 109; propane at 100 degrees F is 172. Row 2: butane at 20 degrees F is 8;

butane at 70 degrees F is 17; butane at 100 degrees F is 38. Row 3: 90 percent propane/10 percent butane at 20 degrees F is 38; 90 percent propane/10 percent butane at 70 degrees F is 100; 90 percent propane/10 percent butane at 100 degrees F is 159.

1.41 LPG Leaks

- LPG leaking from a storage tank or fuel system will vaporize immediately to a gas.
- LPG leaks cannot be reliably detected using human senses alone.
- LPG is colorless - so leaks cannot be "seen."
- LPG is also naturally odorless.
    - A sulfur-based compound (i.e., a mercaptan) with a distinct odor is usually added to commercial LPG to aid in leak detection.
- Smell alone cannot reliably identify the exact location or relative size of a leak.
- The nose (olfactory senses) "fatigues" (i.e., loses its sensitivity to the odor) after a certain period of time (minutes) of exposure to the same odor.

1.42 LPG is Heavier Than Air

Graphic of a vehicle, with gas falling from a leak, collecting at floor level of a building in a partially enclosed space, with some dissipating into the open air.

- LPG vapors are heavier than air, with a specific gravity relative to air of 1.5 to 2.0.
- LPG leaking from an LPG fuel system will therefore tend to fall to the ground, and settle into low points:
- If leaking into open air, LPG vapors will dissipate to non-flammable levels based on mixing -- the greater the air movement, the faster it dissipates.
- If leaking into an enclosed space (vehicle cab, engine compartment, or building), a flammable mixture of LPG can collect in the space at ground level, and pose a significant fire or explosion hazard.

1.43 LPG Flammability Range

LPG has a flammability range of approximately 2–10 percent volume concentration in air—it can vary slightly depending on composition. (This compares with diesel fuel, which has a flammability range of 0.6–5.5 percent, and natural gas, which has a flammability range of 5–15 percent.

- Two percent (20,000 ppm) of LPG is the "lower flammable limit" (LFL)—below 2 percent concentration, a mixture of LPG and air is too lean to sustain a flame.
- Ten percent (100,000 ppm) is the "upper flammable limit" (UFL)—above 10 percent concentration, a mixture of LPG and air is too rich to sustain a flame.

1.44 Lower Flammable Limit (LFL)

The percent of the LFL is often used to determine the severity of an LPG leak based on relative hazard level.

Graphic depicting the lower flammability limits of an LPG gas leak based on the relative hazard level.

Roll over the flame to see more about the percent of lower flammable limit and overall concentrations of LPG. The following text pops up:

- A measured concentration of LPG in an enclosed space that is less than 5,000 ppm (< 25 percent of the 20,000 ppm LFL, < 0.5 percent overall) is not considered hazardous and requires no action.
- A measured concentration of LPG in an enclosed space that is between 5,000-10,000 ppm (25–50 percent of the 20,000 LFL)(.5–1 percent overall) is considered hazardous, and at a minimum occupants should be warned.
- A measured concentration of LPG in an enclosed space that is between 10,000–20,000 ppm (50–100 percent of the LFL)(1–2 percent overall) is considered extremely hazardous and occupants should evacuate.

1.45 Lower Flammability Limit

Natural gas technically has a higher LFL, and higher thresholds for being placed out-of-service. See illustration below. However, for safety reasons, LPG's lower thresholds are also used for natural gas.

Graphic depicting the lower flammability limits of a natural gas leak based on the relative hazard level.

Roll over the flame to see LPG's thresholds, which are also used for natural gas. The following text pops up:

- A measured concentration of natural gas in an enclosed space that is less than 5,000 ppm is not considered hazardous, and requires no action.
- A measured concentration of natural gas in an enclosed space that is between 5,000–10,000 ppm is considered hazardous, and at a minimum, occupants should be warned.
- A measured concentration of natural gas in an enclosed space that is between 10,000–20,000 ppm is considered extremely hazardous and occupants, should evacuate

1.46 Knowledge Check: What Are the Critical Properties of LPG?

What are the critical properties of LPG? (Select all that apply.)

1. LPG has a flammability range of approximately 2–10 percent volume concentration in air. It can vary slightly depending on composition.
2. LPG vapors are heavier than air. LPG leaking from an LPG fuel system will settle into low points.
3. LPG leaks cannot be reliably detected using human senses alone.
4. LPG is stored and moved in bulk as a liquid, in pressurized containers.
5. Liquefied Petroleum Gas (LPG) may also be referred to as "LP Gas" or "Propane."

Answer: The correct response is all of the above (Numbers 1-5 are correct).

1.47 Summary of CNG, LNG, and LPG Properties and Leak Characteristics (Title Slide)

1.48 Summary

Rollover each truck to read about leak characteristics of CNG, LNG, and LPG

Table comparing the state, color, odor, LFL, and leak profile of CNG, LNG, and LPG. CNG's state is compressed gas (up to 3,600 psi), colorless, is usually, but not always odorized with a sulfur smell, with an LFL of 5 percent in air. It rises and can accumulate at the ceiling of an enclosed area. LNG is a cryogenic liquid stored at −260 degrees Fahrenheit. It is colorless, odorless, and has an LFL of 5 percent in air. It can pool on the ground as it thaws, then will rise as it converts to gas. Clouds of water vapor can appear where LNG is changing temperatures. LPG is stored as a pressurized liquid, up to 300 psi. It is colorless, odorized with a sulfur smell, and has an LFL of 2 percent in air. It sinks, and can accumulate to hazardous levels in enclosed space.

Rollover each truck to read about leak characteristics of CNG, LNG, and LPG. The following text pops up:

- CNG: Leaking gas quickly rises vertically. Gas will quickly dissipate to non-hazardous levels in open air. Gas can accumulate to flammable concentration in enclosed space, starting from ceiling level.
- LNG: Leaking liquid may puddle on the ground. Area of cold, vaporized gas may move horizontally before rising vertically as it continues to warm. Visible cloud of water vapor may form in vicinity of leak. Rising gas will dissipate to non-hazardous levels in open air. Gas can accumulate to flammable concentration in enclosed space, starting from ceiling level.
- LPG: Leaking liquid vaporizes immediately to a gas that falls to the ground. Vapors can accumulate in low areas. Vapors leaking into open air will dissipate to non-hazardous levels based on air movement. Vapors entering a closed compartment can accumulate to a flammable concentration starting from floor level.

1.49 Overview of CNG Fuel Systems (Title Slide)

1.50 Locations of CNG Fuel Cylinders

Depending on vehicle type, high-pressure CNG fuel cylinders may be located in one of five places on the vehicle:

- On roof (transit bus).
- On outside of frame rail in typical diesel fuel tank location (Class 8 tractor, box truck, refuse hauler).
- In a compartment behind vehicle cab (Class 8 tractor, refuse hauler).
- Between frame rails under passenger or cargo compartment (school bus, cargo van).
- In cargo compartment (cargo van).

Diagram of box truck showing tanks in five locations—highlighted to indicate each location for potential placement of CNG fuel cylinders.

1.51 Frame-Rail View of Cylinder Locations

CMVs will typically have more than one fuel cylinder manifolded together. The total volume of CNG fuel cylinders is often 3–4 times that of the diesel fuel tanks on a comparable vehicle.

