

***Technical Guideline for the Design and
Operation of Facilities Used For Indoor
Repair, Storage and Cargo
Handling for Vehicles Fuelled by
Compressed Natural Gas and
Liquefied Natural Gas***

Prepared for

*Canadian Natural Gas Vehicle Alliance
350 Sparks Street
Suite 809
Ottawa, On
K1R 7S8*

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Alicia Milner, Canada Natural Gas Vehicle Alliance
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Prepared by

CHANGE

Change Energy Services Inc.
229 St. Clair Street, Suite 300
Chatham, ON N7L 3J4
Canada

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How to Use This Technical Guideline

This document is intended to be a reference guideline related to facility design and operations issues at indoor facilities used for the repair, storage or cargo handling of CNG and LNG fuelled vehicles. It is not a comprehensive specification. Each situation has unique characteristics and the facility designer / operator working in conjunction with a knowledgeable technical expert has the latitude to develop the appropriate solutions to individual problems, all within the context of building and operating a safe and efficient CNG / LNG support facility. The user should consider a few key issues when following this guideline:

1. A fundamental requirement for the renovation of an existing facility or the construction of a new facility is to “meet code”. Become familiar with the applicable municipal, provincial and federal codes, standards and regulations and understand how they will apply to your plans.
2. There are many similarities between the requirements for CNG facilities and LNG facilities but there are some critical differences too. Decide up front whether your facility will host CNG only vehicles, LNG only vehicles, or both CNG and LNG vehicles. Generally speaking, facilities that can host LNG vehicles can also host CNG vehicles but facilities that can host CNG vehicle will likely require additional safeguards to host LNG vehicles. Understanding the differences from the outset can save time and money depending on future plans for the fleet and its support facilities.
3. Know your limitations. This guideline does not provide “all the answers” to the several topics that must be addressed for a proper CNG / LNG facility operation. It may be necessary to engage your Architectural / Engineering team, fuel supplier, vehicle supplier, etc. in order to properly deal with all the issues.
4. This guideline does not speak in any way to issues related to vehicle use and vehicle repair. Consult with the manufacturer or dealer of the vehicle for concerns related to the CNG / LNG equipment installed on the vehicle.

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1.0 INTRODUCTION

Natural gas as a transportation fuel is attracting interest from government and fleet owners. Natural gas presently is seen to be in abundant supply. It is therefore relatively less expensive than other hydrocarbon fuels and it is generally thought that the price of natural gas will be stable for many years. Furthermore, natural gas when used as a transportation fuel is “cleaner” than its petroleum counterparts such as gasoline or diesel. Improvements with respect to Greenhouse Gas Emissions (GHG’s) and Criteria Air Containments (CAC’s) can be expected. In order to be used as a transportation fuel, natural gas must be processed to high pressure (compressed natural gas / CNG) or processed to its cryogenic liquid state (liquefied natural gas / LNG). CNG is often used by short haul, return to base fleets. Refuse collection trucks and transit buses are good applications for CNG Fleets. LNG can provide extended range compared to CNG and is better suited to over-the-road highway fleets.

Just like any other fleet vehicle, CNG / LNG fuelled vehicles require periodic maintenance and repair. Some fleet operators also choose to store their vehicles indoors when they are not in service. In addition, fleet operators may choose to load/unload cargo from these types of vehicles in an indoor area via loading ramps or other facility access points. Please note that this guideline is not intended to apply to the occasional parking of cars or other light duty vehicles in public or private parking garages. The focus is on facilities that are purpose built to host CNG / LNG fuelled medium and heavy duty vehicles and on existing facilities that need to be modified to safely repair, store or load CNG / LNG vehicles.

