



Code-Compliant Maintenance Facility Modification Training

Introductions: Clean Cities

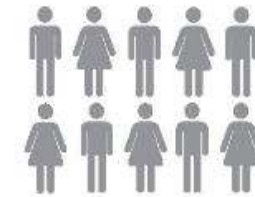
- The U.S. Department of Energy's (DOE's) Clean Cities program advances the nation's economic, environmental, and energy security by supporting local actions to cut petroleum use in transportation.
 - Clean Cities has saved more than 8.5 billion gallons of petroleum since its inception in 1993.
 - 100 local coalitions serve as the foundation of the Clean Cities program.
- This series of workshops was supported by a competitively awarded, cost-shared agreement from the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy (EERE), under Award Number DE-EE0007815.

Introductions: Gas Technology Institute

Independent, not-for-profit established to tackle tough energy challenges, turning raw technology into practical solutions.



- Idea
- Market Analysis
- Technology Analysis
- Product Development
- Lab and Field Testing
- Demonstration
- Commercialization



RESEARCH & DEVELOPMENT



PROGRAM MANAGEMENT



TECHNICAL/ ANALYTICAL



CONSULTING



TRAINING

Introductions:



Clean Energy Fuels Corp. is the leading provider of natural gas fuel for transportation in North America.

Clean Energy builds and operates CNG and LNG vehicle fueling stations; manufacture CNG and LNG equipment and technologies; and deliver more CNG and LNG vehicle fuel than any other company in the U.S.

Clean Energy also sells Redeem RNG fuel and believes it is the cleanest transportation fuel commercially available, reducing greenhouse gas emissions by up to 70%. For more information, visit www.CleanEnergyFuels.com.

The FMS Division within CE was formed in 2012 and has completed over 2,000,000 sq ft of garage space!

Goals

- Summarize applicable codes for NGV garages
- Explain the Detect, Dilute, Extract strategy
- Make recommendations on how to execute the strategy
- Review additional recommended safety measures

Properties

- Methane (CH₄) is the main component of natural gas.
- It is flammable, but only within a narrow concentration range of air to natural gas mixtures.
- Flammability Limits - If natural gas is present in amounts between 5%–15% by volume, the gas may ignite.
- Natural gas is lighter than air and will rise to the top of a structure. This required a detailed review of current codes.

Methane Properties

Compound	Formula	Density (lb/ft ³) Gases @ STP	Auto-Ignition Temperature (°F)	Lower Flammability Limit (LFL) %	Upper Flammability Limit (UFL) %
CNG (Methane)	CH₄ (majority)	0.045	1,004	5.3	15.0
Propane	C ₃ H ₈	0.12	850-950	2.2	9.5
Gasoline	C ₈ H ₁₈	0.29	495	1.4	7.6
Diesel	-	>0.38	600	1.0	6.0
Hydrogen	H ₂	0.0056	1,050-1,080	4.1	74.00
Air	-	0.0806	-	-	-

Risks

- CNG - basic hazard is the unintended release while the vehicle is in the repair garage. Risks include:
 - CNG is a flammable fuel
 - Lighter than air
 - Flammability range 5% to 15% by volume
 - CNG is stored at high pressure
- LNG – basic hazard is accidental spill or slow release and accumulation from the tank relief valve. Risks include:
 - Similar risks as CNG
 - Initially heavier than air
 - A secondary risk of LNG is the potential for cryogenic burns



Code Requirements

Applicable Codes

- There are a number of codes and ordinances dealing with the design and use of a CNG or LNG vehicle maintenance facility.
- Primary Codes:
 1. International Fire Code
 2. NFPA 30A: Code for Motor Fuel Dispensing Facilities and Repair Garages
 3. Local jurisdiction amendments & adoptions
 4. Canada

Extension of Applicable Codes

- Maintenance facility modifications for alternative fuels may also be subject to the following codes:
 - International Building Code
 - International Fire Code
 - NFPA 52 – Vehicular Gaseous Fuel Systems Code
 - NFPA 51B – Hot Works
 - NFPA 88A – Standard for Parking Structures
 - NFPA 101 Life and Safety