Graphic depicting the frame-rail view of potential cylinder locations:

A. Longitudinal, underbody.
B. Behind rear axle, underbody.
C. Behind rear axle, underbody.
D. Interior, cargo floor.

1.52 CNG Cylinder, PRD, and Vent Line

- In the United States, heavy-duty CNG vehicles typically have fuel cylinders designed for a maximum operating pressure of 3,600 pounds per square inch.
- CNG fuel cylinders are equipped with pressure relief devices (PRD) to protect the cylinder against over-pressure in a fire.
- PRDs are usually thermally activated -- high temperature melts eutectic material, allowing all gas to escape from the cylinder to relieve pressure.
- PRDs are usually equipped with vent lines, with vent outlet(s) at vehicle roof level.

Diagram showing CNG cylinder, PRD, and vent line.

1.53 CNG Engine and Fuel System Components

In addition to the fuel cylinders, a CNG vehicle engine and fuel system includes:

- Fuel fill portal.
- Fuel filter.
- Pressure regulators.
- High pressure fuel lines.
- Natural gas engine.
- Low pressure fuel lines.

Group of pictures depicting the CNG Fuel System Components: Fuel Fill Portal, Fuel Filter, Pressure Regulators, High Pressure Fuel Lines, Natural Gas Engine, and Low Pressure Fuel Lines.

1.54 Overview of LNG Fuel Systems (Title Slide)

1.55 Location of LNG Fuel Tanks

- LNG fuel tanks are usually located on the outside of the frame rail of a truck, in the same location as typical diesel fuel tanks.
- Trucks may have one or two LNG fuel tanks.
- The total volume of LNG fuel tanks is often 2 times that of the diesel fuel tanks on a comparable vehicle.

Two pictures of LNG fuel tanks—one located under the cab of a truck and one located behind the cab of a truck.

1.56 LNG Cylinder, PRV, and Vent Line

- LNG tanks are highly insulated, to maintain LNG at −260 degrees Fahrenheit.
- Despite this insulation, some heat is continually absorbed into the tanks, which vaporizes some LNG, raising the vapor pressure in the tank, especially if a vehicle sits for an extended period without running the engine.

Picture showing LNG cylinder, PRV, and vent line.

Rollover the picture to see more information.

The following text pops up:

- LNG fuel tanks are equipped with a pressure relief valve (PRV) to protect the cylinder against over-pressure.
- If the vapor pressure in the tank rises above a set threshold, the tank will vent methane gas through the PRV.
- When the vapor pressure falls back below a set threshold, the PRV will close.
- This methane venting is expected to occur during normal operation.
- LNG tank venting through the PRV is a random and unpredictable event, but it is not a “leak.”
- PRVs are equipped with vent lines, with vent outlet(s) at vehicle roof level.

1.57 LNG Fuel System Components

In addition to the LNG fuel tanks, an LNG fuel system includes: fuel fill portal, fuel vaporizer, pressure regulator, fuel lines, and a natural gas engine.

Graphic depicting LNG fuel system components.

1.58 Overview of LPG Fuel Systems (Title Slide)

1.59 Location of LPG Fuel Tanks

LPG fuel tanks are usually located in one of three places:

1. On the outside of the frame rail in the same location as typical diesel fuel tanks.
2. Between the frame rails (school bus).
3. In the cargo compartment (cargo van).

- Trucks may have more than one LPG tank.
- The total volume of LPG fuel tanks may be 2 times that of the diesel or gasoline fuel tanks on a comparable vehicle.

Picture of LPG fuel tanks between the truck frame-rails.

Picture of an LPG truck with fuel tanks mounted on outside of frame rail behind the cab.

1.60 LPG Cylinder, PRV, and Vent Line

- Vehicular LPG tanks are designed to operate with less than 300 pounds per square inch internal pressure.
- Vehicular LPG tanks are designed to be filled to 80 percent of their volume capacity to maintain sufficient vapor space in the tank.
- LPG tank over-pressure could be caused by elevated ambient temperature (as in a fire) or by tank over-filling.

Picture showing LPG cylinder, PRV, and vent line.

Rollover the picture to see more information. The following text pops up:

- LPG fuel tanks are equipped with a pressure relief valve (PRV) to protect the cylinder against over-pressure.
- If the vapor pressure in the tank rises above a set threshold, the tank will vent gas through the PRV.
- When vapor pressure in the tank falls back below a set threshold the pressure relief valve closes.
- LPG tank venting through the PRV is not expected to occur in normal operation.
- PRVs should be equipped with vent lines, with vent outlet(s) at vehicle roof level.

1.61 LPG Fuel System Components

In addition to the fuel tanks, an LPG vehicle fuel system includes:

- Fuel fill portal.
- Fuel filter.
- Fuel pump.
- Evaporator.
- Fuel lines.
- Pressure regulator.

Graphic depicting the LPG Engine Fuel System Components: Fuel Fill Portal, Fuel Filter, Fuel Pump, Evaporator, Fuel Lines and Pressure Regulator.

1.62 Knowledge Check: What Are the Common Characteristics of CNG, LNG, and LPG Fuel Systems?

What are common characteristics of CNG, LNG, and LPG fuel systems? (Select all that apply.)

1. CNG, LNG, and LPG are all stored in specially insulated containers.
2. CNG, LNG, and LPG fuel systems all have pressure relief devices (PRDs) or pressure relief valves (PRVs).
3. The total volume of CNG, LNG, and LPG fuel tanks may be 2–4 times that of the diesel or gasoline fuel tanks on a comparable vehicle.
4. CNG, LNG, and LPG are all stored in pressurized containers.

Answer: The correct response is Number 2 (CNG, LNG, and LPG fuel systems all have pressure relief devices [PRDs] or pressure relief valves [PRVs]), and Number 3 (the total volume of CNG, LNG, and LPG fuel tanks may be 2–4 times that of the diesel or gasoline fuel tanks on a comparable vehicle).

1.63 Detecting CNG, LNG, and LPG (Title Slide)

1.64 Locations for CNG, LNG, or LPG Leaks

Pictures of potential locations for CNG, LNG, or PNG leaks. Pictures of elbows/joints in fuel lines, tank shut off valves, connection to engine, fuel fill portal, pressure regulators, and fuel filter.

Rollover the picture group to see more information. The following text pops up:

The most likely locations for a CNG, LNG, or LPG fuel leak are at:

- Fuel fill.
- Tank shut-off valve(s).
- Fuel filter.
- Pressure regulator(s).
- Elbows/joints in fuel lines,
- Connection to engine.

PRV/PRD Release:

- LNG vehicles will likely periodically vent a small amount of methane through their fuel tank PRVs.
- LPG vehicles may vent gas through their fuel tank PRVs, in the event of tank overfilling, fire, or equipment (PRV) failure.
- CNG vehicles may vent the entire contents of their fuel cylinders through their PRDs in the event of fire or equipment (PRD) failure.

1.65 More on CNG, LNG, or LPG Leak Detection

- A distinct sulfurous smell and/or a hissing sound may indicate a CNG or LPG fuel leak, warranting further investigation.
- LNG and some CNG is not odorized, so the lack of smell does not necessarily indicate the absence of a leak.
- Smell and hissing alone are usually not sufficient to verify or confirm the existence of a fuel leak or to pinpoint the exact leak location.
    - The hissing sound may be from another vehicle system (i.e., air compressor system).
    - Natural gas/LPG odor can linger after fueling.
- Any suspected fuel leak should be verified or confirmed using a combustible gas detector or by a soap bubble test.
- Use of a combustible gas detector for leak testing is covered in the next module.