Canada does not currently have a code specifying the requirements for maintaining, storing, and/or cargo handling of natural gas fuelled vehicles indoors. This gap was one of ten codes and standards issue areas highlighted in the March 2011 report, *Natural Gas Use in Transportation – Capacity Building Initiative Five-Year Codes & Standards Workplan*.¹

The timeline to develop a new code is estimated at two to three years. In the interim Natural Resources Canada (NRCan) and the Canadian Natural Gas Vehicle Alliance (CNGVA) have determined that a technical guideline that defines the requirements that must be met for safe indoor CNG / LNG vehicle maintenance, storage, and / or cargo loading would be useful to fleet end users and the dealers who sell and service medium and heavy duty CNG / LNG vehicles. With funding support from NRCan, the CNGVA engaged Change Energy Services Inc. to develop a technical guideline to serve as a common reference and resource for use across Canada. The technical guideline will aid fleet facility owners, architectural / engineering firms and building contractors to determine the requirements for existing or planned new facilities to ensure they are safe for CNG / LNG vehicles maintenance, repair, storage or cargo handling.

¹ End users who implement a natural gas vehicle project within their fleets must currently refer to a range of codes, standards, and guidelines to determine what must be done to make an existing or a new facility suitable for servicing and / or storing LNG- and CNG-fuelled vehicles.

2.0 REFERENCED PUBLICATIONS

Listed below are several Codes, Standards and Guidelines that are relevant to the design and operation of facilities where vehicles fuelled by CNG and LNG are repaired, stored or parked for cargo handling:

No.	Type	Edition	ID No.	Title
1	Code	2001	CSA B108	Natural Gas Fuelling Stations Installation Codes
2	Code	2008	NFPA 30A	Code for Motor Fuel Dispensing Facilities and Repair Garages
3	Code	2010	NFPA 52	Vehicular gaseous fuel systems code
4	Standard	2011	NFPA 88A	Standard for Parking Structures
5	Guideline	1996	DOT-FTA-MA-26-7021-96-1	Design Guidelines for Bus Transit Systems using compressed natural gas as an alternative fuel
6	Guideline	1997	DOT-FTA-MA-26-7021-97-1	Design Guidelines for Bus Transit Systems using Liquefied Natural Gas (LNG) as an alternative fuel
7	Guideline	2011		Westport HD Dealer Information Package

To the extent possible we have attempted to refer to applicable sections / paragraphs / clauses of the above listed codes and standards where they are relevant to the subject matter of the topic being discussed. However, copyright laws preclude the reproduction of any of the actual text of the publications. Users of this guideline are encouraged to purchase the publications that are applicable to the fuel type(s) and facility type(s) that are being evaluated for renovation or new construction. The library listed herein is available for internet purchase and the total cost will be in the order of \$400 CDN (2012 prices). It should be noted that the online licensing agreements typically restrict the purchase transaction to one person and one download. For additional information contact:

1. Canadian Standards Association
178 Rexdale Boulevard
Toronto, ON
M9W 1R3
416-474-4000
www.csa.ca
2. National Fire Protection Association
1 Batterymarch Park
Quincy, MA
02269-9101
617-984-9101
www.nfpa.org
3. US Department of Commerce
National Technical Information Service
Springfield, Virginia 22161
www.ntis.gov

4. Westport Innovations Inc.
101-1750 West 75th Avenue
Vancouver, BC
V6P 6G2
1-888-978-4734
www.westport-hd.com

5. [Cummins Westport](http://www.cumminswestport.com)
101-1750 West 75th Avenue
Vancouver, BC
V6P 6G2
www.cumminswestport.com

3.0 PHYSICAL PROPERTIES OF CNG / LNG

3.1 Natural Gas

Natural gas consists mostly of methane, typically more than 95% with the balance made up of other “longer chain” gaseous hydrocarbons such as ethane and propane. In addition, minor amounts of “trace gases” such as carbon dioxide, nitrogen, sulfur and water vapour are usually found in pipeline grade natural gas.

Natural gas is colorless, odourless and tasteless. By regulation, pipeline natural gas is odorized (usually with a chemical called mercaptan). Mercaptan has a foul, rotten-egg like smell. It is added in low amounts, sufficient for the average person to smell the natural gas at a concentration of 1% natural gas in the air. At room temperature and atmospheric pressure, natural gas is about 55% of the density of air and will rise if released from its container.