Code Overview

- Codes that govern maintenance garages are written as guidelines, not design documents. Interpretation of these guidelines is what makes this process confusing and a bit tricky.
- The aim of the codes is to:
 - Protect Personnel and Facility
 - Detect, Dilute, and Extract potential leaks
 - Minimize ignition sources



Major vs. Minor Garages

What Maintenance Falls Under the Code

- When considering a facility modification upgrade, it is important to know if the garage will be a major or minor facility after modification.
 - What repairs are under-way now?
 - What does any future expansions need to include?
- It is essential to determine what areas of a maintenance facility are considered major and minor, as they will have different requirements.

Minor Garages

- A minor repair garage is defined as:

A building or portions of a building used for lubrication, inspection, and minor automotive maintenance work, such as engine tune-ups, replacement of parts, fluid changes (e.g., oil, antifreeze, transmission fluid, brake fluid, air conditioning refrigerants, etc.), brake system repairs, tire rotation, and similar routine maintenance work, including associated floor space used for offices, parking, or showrooms.

Major Garages

- A major repair garage is defined as:

A building or portions of a building where major repairs, such as engine overhauls, painting, body and fender work, and repairs that require draining of the motor vehicle fuel tank, are performed on motor vehicles, including associated floor space used for offices, parking, or showrooms.

Major and Minor Garages



Key Concepts

- **Detect** – Install a properly designed / functioning methane detection system.
- **Dilute** – Provide a means for fresh air to enter the facility.
- **Extract** – Explosion-proof ventilation on stand-by in case of a leak



Gas Detection

The “Detect” part of Detect, Dilute, Extract

Gas Detection Systems

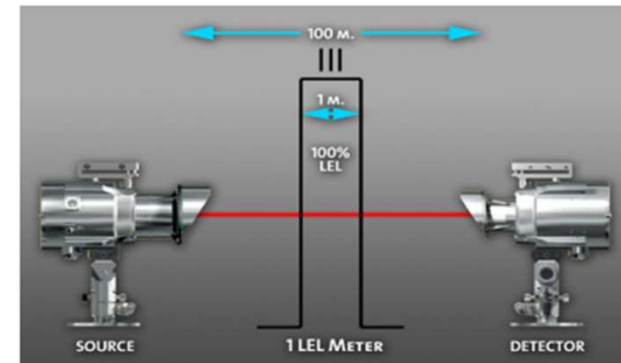
- The primary functions of a combustible gas detection and alarm system are to:
 - Provide warning to occupants that a methane gas release has occurred.
 - Initiate actions to eliminate potential ignition sources.
 - Initiate actions to dilute and extract mixtures of natural gas until levels fall below the LFL.
- Gas detection systems are typically not required by code but are always included as best practices.

Gas Detection Operation with LFL

- Combustible gas detectors used in natural gas vehicle maintenance facilities are designed and calibrated to measure methane concentrations as a percentage of the LFL.
- Gas detectors read from 0%–100% of the LFL
 - A reading of 100% would mean that the LFL has been reached (5% methane in air).
 - A reading of 20% would indicate that the actual concentration of methane in the air is 1%.
- Using this scale, methane detection controllers can be programmed to provide alarms at any concentration.

Gas Detection Systems

- There are two main types of combustible gas detectors used in our industry: infrared and catalytic bead.
 - Infrared detectors are available as either a point-type monitor or an open-path design.
 - IR type detectors are the most common detector today, but there are other options.



Gas Detection Systems

- Generally, combustible gas detectors:
 - Should be near the highest point of the structure's ceiling.
 - May be at intermediate locations to “intercept” the likely path that a vapor release would take as it rises to the high point.
- The number, location, and spacing of detectors must be determined by a licensed design engineer and approved by the AHJ.
- Because the gas detectors are located on or near the structure's ceiling, it is important to select detectors that are equipped with a calibration means that does not require direct access.