1.66 Soap Bubble Test

- For a soap bubble test, spray a non-corrosive detergent solution onto suspected leak locations (i.e., joints).
- Persistent bubbling indicates a leak.
- NEVER check for leaks using a lit match or lighter.

Grouping of three pictures depicting examples of the soap bubble test.

1.67 What to do if a Vehicle Has a Suspected Fuel Leak (Title Slide)

1.68 FMCSR Fuel System Safety Requirements

According to Appendix G to Subchapter B of Chapter III of the FMCSRs, a vehicle does not pass an inspection because of fuel system issues if it has one of the following defects or deficiencies:

A. A fuel system with a visible leak at any point.
B. A fuel tank filler cap missing.
C. A fuel tank not securely attached to the motor vehicle by reason of loose, broken or missing mounting bolts or brackets (some fuel tanks use springs, or rubber bushings to permit movement).

- Because a fuel leak on a CNG/LNG or LPG vehicle may not be visible, fuel leaks may have to be detected using a soap bubble test, or with a combustible gas detector.
- Leaking gas that can enter a closed compartment poses the most significant risk of fire or explosion.

1.69 Out-of-Service Criteria

According to Appendix G to Subchapter B of Chapter III of the FMCSRs,

- A vehicle(s) is placed out-of-service only when by reason of its mechanical condition or loading it is determined to be so imminently hazardous as to likely cause an accident or breakdown, or when such condition(s) would likely contribute to loss of control of the vehicle(s) by the driver.
- When a fuel leak is verified on a CNG/LNG and LPG vehicle, by a soap bubble test, or by a reading of 5,000 parts per million (ppm) or more on a combustible gas detector, the condition is deemed hazardous, and the vehicle is declared out-of-service.

1.70 Out-of-Service Indicators

Indicators that verify that a fuel system leak exists, requiring that a vehicle be declared out-of-service until the leak is repaired, include:

- A reading of 5,000 ppm or more on a combustible gas detector that is sampling air inside the engine compartment, vehicle cab, fuel compartment, cargo compartment, or any other enclosed space on the vehicle.
- Persistent bubbling when conducting a soap bubble test, or a reading of 5,000 ppm or more on a combustible gas detector sampling at any of these locations:

- The fuel fill portal.
- Elbows/joints in fuel lines.
- Where the fuel line connects to the engine.
- Threaded connections to fuel valves, pressure regulators, or fuel filters.

1.71 Inspector Discretion

According to Appendix G to Subchapter B of Chapter III of the FMCSRs:

- A certain amount of flexibility is given to the inspecting official whether to place the vehicle out-of-service at the inspection site or if it would be less hazardous to allow the vehicle to proceed to a repair facility for repair. The distance to the repair facility must not exceed 25 miles. The roadside type of inspection, however, does not necessarily mean that a vehicle has to be defect-free in order to continue in service.
- Inspectors have discretion to declare a vehicle out-of-service even if a leak cannot be verified, if there is evidence that gas may be accumulating in a closed compartment on the vehicle, such as the operator cab or passenger/cargo compartment.
- When in doubt, it may be appropriate to declare a vehicle out-of-service, because there are very few repair facilities for natural gas or propane vehicles.

1.72 When Leaks are below the Threshold

- Depending on State regulations, vehicles with suspected fuel leaks of less than 5,000 ppm may be given a repair order. If the State does not issue repair orders, then the inspector should issue a violation of the Minimum Periodic Inspection Standards (listed in Appendix G to Subchapter B of Chapter III of the FMCSRs) on the truck inspection form citing a leak from the fuel system.
- You cannot cite a violation, or give a repair order, unless there is evidence of a leak. If you suspect a leak and cannot verify it, then there are no grounds for citing a violation or for issuing a repair order.
    - Collecting evidence of a leak may not be possible if the required equipment is not available.
    - Some areas of the fuel system may be inaccessible during a roadside inspection, making collecting evidence of a leak impractical, even if equipment is available.

1.73 Vehicles Declared Out-of-Service

- Tractors and straight trucks with verified fuel leaks should be declared out-of-service until the leak is repaired.
- Some CNG and LPG vehicles do have fuel tanks mounted either directly inside the cargo compartment or between the frame rails under the floor of the cargo compartment. For these vehicles it would be prudent to include a check of the cargo compartment for accumulated, leaked gas.
- Trailers are not normally declared out-of-service because they typically do not contain CNG/LNG or LPG fuel tanks or other fuel system components, and fuel system leaks from the tractor are generally not close enough to the trailer for leaked gas to accumulate in the trailer.

1.74 Out-Of-Service Rules

Vehicles declared out-of-service for a fuel leak:

- May not be operated. The part of the fuel system with a confirmed leak must be isolated and defueled by a qualified technician before the vehicle is moved by a tow truck to a repair shop.
- Must not be moved or parked indoors unless the indoor facility is approved for storage of CNG, LNG, or LPG vehicles by the authority having jurisdiction.
- May not be operated until the leak is repaired and the out-of-service order is removed by the CMV enforcement agency that issued the order.

Picture of the 2014 North American Standard Out-of-Service Criteria Handbook and Pictorial.

1.75 Vehicles Involved in Accident or Fire

CNG, LNG, LPG vehicles involved in an accident or fire:

- Vehicles involved in an accident which incur “disabling damage”, and vehicles involved in a fire, should be declared out-of-service until the CNG, LNG, or LPG fuel system can be checked for damage by a qualified technician.
- If damage is suspected or confirmed, the damaged part of the system must be isolated and defueled before the vehicle is towed away for repair.

Graphic of a commercial vehicle/tank truck that was involved in an accident and fire.

1.76 Knowledge Check: What to do if a Vehicle Has a Suspected Fuel Leak

1.77 Fuel leaks in CNG/LNG or LPG CMVs can be detected and verified by: (Select two.)

Fuel leaks in CNG/LNG or LPG CMVs can be detected and verified by (select two):

1. The smell of gas in the engine compartment.
2. A hissing sound near gas line components.
3. Conducting a soap bubble test on components of the fuel system.
4. Using a combustible gas detector to detect concentrations of combustible gas greater than 5,000 ppm in enclosed compartments on the vehicle or near components in the fuel system.

To review how to detect and verify fuel leaks, refer to slides/sections 1.65 through 1.70.

Answer: The correct response is Number 3 (conducting a soap bubble test on components of the fuel system) and Number 4 (using a combustible gas detector to detect concentrations of combustible gas greater than 5,000 ppm in enclosed compartments on the vehicle or near components in the fuel system).

Smell and hissing alone are usually not sufficient to confirm the existence of a fuel leak or to pinpoint the exact leak location. Any suspected fuel leak should be confirmed using a combustible gas detector or by a soap bubble test. See slides 1.65, 1.68-1.70.

1.78 A natural gas CMV should be placed out-of-service when ____ of combustible gas are detected by a combustible gas detector. (Select all that apply.)

A natural gas CMV should be placed out-of-service when _____ of combustible gas are detected by a combustible gas detector. (Select all that apply.)

1. 2,000 ppm
2. 4,000 ppm
3. 5,000 ppm
4. 6,000 ppm
5. 10,000 ppm
6. 12,500 ppm

To review what is the minimum concentration of combustible gas, detected by a combustible gas detector, that is required to declare a CNG or LNG vehicle out-of-service, refer to slides 1.45, and 1.69-1.73.