Measurement of natural gas usually references Standard Temperature and Pressure (STP) (Inch Pound units, IP) or Normal Temperature and Pressure (NTP) (Standard International units, SI). Unfortunately, the engineering and scientific communities have not been able to agree on one global standard for STP and NTP. For the purposes of this technical guideline we will define STP using 70°F and 0 psig and NTP using 0°C and 0 barg.

Note: Conversion from IP to SI or SI to IP is not a simple geometric calculation due to the different reference temperatures. The geometric volume conversion is 1 cubic metre x 0.028317 = 1 cubic foot. The gas volume conversion is 1 Normal cubic metre x 0.026853 = 1 standard cubic foot.

3.2 Compressed Natural Gas

Natural gas at Normal temperature and pressure has very low energy density compared to liquid petroleum fuels. One Normal litre of natural gas has an energy content in the order of 0.0372 megajoules. One litre of diesel fuel has an energy content of about 38.68 megajoules. In order to use natural gas in its gaseous form as a vehicle fuel it is typical to compress it in order to store more energy in the same volume. In Canada, natural gas for vehicles can be handled at 200 barg² at public fuelling stations or 250 barg at private fuelling stations. At 250 barg, the compression ratio is approximately 296 to 1. While this is nearly 300 times better, diesel fuel still contains approximately 3.5 times more energy on a litre to litre basis compared with compressed natural gas (CNG). As a result, CNG is best suited for light duty vehicles or heavy duty vehicles on short haul return to base routes.

3.3 Liquefied Natural Gas

An alternative means to contain more natural gas in less space is to liquefy it. This involves cooling the natural gas to -162°C (-260°F) and requires very sophisticated refrigeration technology to obtain such extremely low temperatures. Keeping the natural gas in its liquid state also requires storage containers with excellent insulating characteristics, usually insulated vacuum jacketed double wall tanks. The end result is that liquefied natural gas (LNG) has an energy content of approximately 23.50 megajoules per litre, reducing diesel fuel’s advantage to about 1.65 to 1 on a litre to litre basis. LNG makes it possible to use natural gas as a transportation fuel for heavy duty, long haul vehicles.

² 1 barg ≈ 14.5 psig

200 barg ≈ 2900 psig

250 barg ≈ 3600 psig

A notable difference between CNG and LNG is that LNG cannot be odourized. The liquefaction process removes the mercaptan odorant and extra precautions must be taken since it is no longer possible to rely on smell as a detection tool.

3.4 Hazards Associated with CNG

Natural gas is a hydrocarbon fuel and like all fuels, precautions are necessary for its safe handling and use. Hazards to be aware of include:

1. **Flammability:** Natural gas is flammable in air. It can be ignited by an open flame, an electrical spark or even exposure to a hot surface (at least 540°C / 1003°F). Natural gas has a Lower Flammability Limit (LFL), 5%, and an Upper Flammability Limit (UFL), 15%, which means that the concentration of natural gas in air must be at least 5% by volume before ignition can occur but if the concentration is more than 15% natural gas in air, ignition cannot occur.

In the situation where CNG is released **at any pressure** from a CNG fuel system on board a vehicle, it is likely that the gas concentration near the release point will be above the UFL. This does not mean that the “plume” of natural gas that forms around the release point will not burn. As the lighter than air natural gas disperses, even high natural gas concentration clouds have pockets of gas at the edges which have flammable concentration. Should ignition sources be present within these “flammable gas pockets,” ignition of the cloud is possible.