Ventilation

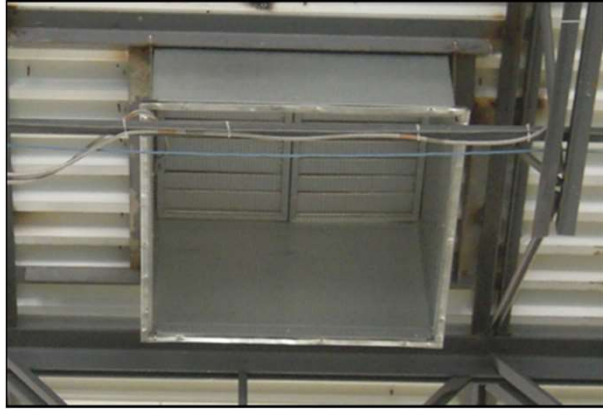
The “Dilute” and “Extract” parts of “Detect, Dilute, Extract”

Ventilation Requirements

- Both NFPA 30A and IFC use ventilation as a primary strategy to prevent natural gas accumulations at concentrations within the combustible range.
- Daily ventilation vs Emergency ventilation
- Most garages use one of three options for emergency ventilation:
 1. Continuously
 2. Upon demand for ventilation triggered by the methane detection system
- Continuous or on-demand ventilation will quickly dilute and extract a natural gas release so that the gas concentration quickly returns below the LFL and may prevent reaching the LFL entirely.

Ventilation Strategies

- The codes do not specifically address how the ventilation is to be achieved.
- The most common form of facility ventilation is roof-mounted up-blast fans that exhaust to the atmosphere in a safe area. These exhaust fans can pull air directly from the space via the fan inlets or through ductwork.



Ventilation Strategies

- Roof-mounted fans require certain characteristics to be suitable for use in a natural gas vehicle maintenance facility:
 - The fan blades and shrouds must be constructed from non-sparking materials (i.e., plastic or aluminum) to prevent the potential of igniting a release.
 - The electric motor that drives the fan must be explosion-proof or located where the fan intake or exhaust does not pass over the electric motor.

Ventilation Strategies – Makeup Air

- Sufficient makeup air is needed to properly dilute and extract a natural gas leak. Potential sources are:
 - In-wall louvers
 - Powered sidewall fans
 - Open bay doors
- Makeup air needs to come from the outdoors, away from exhaust vents.
- Makeup air inlets should be located away from the ceiling to bring air in, up, and out.

Paths of Migration

- Because natural gas is lighter than air, any release will rise. The plume of gas will tend to migrate as it rises.
- Paths of migration are also affected by air movement within the maintenance facility. For this reason, a maintenance facility must include a properly designed ventilation system to ensure all of the gas is removed.
- The gas cannot be allowed to migrate out of the protected area into spaces adjacent to the upgraded shop. This can be accomplished by:
 - Pressurizing adjacent areas and sealing gaps in the structure will prevent migration of natural gas into unprotected areas.

Examples of Migration Paths



- Stairways accessing an upper level will allow the gas to move into a second floor.
- This potential path of migration could be cut off by installing a door that would prevent upward gas flow.
- The door must be fitted with a self-closing mechanism to keep it closed except when in use. The door should also have edge seals to ensure gas can't leak around the door into adjacent spaces.

Ventilation in Pits – Lower Classified Zone

- LNG vapors are cold, dense, and may be heavier than air. LNG will pool and LNG vapors may temporarily sink into sub-grade areas or pits.
- Ventilation requirements for pits are part of the basic requirements for liquid fuels. This requirement should already be met by the existing maintenance facility. However, the codes are not harmonized as to the ventilation rate.
- In pits, IFC requires 1.5 cfm/sqft while NFPA requires 1.0 cfm/sqft.
- LNG will also require detection in the pits or sub-grade areas.