Answer: The correct response is Numbers 3–6. A natural gas CMV should be placed out-of-service when 5,000 or more ppm of combustible gas is detected by a combustible gas detector. See slides 1.68 and 1.69

1.79 An LPG CMV should be placed out-of-service when ____ of combustible gas are detected by a combustible gas detector. (Select all that apply)

An LPG CMV should be placed out-of-service when _____ of combustible gas are detected by a combustible gas detector. (Select all that apply)

1. 2,000 ppm
2. 4,000 ppm
3. 5,000 ppm
4. 6,000 ppm
5. 10,000 ppm
6. 12,500 ppm

To review what is the minimum concentration of combustible gas, detected by a combustible gas detector, that is required to declare an LPG vehicle out-of-service, refer to slides 1.44, and 1.69 through 1.73.

Answer: The correct response is Numbers 3-6. An LPG CMV should be placed out-of-service when 5,000 or more ppm of combustible gas is detected by a combustible gas detector. See slides 1.69 and 1.70.

1.80 What are the most likely places for leaks in CNG, LNG, or LPG fuel systems? (Select all that apply.)

What are the most likely places for leaks in CNG, LNG, or LPG fuel systems? (Select all that apply.)

1. Where the fuel line connects to the engine

2. All threaded joints or connectors in fuel lines
3. Fuel fill portal
4. Fuel filter connections
5. Where the fuel line enters the engine compartment
6. Tank shut-off valves
7. Pressure regulators

To review the most likely places for leaks in CNG, LNG, or LPG fuel systems, review slide 1.64 and 1.70, and watch the video in slide 1.89.

Answer: The correct response is Numbers 1-4 and Numbers 6 and 7. Potential fuel leak locations include: the fuel fill portal, elbows/joints in fuel lines, where the fuel line connects to the engine, threaded connections to fuel valves, pressure regulators, and fuel filters.

1.81 When using a combustible gas detector to check for fuel leaks on a CNG tractor and trailer, you detect a concentration of 5,000 ppm of combustible gas in the engine compartment. What should you do?

When using a combustible gas detector to check for fuel leaks on a CNG tractor and trailer, you detect a concentration of 5,000 ppm of combustible gas in the engine compartment. What should you do?

1. Declare the trailer out-of-service.
2. Declare the driver out-of-service.
3. Declare the tractor out-of-service.
4. Declare the tractor and trailer out-of-service, in combination.
5. Give the driver a repair order, or issue a Violation of the Minimum Periodic Inspection Standards.

To review when to declare a vehicle out-of-service, refer to slides 1.69-1.73, and watch the videos in slides 1.88 and 1.89.

Answer: The correct response is Number 3 (declare the tractor out of service). You would declare the tractor out-of-service because 5,000 ppm is the threshold for placing the CMV out-of-service. Because the leak is isolated to the tractor, the trailer would not be declared out-of-service. .

1.82 When using a combustible gas detector to check for fuel leaks on an LPG tractor and trailer, you detect a concentration of 4,000 ppm in the engine compartment. What should you do?

When using a combustible gas detector to check for fuel leaks on an LPG tractor and trailer, you detect a concentration of 4,000 ppm in the engine compartment. What should you do?

1. Declare the trailer out-of-service
2. Declare the driver out-of-service
3. Declare the tractor out-of-service
4. Declare the tractor and trailer out-of-service, in combination
5. Give the driver a repair order, or issue a Violation of the Minimum Periodic Inspection Standards

To review when to declare a vehicle out-of-service, refer to slides 1.69-1.73, and watch the videos in slides 1.88 and 1.89.

Answer: The correct response is Number 5 (give the driver a repair order, or issue a Violation of the Minimum Periodic Inspection Standards). CMVs with less than 5,000 ppm of combustible gas detected by a combustible gas detector, or with suspected fuel leaks that cannot be verified, should be given a repair order, or issue a Violation of the Minimum Periodic Inspection Standards. See slide 1.71.

1.83 Module Two: Video – Conducting a Leak Test with a Combustible Gas Detector (Title Slide)

1.84 VIDEO Demonstration Objectives

The following videos will demonstrate and describe how to:

- Turn on and set up one or more typical commercially available combustible gas detectors.
- Conduct a leak test of the CNG, LNG, or LPG fuel system on a CMV using a typical commercially available combustible gas detector.
- Interpret the results of a leak test using a typical commercially available combustible gas detector.
- Determine whether to declare a vehicle out-of-service.

1.85 Video Segments

1. Typical Commercially Available Combustible Gas Detectors.
2. Turning on and Using a Combustible Gas Detector.
3. Combustible Gas Detector Readings that Indicate a Leak.
4. Demonstration of a Leak Test on a CMV.

From this slide, users can opt to skip the videos and go directly to the test.

1.86 Typical Commercially Available Combustible Gas Detectors

Video 1 – Typical Commercially Available Combustible Gas Detectors – can be viewed here: http://youtu.be/fOrIXlRCACs.

Video Narrative:

I have here with me two commercially available combustible gas detectors that could be used to detect fuel leaks in vehicle CNG, LNG, or LPG fuel systems. [Zoom in to see the two devices on a table or held in hand.]

Both of these devices are designed to measure the concentration in sampled air of a range of combustible gases, including methane, ethane, propane, and butane - the major constituents of natural gas and LPG.

These devices were chosen for this training to represent the range of equipment that would be available commercially for combustible gas leak detection, in terms of both cost and capability.

[Pick up first device.] This first device [Test Products International (TPI) 725] fits in a shirt pocket and costs about $60. It is specifically designed for use by HVAC technicians to help them look for natural gas leaks in LPG piping systems or appliance installations. It uses two AAA batteries that are reported to last for three hours of use.

[Pick up second device.] This second device costs about $250. It is very similar to the first, except that it allows a user to measure combustible gases at two different sensitivity levels - this device can detect much lower levels of gas than this less expensive device. This device uses two AA batteries that are reported to last for 10 hours of use, and it also comes with this long, flexible probe.

Both of these devices measure the volume concentration of combustible gases in sampled air, but they cannot determine which gas has been detected.

Both of these devices indicate to the user how much gas has been detected by lighting a series of "bars" on the face of the device - the more bars that are lit the more gas has been detected.

For these two specific devices you can determine the actual range of gas being detected by referring to the literature that comes with the unit. Now not all similar devices that you can buy allow you to determine the actual level of gas detected - some devices provide a relative indication, you know, high or low, but they don't tell you the actual level, so therefore it is difficult to compare the results to a threshold leak definition.

[Pick up TPI 725 - zoom in on face.] For this unit, the product literature says that if only the bottom light is lit, the unit has detected between 1,000 and 2,000 parts per million of combustible gas. If two lights are lit the unit has detected between 2,000 and 4,000 ppm of gas. If three lights are lit the unit has detected between 4,000 and 5,000 ppm of gas. When the top, 4th light is lit, the unit has detected more than 5,000 parts per million of gas.

[Pick up Ridgid micro CD-100 - zoom in on face] This unit has 5 lights and two sensitivity levels. The user manual says that when it is in the high sensitivity range, lighting the first light means that it has detected between 40 and 80 parts per million of gas, while if you light all the way up to the fifth light it means more than 640 parts per million of gas has been detected. When the unit is in the low sensitivity range, lighting one light means the unit has been detected between 400 and 800 ppm of gas, while all five lights means the unit has detected more than 6,400 ppm of gas. When using this unit to detect leaks from CNG, LNG, or LPG fuel systems, one would most likely use the low sensitivity range.