2. **Detonation:** In the situation where CNG is released **at any pressure** from a CNG fuel system in a confined area like a garage or warehouse, detonation is possible if there is a source of ignition where the natural gas accumulates, at the ceiling for example. Detonation is a local and intense increase in pressure that can be catastrophically destructive. Depending on the degree of confinement, the quantity of natural gas and the geometry of the space, the detonation can form a blast wave capable of causing serious structural damage and worse, serious injury or death to the building’s occupants.
3. **High pressure gas release:** In the situation where natural gas is released **at high pressure** from a CNG fuel system, a high velocity and high momentum cold jet will occur. Hazards associated with a high pressure cold gas jet include:
 - Injury from small particles and floor debris picked up by the jet.
 - Injury from high jet momentum or exposure to very cold gas near the release point.
 - Ignition of the jet by a static discharge between the jet and the leak source. Ignition of a high velocity CNG jet will result in a jet fire (also called a “torch fire”) which can be at high temperature. Such a torch fire impinging on a person can cause serious burns within seconds, and can cause damage to structural elements.
 - High intensity noise from the high velocity jet.
4. **Asphyxiation:** Natural gas is non-toxic but it also displaces the air when it accumulates in a confined space. This could potentially asphyxiate a worker who enters a confined space filled with natural gas.

3.5 Hazards Associated with LNG

An LNG spill poses hazards in common with, but also unique from, other liquid fuel spills:

1. **Pool Fires:** If LNG is released from a fuel system onto the ground and the vapours produced are ignited immediately, a pool fire will occur. The shape of the pool base will depend on the shape of the containment area on the ground. Unconfined pools spreading on a level surface can be expected to burn with a near circular base. The size of the fire (height of the flames) will depend on the base pool

size and the substrate on which the LNG is burning (i.e. ground or water) and wind conditions. In the case of ground, the evaporation rate of LNG is lower than on water and hence, will burn with a shorter height flame. The principal hazard from this type of fire is due to thermal radiation. It is estimated that the radial distance from the edge of the pool fire to a skin burn hazard zone is about three times the pool diameter.

2. Cryogenic Hazards: Exposure of human skin to LNG results in the skin tissue being frozen, i.e., a cold burn results. Prolonged exposure without the appropriate and immediate burn treatment will result in permanent damage to exposed skin areas.

Carbon steel structural members exposed to LNG will become very brittle. If the structural member is in tension it may fail or develop a crack, thus weakening the structure.

3. Asphyxiation: LNG vapour is not toxic, per se. However, LNG vapour starts out heavier than air and displaces air from lower areas, such as a service pit for example, and could, therefore, pose an asphyxiation hazard to human beings. Also, prolonged breathing of cold vapours can result in lung tissue damage.
4. Rapid Phase Transitions: A Rapid Phase Transition (RPT) explosion results when a colder, more volatile liquid superheats after coming in contact with a hot liquid. The temperature of the colder liquid increases with time. When this temperature reaches a critical value, termed the “superheat limit temperature”, spontaneous boiling occurs in a very short period of time (nanoseconds), resulting in an explosion. Serious, but localized, pressure shocks can result, destroying equipment and causing injury to nearby personnel. It should be noted that this phenomenon is not very common with LNG and requires the spill of LNG onto water.
5. CNG Hazards: After LNG vapour warms up and begins to rise, it presents similar flammability and detonation hazards as a CNG release.

4.0 GENERAL REQUIREMENTS

This chapter deals with the General Requirements for designing and securing approval for the occupancy and operation of Compressed Natural Gas (CNG) and Liquefied Natural Gas (LNG) Repair Garages, Parking Structures and Cargo Handling Facilities.

When these types of facilities are considered, the reference publications (also referred to as Codes, Standards and Regulations or CSR's) noted in Chapter 2.0 of this document, are generally the primary documents that officials charged with the responsibility of reviewing and approving the construction and operation of the facility will reference. These officials are collectively referred to as the Authorities Having Jurisdiction (AHJ's). The AHJ's vary from municipality to municipality and generally consist of a group of people that includes provincial/territorial officials such as technical standards enforcement agencies and the fire marshal as well as municipal officials such as local fire officials and building inspectors.