Sources of Ignition

Space Heating

- NFPA 30A states that *“open flame heaters or heating equipment with exposed surfaces having a temperature in excess of 750 °F shall not be permitted in areas subject to ignitable concentrations of gas.”*
- Because it is difficult to separate *“areas subject to ignitable concentrations of gas,”* all heating devices in a major repair garage may be subject to this limitation.
- The IFC does not have any specific requirements for CNG and LNG repair garages with respect to sources of ignition. Low-lying heaters are an issue in LNG facilities.



18” Classified Zones

18” Classified Zones

- Code focuses on electrical sources of ignition in the area 18” on the under-side of the ceiling
- This space is considered a Class I, Division 2 Zone.
- Electrical devices located in this area need to meet Class I, Division 2 specification unless the structure has an effective continuous ventilation rate of at least 4 air changes per hour.
- If the structure does not have a continuous ventilation rate of at least 4 air changes per hour:
 - Existing electrical devices that do not meet the Class I, Division 2 specification must be relocated outside of the classified zone.
 - Devices may be replaced with electrical devices rated Class I, Division 2.

Electrical Classification

- Electrical appliances must meet Class I, Division 2 requirements (i.e. explosion proof or intrinsically safe) or they must be relocated or eliminated from the hazardous zone.
- Examples of equipment that might be an ignition risk
 - Fans
 - Lights
 - Conduit
 - Garage door motors
 - Cranes





Alarm Systems

Best Practice - Alarms

- NFPA 30A states that a detection level of 25% of the LFL should be used to initiate alarms and other actions.
- The use of two gas detection levels rather than a single value has gained wide acceptance, but still needs AHJ approval.
- A two-level approach reduces the incidence of “nuisance” alarms while still ensuring personnel and facility safety.
- Example: using two levels 20% and 40% of the LFL
 - 20% detection occurs earlier so that protective actions can be initiated and self re-set.
 - 40% detection triggers more extreme actions and latches.



Shunt Trips

- Electrical circuits may be modified so that shunt trips are provided on all non-critical electrical circuitry.
- Shunt trips are recommended for any spark producing equipment in a shop.
- The following items should not be on shunt trips:
 - Electric controls for automatically opening overhead doors and other sources of makeup air
 - Ventilation fans
 - Gas detection and alarm systems and controls
 - Emergency lighting
 - Critical data collection or storage functions (computers, servers, etc.).

Review

- **Detect** - Gas detection systems that alarm at 20% and 40% of LEL
- **Dilute** - Bring in fresh makeup air from near the floor.
- **Extract** - Intermittent, Continuous, or Natural ventilation
- **Eliminate Ignition Sources** -Locate electrical and heating devices away from potential gas collection zones or by installing electrically classified equipment.

Training

- While physical modifications to the maintenance facility will help mitigate any potential hazard from adding CNG and LNG vehicles to facility operations, proper training of personnel is critical to maintaining a safe work environment.
- The training program may cover the following:
 - The physical properties of compressed natural gas
 - The physical properties of liquefied natural gas
 - Hazards associated with CNG
 - Hazards associated with LNG
 - Operation and use of hand held flammable gas detectors
 - Manufacturer's instructions for maintenance, operation and calibration natural gas detection systems installed in the garage

Training

– The training program can also cover:

- Instructions and recommended maintenance procedures for the onboard fuel storage system and engine fueling components for both CNG and LNG vehicles
- Cylinder or cylinder valve manufacturer instructions for defueling and valve maintenance or removal
- Instructions for maintenance and calibration of on board LNG vehicle natural gas detection systems
- CNG cylinder inspection certification of at least one maintenance technician
- Consider ASE certification of CNG vehicle technicians (F1 Test)

FACILITY MODIFICATION- STRATEGY

Facility Assessment / Gap Analysis

- Classified Zones
- Appliances
- Roof and Wall Construction
- Mechanical Exhaust and Supply for Ventilation
- Electrical System Capacity
- Conceptual Plan
- Cost Estimate
- Alternatives