Both of these units also provide an audible signal - a beep - when gas has been detected, and the rate of beeping changes in response to higher concentration of detected gas. The second, more expensive device also has the capability of vibrating when gas is detected. On this device, both the vibrating mode and the audible alarm can be turned off.

1.87 Turning On and Using a Combustible Gas Detector

Video 2 – Turning On and Using a Combustible Gas Detector – can be viewed here: http://youtu.be/mkqwjZUs3qE.

Video Narrative:

Both of these devices are easy to use.

[Pick up TPI 725.] This device has a single on/off button. You should always turn these units on in an area where you do not expect any combustible gas in the air, because the first thing they do when you turn them on is to automatically zero their sensors.

[Push on/off button.] On this unit, when you push the "on" button, all of the LEDs light to show you the device is zeroing. When it's ready to go, this bottom green LED is lit.

Now you remove the sensor cap [show end of device with sensor], and you are ready to test for gas, using this end of the device.

I have here a canister of methane to demonstrate what happens when this device senses combustible gas in air.

Remember that as methane rises away from a leak point it tends to dissipate to a lower concentration, so I'm going to start with the device high above the canister where the concentration will be low. [Hold detector over leak source.]

As I move the device down towards the leak point, at some point it will start to sense gas, and you'll see it react.

So I'm going to turn on my leak [Open valve.] - and I move the sensor down - you see that because the sensor is now sensing gas, because the LEDs are lit and it's making a beeping noise. Because all four LEDs are lit means that the sensor is detecting more than 5,000 ppm of gas. [Close valve on leak source.]

[Pick up Ridgid CD-100.] This device is a little bit more complicated than the last one, but it operates in the same way.

This middle button in the on/off button. [Push on/off button.] When I push it, the LED starts to flash, indicating that the unit is zeroing, and it's going to take a few minutes to do that.

In addition to lighting LEDs, this unit can alert the user to detected gas with an audible signal and by vibrating. These buttons on the left allow the user to turn off the audible signal as well as the vibration.

These buttons on the right which are labeled "H" and "L", allow you to put the unit into "High" or "Low" sensitivity mode.

In a minute, when the unit has calibrated, all these red LED lights will flash, and one of these two yellow lights at the bottom will start to flash, to indicate the unit is ready to go. It will also start to beep. We'll wait for it to do that… (Three beeps.) Now the unit is ready to sense gas.

When the light on the right is flashing it means that the unit is in the "high" sensitivity range. I'm going to push the "L" to put it into the low sensitivity range, and the light on the right hand side will start to flash.

Again, I'm going to use my canister of methane to demonstrate what this unit looks like when it detects gas. [Open valve.]So I'm going to start with my probe well above the canister, well above the leak, where the gas will have dissipated to a low concentration. As I move the unit down, at some point it will start to detect gas, and one of the LEDs will light. (Rapid beeping) You'll see that the unit is detecting

gas, and because all of the LEDs are lit, it means that it is detecting more than 6,400 parts per million. [Close valve on leak source.]

1.88 Combustible Gas Detector Ratings that Indicate a Leak

Video 3 – Combustible Gas Detector Ratings that Indicate a Leak – can be viewed here: http://youtu.be/XIiqHXbm3vw.

Video Narrative:

[Standing in front of a commercial vehicle with a CNG or LNG fuel system.]

I am now going to talk about how to conduct a leak test of a commercial vehicle using a combustible gas detector, starting with the question - What reading on my detector would indicate that there is a "leak"?

Now technically, concentrations of combustible gas as low as 500 parts per million, especially if measured with the detector directly against a potential leak source - like a joint in the fuel system, might indicate that there is a leak. [Demonstrate by putting detector against a potential leak point on the vehicle.]

However, it is important to recognize that during a roadside inspection there may be other sources of combustible gases in the air that could contribute to the reading on your detector - so for example, gasoline vapors or carbon monoxide from passing traffic.

So, in order to guard against "false positives" that would put a vehicle out of service unnecessarily, it is appropriate to adopt a higher concentration as a threshold definition of a leak.

So, for our leak definition, we will use standard industry practice for monitoring combustible gases in enclosed spaces. Now, generally, a measured concentration less than 25 percent of the lower flammable limit of a gas is not considered hazardous, while anything greater than 25 percent of the lower flammable limit is considered hazardous.

Now, the lower flammable limit for natural gas in air is 5 percent, which is 50,000 parts per million, and the lower flammable limit for LPG is 2 percent, or 20,000 parts per million.

So, 25 percent of the lower flammable limit for natural gas would be 12,500 ppm. Twenty-five percent of the lower flammable limit for LPG would be 5,000 ppm.

So, for conservatism we are going to adopt as our threshold definition of a "leak" a measured concentration of combustible gases of more than 5,000 parts per million. So, this threshold is high enough to protect against false positive readings, but it's low enough to ensure that a vehicle with a fuel leak is removed from service before gas has accumulated to a hazardous level.

So, when conducting a fuel leak test on a commercial vehicle, if your combustible gas detector measures more than 5,000 ppm of combustible gases, either in an enclosed compartment on the vehicle, or at any specific leak point in the system, that measurement constitutes confirmation that there is a fuel leak, and the vehicle should be put out of service. An enclosed compartment would, for example, be the vehicle cab, the engine compartment, or the cargo compartment of the vehicle.

For the two detectors that we have with us today [hold up the detectors], more than 5,000 ppm of detected gas would be indicated if all four [hold up TPI 725], or in this detector [hold up Ridgid CD-100], all five of the LEDs had been lit up.

1.89 Demonstration of Leak Test on a CMV

Video 4 – Demonstration of Leak Test on a CMV – can be viewed here: http://youtu.be/Jw8sz0g5WVw.

Video Narrative:

[Standing in front of a vehicle with a CNG fuel system, with CNG fuel cylinders in a compartment behind the vehicle cab.]

Behind me is a commercial tractor with a compressed natural gas fuel system. The CNG tanks on this truck are located in this box behind the vehicle cab, which is a typical location for many CNG trucks.

You can also tell that this in a CNG truck by looking for the blue diamond CNG label located here on the fuel port. I am going to use this truck to demonstrate how to conduct a fuel leak test using a combustible gas detector. [Hold up Ridgid CD-100.]

The first thing we're going to do is to turn on the combustible gas detector. I'm going to do it a few feet away from the truck, so in case there is a fuel leak, it won't interfere with the instrument's ability to zero its sensors. [Turn unit on.]

Now, a fuel leak of a commercial vehicle should be done with the vehicle engine running. This is because most CNG, LNG, and LPG vehicles are designed so that when the ignition is off; it closes valves, and isolates the fuel to the fuel cylinders.

If you conducted a leak check with the engine off, fuel would not be flowing through the entire system, from the fuel tank to engine, so some leaks might be missed.

For this demonstration I will keep the truck engine off, however, to reduce the amount of ambient noise and make it easier for you to hear me.

The combustible gas detector is now beeping, indicating that it is ready to use. Again, in the interest of making it easier for you to hear me during this demonstration, I will turn off the audible alarm. [Turn off alarm.]