AHJ's are often charged with a wide range of responsibilities. Reviewing and approving CNG and LNG facilities are usually a very small part of their regular activities and one that they do not engage in very often. Therefore, a strong reliance on the reference publications is very common. Given this set of circumstances, a few key elements for dealing with AHJ's are:

- Always approach the AHJ's with a plan of action in hand. Never approach them empty handed. You may lose control of your project, putting your timeline, design and budget at risk.
- Present your facility concept to them early in the design process to establish a line of communication and to identify and resolve AHJ jurisdictional conflicts.
- Cite specific CSR references when presenting your design to the AHJ's for approval.
- Be able to defend the CSR's cited.
- Provide other project documents that help to reinforce with the AHJ your understanding of the use of these fuels. These documents may include your Hazard Identification and Risk Assessment (HIRA), your Operating and Maintenance Procedures and your Emergency Response Plan.

In Canada, it is typically necessary to work with Authorities Having Jurisdiction (AHJ's) at the municipal level and at the provincial / territorial level.

The municipal AHJ is most often the Building Department. There are usually four building disciplines that must be addressed before the building department will issue the necessary permit(s) for the construction of new facilities or the renovation of existing facilities. They are:

- Architectural / civic / structural, i.e., the "bricks and mortar" aspects.
- Mechanical, i.e., the heating and plumbing aspects
- Electrical, i.e., the lighting and power aspects.
- Life safety, i.e., fire alarm and fire control aspects.

Depending on the local municipal structure, a few as one to as many as four municipal permits may be required.

Provincial and territorial AHJ's can have jurisdiction over more than one aspect but for the most part they are the typically the authority with respect to boilers and pressure vessels. They may be involved in a CNG / LNG project since both fuel types are contained in pressure vessels. Depending on the scope of the CNG / LNG project, it may or may not be necessary to obtain permit(s) from provincial / territorial AHJ's. Provincial / territorial AHJ's have jurisdiction over aftermarket CNG vehicle conversions and garages that install conversion kits whereas factory-built CNG and LNG vehicles are the exclusive domain of Transport Canada.

Regardless of the “level” of the Authority Having Jurisdiction, the by-laws and regulations by which they administer the codes and standards usually include authority with respect to:

1. **Retroactivity:** In the case of a project that involves renovations to an existing vehicle repair garage and / or vehicle parking structure, it is prudent to conduct an assessment of the facility to determine whether there are any deficiencies associated with its current use for the repair / storage of diesel or gasoline vehicles. If the AHJ deems the existing situation to represent an unacceptable risk, they are usually authorized to apply codes and standards retroactively to require the facility owner to undertake remedial measures so the facility “meets code” and more important, can be operated at an acceptable level of risk.

Several CSR’s state that the most recent, approved version supersedes previous versions and that any new requirements in the most recent version are not retroactive. However, this has to be considered in light of CSR’s that are adopted by provinces/territories or municipalities. Often these jurisdictions will adopt a specific version of a CSR and that version is the starting point for the AHJ review. Each CSR usually states that the AHJ has the discretion to impose retroactive modifications if they deem it appropriate.

2. **Equivalency:** Codes and standards are often very prescriptive and the measures that are prescribed are based on technology and systems that have been successfully implemented over many years and many hundreds or thousands of facilities. Occasionally those “time tested” technologies and systems just do not work, especially for renovation projects. Also, new technology is continually emerging, presenting opportunities to improve on the “time tested” ways.

Most CSR’s cite the concept of equivalency and state that design or operational alternatives are acceptable as long as the designer and/or operator can show the AHJ why the equivalent feature is equal to or greater than the prescribed design or operating requirement in the CSR. Keep in mind though; the AHJ may not necessarily be formally trained in the field that you are asking them to consider so citing prescribed CSR requirements may be easier in the long run unless the prescribed CSR requirements cannot be met.

3. **Enforcement:** As already stated, the AHJ’s are tasked with the administration and enforcement of CSR’s associated with your CNG / LNG project. However, it is important to understand, particularly in large organizations, that the people that are involved with the project at the design and approval to build stage may not necessarily be the same people that are involved during construction and especially when it is time to start up and operate your new facility. Find out early who will be involved throughout the project, engage them early and avoid unpleasant surprises at the last minute.