Engineering Design

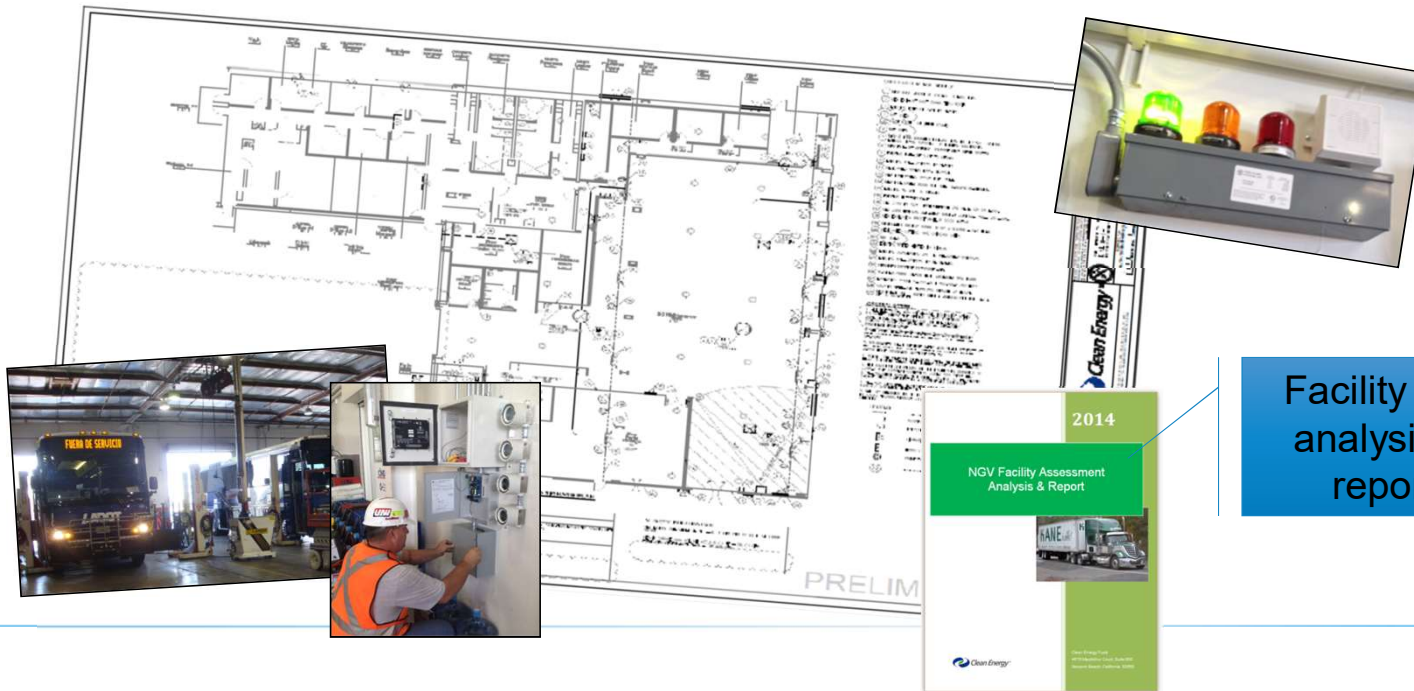
- Develop Detailed Construction Documents
- Complete Permitting through Local Jurisdiction
- Fire Plan

Construction

- Construction Administration
- Experienced Supervisors and Craftsmen
- Qualified contractors
- Industrial Equipment
- Startup, Testing & Training

FACILITY MODIFICATIONS - OPTIONS

Full or partial shop modifications



Facility gap analysis & report

FIT SERVICE PROGRAM

The successful function of a gas detection and mitigation system hinges on a properly executed service plan.



Program Details:

- Trained OEM certified technicians.
- Bi-annual testing (recommended), inspections, and light maintenance is performed on mechanical and electrical system components.
- System health is evaluated, and potential trouble points identified, including recommended remediation measures provided.
- A report is generated for the client.
- Record keeping, data logging, and on-going support, available.

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