As discussed in the first module of this training, natural gas and LPG leaks into open air pose relatively little danger, but gas that accumulates in an enclosed space can produce a significant risk of fire or explosion. For that reason I will concentrate our efforts during this leak check on enclosed compartments of the vehicle, beginning with the operator cab.

[Open door and climb into vehicle cab.] Remember that natural gas is lighter than air, and leaking gas rises - so you should start by sampling air at the ceiling level of the cab where the leaked gas might accumulate. [Move detector around cab at ceiling level.]

If this was an LPG vehicle I would not sample at ceiling level, but would rather start at floor level. This is because LPG is heavier than air and gas tends to collect in low spots. [Move detector around floor level in cab.]

[Move from vehicle cab to side of truck.] Next we're going to check for evidence of leaked gas inside the engine compartment.

[Open vehicle hood.] Because this is a CNG vehicle, we're going to first just crack the hood, and stick the probe up near the top of the hood where some gas might have accumulated.

[Move detector to various areas in the engine compartment.] Next, we're going to use our probe to check parts of the fuel system where there are connections, because these are the most likely places where a leak could develop. For example, here where the fuel filter is, you can see there are some threaded connections here, and also where the fuel line enters the engine.

Now, if this were an LPG vehicle, again, I wouldn't start by checking near the top of the hood. But I'd start by running my detector up underneath the engine like this, because again, LPG vapors are heavier than air, and tend to collect in low spots. [Move detector below engine compartment.]

[Move to behind vehicle cab.] Next, I'm going to check for leaks in the vicinity of the vehicle fuel tanks. Now, on this vehicle the fuel tanks are located in this box, and fortunately there are access points in the side of the box that will allow us to insert our probe. [Climb onto truck and insert probe into top access point on side of fuel compartment.]

Again, this is a CNG vehicle, so I'm going to start at the top of the box, because leaked gas will tend to rise and accumulate at the top. [Put detector probe in top access point.]

However, in a vehicle fuel system, there are lots of little potential individual leak points where valves and other components are connected, so I'm going to check all of those locations here that are accessible to me in this fuel container. [Insert the detector in the other access points.]

[Move to stand in front of fuel-fill port on truck.] Finally, I'm going to check the fuel fill access point, because that's also a place where fuel could be leaking. [Place sensor at various points around fuel fill portal.]

This completes the leak check on this vehicle.

[Move to stand beside the fuel tanks on an LNG vehicle.] Behind me is an LNG vehicle with the LNG fuel tanks mounted on the outside of the frame rail, underneath and behind the vehicle cab. This is a typical location for LNG fuel tanks. It is also a possible location for CNG and LPG fuel tanks on various types of commercial vehicles.

I'm going to use this vehicle to demonstrate how to conduct a leak test when the vehicle fuel tanks are located in this position. The scan of the passenger compartment, and the engine compartment, would be the same on this vehicle as for the CNG vehicle that was previously demonstrated.

Since this fuel tank is not mounted in an enclosure, the leak check should focus on the locations where there are valves, connectors, and fuel lines mounted on the tank - these are the most likely locations for a leak. On this tank, which is typical, most of the exposed components are located behind this cover. So

we will use our detector to come in close to all of the leak points here. In each location, we put the detector probe directly against the leak point. [Place sensor at all connectors and valves.] For a CNG vehicle, you typically would want to have the detector above the top of the joint, because leaked gas will go up. On an LPG vehicle, you might more typically want to have the probe on the side or slightly below, because again, LPG tends to fall. [Demonstrate.]

Now this truck only has one LNG tank, but some trucks have two. So obviously, if this truck had two tanks, you'd want to repeat the test on the other side to the other tank.

Neither of the trucks that we just checked has a cargo compartment. For trucks that do have a cargo compartment, inspectors should use their discretion as to whether or not they should check for accumulated, leaked gas in the cargo compartment. For most trucks such a check will not be necessary, because there are generally no fuel tanks, fuel lines, or fuel system components mounted in the cargo compartment. However, some CNG and LPG vehicles do have fuel tanks mounted either directly inside the cargo compartment or between the frame rails under the floor of the cargo compartment. For these vehicles it would be prudent to include a check of the cargo compartment for accumulated, leaked gas.

This completes our leak test demonstration today. We would like to thank the generosity of Ryder Systems for providing the vehicles that we used in the demonstration.

1.90 Test: Conducting a Leak Test with a Combustible Gas Detector

1.91 The most important considerations when selecting a combustible gas leak detector are that ____. (Select three.)

The most important considerations when selecting a combustible gas leak detector are that _____. (Select three.)

1. It is affordable for your department.
2. It can distinguish between different types of combustible gases.
3. It can easily be used to probe locations where gas may be leaking or accumulating.
4. It indicates the actual range of combustible gas concentration (ppm) detected, using lights, sounds, or digital readout, not just a relative indication of low/high.
5. It can indicate whether the detected concentration of combustible gas is less than 5,000 ppm, or more than 5,000 ppm.

To review the most important considerations for selecting combustible gas leak detectors, watch the videos in slides 1.86 through 1.89.

Answer: The correct response is Numbers 3, 4, and 5.

1.92 Where should a combustible gas leak detector be turned on?

Where should a combustible gas leak detector be turned on?

1. In the vehicle cab, where leaked gas may have accumulated
2. In the trailer or cargo compartment, where leaked gas may have accumulated

3. Away from running vehicles and other potential gas leak sources, so the leak detector can zero its sensors
4. Close to running vehicles that might be leaking gas into the air

See the video on slide 1.88 to review where you should be when you turn on a combustible gas leak detector.

Answer: The correct response is Number 3 (away from running vehicles and other potential gas leak sources, so the leak detector can zero its sensors).

1.93 What is the correct abbreviation for liquefied natural gas?

What is the correct abbreviation for liquefied natural gas?

1. LPG or Propane
2. CNG
3. LNG
4. PPG

To review the acronyms for the various gases, review slide 1.2.

Answer: The correct response is Number 3 (LNG).

1.94 What is the correct abbreviation for liquefied petroleum gas?

What is the correct abbreviation for liquefied petroleum gas?

1. LPG or Propane
2. CNG
3. LNG
4. PPG

To review the acronyms for the various gases, review slide 1.2.

Answer: The correct response is Number 1 (LPG or Propane).

1.95 What is the correct abbreviation for compressed natural gas?

What is the correct abbreviation for compressed natural gas?

1. LPG or Propane
2. CNG
3. LNG
4. PPG

To review the acronyms for the various gases, review slide 1.2.

Answer: The correct response is Number 2 (CNG).

1.96 When inspecting an LNG/CNG or LPG CMV for gas leaks, ____.

When inspecting an LNG/CNG or LPG CMV for gas leaks, _____.

1. The engine should be warm, but turned off.
2. The engine should be running.
3. The transmission should be in neutral.
4. The engine should be turned off.

To review the engine conditions during an inspection for a leak, watch the video in slide 1.89

Answer: The correct response is Number 2. The engine should be running; fuel will be flowing throughout the fuel system.

1.97 Fuel leaks in CNG/LNG or LPG CMVs can be detected and verified by ____. (Select two.)

Fuel leaks in CNG/LNG or LPG CMVs can be detected and verified by _____. (Select two.)