Engaging the services of a firm experienced in the application of the CSR’s is often helpful to the AHJ’s because it will allow the AHJ to understand what has been done in other jurisdictions and may provide AHJ peer contacts that could prove useful during the approval phases.

We have provided specific reference to the sections / paragraphs / clauses of the four codes and standards listed in Chapter 2.0 for this Guideline which might help you to understand the General Requirements associated with your CNG/ LNG project.

5.0 FACILITY DESIGN

This chapter deals with the indoor space where repairs, storage or cargo handling of CNG and LNG fuelled vehicles will take place (“facility type”) and the fuels that will be handled in each facility type (“fuel type”). Repairs mean those functions performed in a Repair Garage as described in NFPA 30A and are further divided into “Major” Repair Garages and “Minor” Repair Garages. Repair garages may also be referred to by other terms such as Maintenance Facilities or Maintenance Shops.

NFPA 30A defines a Major Repair Garage 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. A major repair is also often associated with a time frame of 8 to 12 continuous hours. This is important for LNG vehicles because the fuel is typically not refrigerated so, as the LNG fuel tank is exposed to ambient temperatures, the LNG liquid will vapourize and the resulting vapour pressure must be managed.

NFPA 30A defines a Minor Repair Garage 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. A minor repair is often associated with a time frame of less than 8 to 12 continuous hours. As is the case for major repairs, the vapourization of the liquid onboard LNG vehicles is a concern, but the shorter time frame typically makes it less critical unless the fuel tank has a significant “heat” leak.

NFPA 88A defines a Parking Structure as a building, structure, or portion thereof used for the parking, storage, or both, of motor vehicles. A Parking Structure may also be referred to by other terms such as vehicle Storage Facility or vehicle Storage Shop. Storage is further divided into short term storage, or Parking, that is defined as 12 hours or less and long term Storage that is defined as greater than 12 hours.

Cargo Handling is not defined in either NFPA 30A or NFPA 88A but is important for this guideline because it refers to the loading or unloading of the cargo on board CNG or LNG fuelled vehicles (i.e. payload) indoors. It includes medium and heavy duty trucks as well as buses.

Even though the hazards and risks are similar for each facility type, each facility type and fuel type requires a slightly different set of guidelines.

This guideline does not address indoor or outdoor vehicle fuelling facilities except as it relates to defuelling and refuelling to accommodate major vehicle repairs.

In Chapter 3.0, LNG is described as being at nominally -162°C in its liquid state. If a liquid release occurs this very cold liquid will behave as a liquid and pool at the lowest elevation possible. The pool will then begin to warm and will form a heavier than air vapour cloud around it. The edges of the vapour cloud exposed to the relatively warm ambient air, even at say -20°C , will become gaseous. In a gaseous state natural gas is approximately 2 times lighter than air so it will quickly rise to the highest point in the room and collect there. CNG is already in a gaseous form so it will also quickly rise to the highest point in the room and pool there. These are the key phenomenon that need to be safely managed.

Facility Design elements that need to be considered and that are addressed in this technical guideline include:

1. Roof/Ceiling shape - ensuring that natural gas (NG) is not trapped at the ceiling level in the event of a release and structural elements and roof construction.

2. Fire Resistance Ratings for roof, walls and partitions (interior and exterior).
3. Floor construction including drains, service pits and wash bays – ensure LNG cannot enter these structural elements in the event of a release.
4. Means of Egress.
5. Electrical system design and classifications – including alternatives for classified zones.
6. Heating, Ventilating and Air Conditioning (HVAC) - including regular heating and cooling (i.e. make-up air units balanced with exhaust fans), type of heating system (i.e. indirect fired), multi-stage HVAC systems including “purge” fans in the event of a release and passive ventilation systems to handle on board overpressure releases.
7. Gas/Flame/Fire Monitoring, Detection and Alarm systems – including types of systems, placement of systems, interoperability of these systems.
8. Fire Suppression systems – including types of suppression agents and the hierarchy of operation between combustible gas monitoring and alarm systems and fire alarm system activations.
9. Emergency Shutdown Device (ESD) systems – including interlocking of the various alarm systems with local and remote annunciation and building systems responses such as increasing the ventilation rate and activating an audible/visual alarm system.
10. Facility Operations – especially in Repair Garages where several operations are taking place in close proximity to each other involving different fuels such as diesel, CNG or LNG. The tools and equipment associated with this work will be addressed.
11. Defuelling system – it is often necessary to defuel a vehicle before repairs can proceed. Defuelling has safety, environmental and commercial issues that will be addressed. Refuelling will also be addressed.

5.1 Roof / Ceiling Shape and Construction Elements

The facility types that are used for Repair Garages, Parking Structures and Cargo Handling vary widely. They are typically high ceilinged to accommodate the vehicles with large floor areas but can meet these requirements in several ways. There is no one roof or ceiling shape that best describes this type of facility. Instead, we need to consider the functional design requirements of the roof/ceiling as it relates to CNG and LNG.

As natural gas rises to the ceiling or underside of the roof deck, it should be able to easily migrate to the highest point in the ceiling structure where it can be released to the atmosphere via a passive or active ventilation system.

The ceiling should not allow the natural gas to be trapped. Places where it can be trapped are between the roof's structural elements. These structures are built using one of the types of construction defined in NFPA 220. The best practice is to use “open” type structural elements such as open webbed steel joists that cannot trap the natural gas between them.

Another concern is the potential for natural gas to be trapped within the layers of the roof deck. It is not uncommon for these types of structures to use insulation that is covered in a plastic vapour barrier and fitted between the structural roof elements. Natural gas cannot be allowed to migrate into these insulation layers and be trapped.

Functionally what the designer needs to achieve is a smooth surface that is shaped to safely communicate any natural gas to the highest point in the ceiling so it can be evacuated to the outdoors.

5.2 Wall Construction

All walls, partitions and roofs enclosing the facility type servicing CNG or LNG vehicles should comply with the locally adopted building code. The designer may choose to consult NFPA 5000 regarding Type I and Type II construction that is recommended for these types of structures. As per NFPA 30A, the Occupancy Classification of a Repair Garage used for CNG and LNG vehicles shall be a special purpose industrial occupancy as defined in NFPA 101, Life Safety Code.

As with the construction of the ceiling, the walls and interior partitions should present a smooth surface that will safely communicate any natural gas to the highest point in the ceiling so it can be evacuated to the outdoors. It should not trap any natural gas that could find its way into the walls in the event of a release.

5.3 Fire Resistance Rating

The Fire Resistance Rating (FRR) should comply with the local building code adopted by the municipality. CAN/CSA B108 and NFPA 52 both deal with CNG and LNG fuelling so the requirements are typically more stringent than those in NFPA 30 and NFPA 88A. However, both B108 and NFPA 52 cite a 2 hour FRR for any interior fuelling rooms. A conservative approach to design Repair Garages, Parking Structures and Cargo Handling buildings such that they achieve a minimum of a 2 hour Fire Resistance Rating (FRR) and comply with NFPA 5000 regarding Type I and Type II construction.

As this may not always be possible, active systems such as combustible gas monitoring and alarming systems in concert with purge ventilation strategies and fire monitoring, alarm and suppression systems may have to be considered to overcome any FRR deficiency. These specific systems and the overall protection strategy needs to be discussed with, and approved by, the AHJ.

5.4 Floors, Drains and Pits

The floors of these facilities should be constructed of non-combustible material that will not absorb LNG if there is a release. Most large facilities are made with reinforced concrete which meets the intent of this requirement.

If the floors are coated, they should be coated with a material that is non-combustible and non-absorbent.

Many of these facilities use in-floor drainage systems. The in-floor drains are often open and covered with a grate. They typically drain to an enclosed holding tank. The tank may allow its contents to flow to the municipal sanitary sewer system after flowing through an oil separator system or the contents could be periodically removed by a licensed waste hauler.