1. The smell of leaked gas
2. The presence of a vapor cloud around the vehicle
3. Conducting a soap bubble test on components of the fuel system
4. Using a combustible gas detector to detect concentrations of combustible gas greater than 5,000 ppm in enclosed compartments on the vehicle or near components in the fuel system

To review how to detect and verify fuel leaks, refer to slides 1.65, 1.66, and 1.69-1.73..

Answer: The correct response is Number 3 and Number 4.

1.98 Where do you insert the leak detector probe to detect an accumulation of LPG in the vehicle cab?

Where do you insert the leak detector probe to detect an accumulation of LPG in the vehicle cab?

1. Near the floor
2. Close to the ceiling
3. By the front window
4. At the back of the cab

To review where to place the leak detector probe to detect an accumulation of LPG in the vehicle cab, watch the video in slide 1.89.

Answer: The correct response is Number 1 (near the floor).

1.99 Where do you insert the leak detector probe to detect a CNG/LNG accumulation in the vehicle's engine compartment?

Where do you insert the leak detector probe to detect a CNG/LNG accumulation in the vehicle's engine compartment?

1. Underneath the engine
2. Immediately under the hood
3. In the front of the engine compartment
4. In the back of the engine compartment

To review where to insert the leak detector probe to detect a CNG/LNG accumulation in the vehicle's engine compartment, review the video in slide 1.89.

Answer: The correct response is Number 2 (immediately under the hood).

1.100 On a CMV, a hazard is created when leaked natural gas or LPG accumulates in the ____. (Select all that apply.)

On a CMV, A hazard is created when leaked natural gas or LPG accumulates in the _____. (Select all that apply.)

1. Vehicle cab
2. Fuel tank compartment
3. Cargo compartment
4. Engine compartment

To review where a hazard may be created when leaked natural gas or LPG accumulates, refer to slides 1.48, 1.68, and 1.73 and watch the videos in slides 1.88 and 1.89.

Answer: The correct response is all of the above (Numbers 1 through 4).

1.101 What are the most likely places for leaks in CNG, LNG, or LPG fuel systems? (Select all that apply.)

What are the most likely places for leaks in CNG, LNG, or LPG fuel systems? (Select all that apply.)

1. Where the fuel line connects to the engine.
2. All threaded joints or connectors in fuel lines.
3. At the fuel fill portal.
4. At fuel filter connections.
5. Where the fuel line enters the engine compartment.
6. On the side of the fuel cylinder.

To review the most likely places for leaks in CNG, LNG, or LPG fuel systems, review slide 1.64, and watch the video in slide 1.89.

Answer: The correct response is Numbers 1 through 4 (where the fuel line connects to the engine; all threaded joints or connectors in fuel lines; at the fuel fill portal; at fuel filter connections).

1.102 When should you check for combustible gas in a vehicle's cargo compartment? (Select all that apply.)

When should you check for combustible gas in a vehicle's cargo compartment? (Select all that apply.)

1. Always.
2. Only if you smell gas.
3. When fuel tanks are mounted inside the cargo compartment.
4. When fuel tanks are mounted between the frame rails under the floor of the cargo compartment.

To review when should you check for combustible gas in a vehicle's cargo compartment, review slide 1.73, and watch the video in slide 1.89.

Answer: The correct response is Number 3 and Number 4 (when fuel tanks are mounted inside the cargo compartment and when fuel tanks are mounted between the frame rails under the floor of the cargo compartment).

1.103 What should you do when you smell gas in the engine compartment of a CNG CMV tractor? (Select all that apply.)

What should you do when you smell gas in the engine compartment of a CNG CMV tractor? (Select all that apply.)

1. Declare the tractor out-of-service.
2. Check for accumulated gas in the engine compartment using a combustible gas detector.
3. Check for accumulated gas in the vehicle cab using a combustible gas detector.
4. Conduct a leak test of all accessible fuel system components using a combustible gas detector or a soap bubble test.

To review what you should do when you smell gas in the engine compartment, refer to slide 1.65, and watch the videos in slides 1.88 and 1.89.

Answer: The correct response is Number 2, Number 3, and Number 4.

1.104 What is the minimum concentration of combustible gas detected with a combustible gas detector that is required to declare a CNG or LNG vehicle out-of-service?

What is the minimum concentration of combustible gas detected with a combustible gas detector that is required to declare a CNG or LNG vehicle out-of-service?

1. 2,000 ppm
2. 5,000 ppm
3. 10,000 ppm
4. 12,500 ppm
5. 25,000 ppm

To review what is the minimum concentration of combustible gas, detected by a combustible gas detector, that is required to declare a CNG or LNG vehicle out-of-service, refer to slide 1.45, 1.69-1.73, and watch the videos in slide 1.88-1.89.

Answer: The correct response is Number 2 (5,000 ppm).

1.105 What is the minimum concentration of combustible gas detected with a combustible gas detector that is required to declare an LPG vehicle out-of-service?

What is the minimum concentration of combustible gas detected with a combustible gas detector that is required to declare an LPG vehicle out-of-service?

1. 2,000 ppm
2. 5,000 ppm
3. 7,500 ppm
4. 10,000 ppm
5. 12,500 ppm

To review what is the minimum concentration of combustible gas, detected by a combustible gas detector, that is required to declare an LPG vehicle out-of-service, refer to slides 1.44 and 1.69 through 1.73, and watch the videos in slides 1.88 and 1.89.

Answer: The correct response is Number 2 (5,000 ppm).

1.106 When using a combustible gas detector to check for fuel leaks on a CNG tractor and trailer, you detect a concentration of 6,000 ppm of combustible gases at the top of the fuel tank compartment on the tractor. What should you do?

When using a combustible gas detector to check for fuel leaks on a CNG tractor and trailer, you detect a concentration of 6,000 ppm of combustible gases at the top of the fuel tank compartment on the tractor. What should you do?

1. Declare the trailer out-of-service.
2. Declare the driver out-of-service.
3. Declare the tractor out-of-service.
4. Give the driver a repair order, or issue a Violation of the Minimum Periodic Inspection Standards.
5. Declare the tractor and trailer out-of-service, in combination.

To review when to declare a vehicle out-of-service, refer to slides 1.69 through 1.73, and watch the videos in slides 1.88 and 1.89.

Answer: The correct response is Number 3 (declare the tractor out-of-service).

1.107 When using a combustible gas detector to check for fuel leaks on an LNG tractor and trailer, you detect a concentration of 7,000 ppm of combustible gas at one of the connections on the end of the LNG tank, which is mounted on the outside of the frame rail underneath and behind the vehicle cab. What should you do?

When using a combustible gas detector to check for fuel leaks on an LNG tractor and trailer, you detect a concentration of 7,000 ppm of combustible gas at one of the connections on the end of the LNG tank, which is mounted on the outside of the frame rail underneath and behind the vehicle cab. What should you do?

1. Declare the trailer out-of-service.
2. Declare the driver out-of-service.
3. Declare the tractor out-of-service.
4. Declare the tractor and trailer out-of-service, in combination.
5. Give the driver a repair order, or issue a Violation of the Minimum Periodic Inspection Standards.

To review when to declare a vehicle out-of-service, refer to slides 1.69 through 1.73, and watch the videos in slides 1.88 and 1.89.

Answer: The correct response is Number 3 (declare the tractor out-of-service).

1.108 When using a combustible gas detector to check for fuel leaks on a CNG tractor and trailer, you detect a concentration of 6,000 ppm of combustible gas at the fuel filter. You do not detect combustible gas elsewhere. What should you do?

When using a combustible gas detector to check for fuel leaks on a CNG tractor and trailer, you detect a concentration of 6,000 ppm of combustible gas at the fuel filter. You do not detect combustible gas elsewhere. What should you do?

1. Declare the trailer out-of-service.
2. Declare the driver out-of-service.
3. Declare the tractor out-of-service.
4. Declare the tractor and trailer out-of-service, in combination.
5. Give the driver a repair order, or issue a Violation of the Minimum Periodic Inspection Standards.

To review when to declare a vehicle out-of-service, refer to slides 1.69 through 1.73, and watch the videos in slides 1.88 and 1.89.

Answer: The correct response is Number 3 (declare the tractor out of service).

1.109 When using a combustible gas detector to check for fuel leaks on an LPG tractor and trailer, you detect a concentration of 4,000 ppm of combustible gas on the floor of the vehicle cab. You do not detect combustible gas elsewhere. What should you do?

When using a combustible gas detector to check for fuel leaks on an LPG tractor and trailer, you detect a concentration of 4,000 ppm of combustible gas on the floor of the vehicle cab. You do not detect combustible gas elsewhere. What should you do?

1. Declare the trailer out-of-service
2. Declare the driver out-of-service
3. Declare the tractor out-of-service
4. Declare the tractor and trailer out-of-service, in combination
5. Give the driver a repair order, or issue a Violation of the Minimum Periodic Inspection Standards

To review when to declare a vehicle out-of-service, refer to slides 1.69 through 1.73, and watch the videos in slides 1.88 and 1.89.

Answer: The correct response is Number 5 (give the driver a repair order, or issue a Violation of the Minimum Periodic Inspection Standards).

1.110 When using a combustible gas detector to check for fuel leaks on an LNG straight truck, you detect a concentration of 6,000 ppm of combustible gas near the ceiling of the cargo compartment. You don't detect combustible gas anywhere else. What should you do?

When using a combustible gas detector to check for fuel leaks on an LNG straight truck, you detect a concentration of 6,000 ppm of combustible gas near the ceiling of the cargo compartment. You don't detect combustible gas anywhere else. What should you do?

1. Let the driver proceed.
2. Declare the driver out-of-service.
3. Declare the truck out-of-service.
4. Give the driver a repair order, or issue a Violation of the Minimum Periodic Inspection Standards.

To review when to declare a vehicle out-of-service, refer to slides 1.69 through 1.73, and watch the videos in slides 1.88 and 1.89.

Answer: The correct response is Number 3 (declare the truck out-of-service).

1.111 When using a combustible gas detector to check for fuel leaks on a CNG/LNG or LPG CMV, you should always check for concentrations of combustible gas in the following places.

When using a combustible gas detector to check for fuel leaks on a CNG/LNG or LPG CMV, you should always check for concentrations of combustible gas in the following places.

1. In the vehicle cab
2. In the fuel tank compartment
3. In the cargo compartment
4. In the engine compartment
5. At the fuel fill port
6. At the fuel filter
7. At fuel valves and connections in the fuel system
8. At fuel pressure regulators

To review where to check for fuel leaks on a CNG/LNG or LPG CMV, using a combustible gas detector, refer to slides 1.64 and 1.70, and watch the video in slide 1.89.

Answer: The correct response is Numbers 1, 2, and 4 through 8.

1.112 Which statements are true about CNG, LNG, or LPG CMVs that have been declared out-of-service for a fuel leak? (Select all that apply.)

Which statements are true about CNG, LNG, or LPG CMVs that have been declared out-of-service for a fuel leak? (Select all that apply.)

1. The part of the fuel system with a confirmed leak must be isolated and defueled by a qualified technician before the vehicle is moved by a tow truck to a repair shop
2. The vehicle must not be moved or parked indoors unless the indoor facility is approved for storage of NG or LPG vehicles by the authority having jurisdiction
3. The vehicle may not be operated until the leak is repaired and the out-of-service order is removed by the CMV enforcement agency that issued the order
4. After the part of the fuel system with a confirmed leak has been isolated and defueled by a qualified technician, the CMV may be parked indoors at any facility

To review regulations for CNG, LNG, or LPG CMVs that have been declared out-of-service for a fuel leak, refer to slide 1.74.

Answer: The correct response is Numbers 1, 2, and 3.

1.113 Results

The interactive version of the training auto-generates user scores based on responses to the knowledge checks and test. A passing score is 80 percent.

1.114 Acknowledgements

- Federal Motor Carrier Safety Administration, U.S. Department of Transportation: funding of the training.
- Commercial Vehicle Safety Alliance: review of the training.
- EnDyna: instructional design contractor.
- M J Bradley & Associates: subject matter expertise.
- Ryder: provider of the natural gas trucks used for the leak detection demonstration.

1.115 Resources

2012_ NAS_ Inspection Brochure

Natural-Gas-Systems-Report revised 5-2013

Training Bulletin for Natural Gas Commercial Vehicles

Recommended Combustible Gas Detectors Follow-up Memo_01152014

1.116 Glossary

(C2H6): ethane

(C3H8): propane

(C4H10): butane

(C5H12): pentane

(symbol °F): Fahrenheit (symbol °F) is a temperature scale based on one proposed in 1724 by the physicist Daniel Gabriel Fahrenheit (1686-1736), after whom the scale is named. On Fahrenheit's original scale the lower defining point was the lowest temperature to which he could reproducibly cool brine (defining 0 degrees), while the highest was that of the average human core body temperature (defining 100 degrees)

BTU: British Thermal Unit

CFR: Code of Federal Regulations

CH4: Methane

CMV: Commercial Motor Vehicle

CNG: Compressed Natural Gas

CVSA: Commercial Vehicle Safety Alliance

degree Celsius (°C): Celsius, also known as centigrade,[1] is a scale and unit of measurement for temperature. It is named after the Swedish astronomer Anders Celsius (1701-1744), who developed a similar temperature scale. The degree Celsius (°C) can refer to a specific temperature on the Celsius scale as well as a unit to indicate a temperature interval, a difference between two temperatures or an uncertainty. The unit was known until 1948 as "centigrade" from the Latin centum translated as 100 and gradus translated as "steps".

FMCSA: Federal Motor Carrier Safety Administration

FMCSRs: Federal Motor Carrier Safety Regulations

Mercaptan: Mercaptan is also known as methanethiol and is a harmless but pungent-smelling gas which has been described as having the stench of rotting cabbages or smelly socks. It is often added to natural gas, which is colorless and odorless, to make it easier to detect.

NAS: North American Standard

NTC: National Training Center

OOS: Out-Of-Service Criteria contained in 49 CFR Chapter III, Subchapter B, Appendix G.

Ppm: Parts Per Million

Psi: Pounds Per Square Inch

Scf: Standard Cubic Foot

TPI: Test Products International

C2+ hydrocarbons: Hydrocarbons with more than one carbon atom in each molecule, for example ethane (C2H6) with two carbon atoms and six hydrogen atoms in each molecule, propane (C3H8) with three carbon atoms, and butane (C4H10) with four carbon atoms

NFPA: National Fire Protection Association

Parts Per Million: ppm

LEDs: Light-emitting Diodes

LFL: Lower Flammable Limit

PRV: Pressure Relief Valve

UFL: Upper Flammable Limit

LPG: Liquefied Petroleum Gas

LNG: Liquefied Natural Gas