Although this is a low probability event, it is critical that LNG liquid is not allowed to enter an enclosed drainage system. This can be managed by establishing specific bays for LNG vehicles that do not use in-floor drains or by deploying temporary containment under and around the LNG vehicle when it is in the facility or temporarily blocking off the in-floor drains near an LNG vehicle when it is in the facility.

Pits and wash bays are common features in these types of facilities. Pits can be used to service vehicles for major and minor repairs. These structures are typically called Service Pits. Pits can also be located

under wash bays to collect the wash water and solid run-off as the vehicles are cleaned. These are typically called such names as Mud Sump Pits or Wash Bay Pits.

Service Pits are occupied when the LNG or CNG vehicles are over the pits. An LNG release may very well flow into the Service Pit and then into the drainage system. Service Pits must be carefully designed and adhere to NFPA 30A standards. NFPA 30A addresses such features as the type of construction that the pit must comply with, the electrical classification of the pit, the ventilation requirements of the pit and egress from the pit. These requirements apply to diesel and gasoline fuelled vehicles as well as LNG fuelled vehicles.

Mud Sump Pits are typically not occupied when the vehicle is over them. They are used to collect the run-off from the wash process and are only occupied for the periodic clean out of the pit. Run-off wash water is typically collected in the pit and then sent to a holding tank or released to the municipal sanitary sewer system after going through an oil separator system.

Similar to in-floor drains, LNG should not be allowed to enter an enclosed drainage system. Also, LNG is subject to Rapid Phase Transition (RPT) when it comes in contact with relatively hot liquid such as wash water. It could result in an explosion as the RPT occurs. Therefore, it is important to ensure that no LNG interacts with the wash water or, if there is an inadvertent release, that it is detected and managed quickly and safely. See Section 5.7 for more details.

5.5 Means of Egress

The Means of Egress from one of these types of facilities should comply with the local building code adopted by the municipality. Facility designers can refer to NFPA 30A that states that in a Repair Garage, the required number, location, and construction of Means of Egress shall meet all applicable requirements for special purpose industrial occupancies, as set forth in NFPA 101, Life Safety Code. This would apply to Parking Structures and Cargo Handling facilities also.

5.6 Electrical System Design and Classification

Except in Pits, the electrical classification for facilities that service CNG and LNG vehicles is Class I, Zone 2, Group IIA (Division 2, Group D). This means that CNG or LNG may be present periodically due to inadvertent releases. Because Pits will likely accumulate LNG in the event of an inadvertent release the electrical classification in the Pit is Class I, Zone 1, Group IIA (Division 2, Group D).

In addition, NFPA 30A states that in a Service Garage where CNG and LNG vehicles are serviced, the area 455mm (18") above the floor and 455mm (18") below the underside of the ceiling is a Class I, Zone 2, Group IIA (Division 2, Group D) area. However, NFPA 30A goes on to state that if a constant ventilation rate of 4 air changes per hour is maintained then the entire facility, except any pits, can be electrically unclassified.

Grounding and bonding is also a critical concern. The energy for ignition is significantly less for natural gas than it is for diesel. Therefore, ensuring that the vehicle is grounded when it is being worked on is very important. This may be accomplished by affixing a temporary ground wire to the vehicle when it is brought into the shop. Another method is to install a "low ohm" concrete floor that is capable of grounding the vehicle without it being physically tethered. This method "designs out" the risk but is likely only economic for new facilities.

Ideally, the life safety components of the system should be on a back-up power supply that will keep them operating in the event of a power failure. The life safety systems include the combustible gas monitoring and alarm system, the fire alarm system, the emergency lighting, the purge fans and associated make-up

air intakes, the alarm annunciation system and the emergency shutdown device (ESD) system. However, backup power systems are not inexpensive and it may be necessary to develop other ways to “stay safe” during a power outage.

5.7 Heating, Ventilating and Air Conditioning (HVAC) and Vent Design

HVAC design is a critical component when developing a total system for handling CNG and LNG in these types of facilities. It has safety and economic aspects.

Facilities designed to handle diesel vehicles typically use HVAC systems that introduce make-up air and extract exhaust air at the ceiling level. They typically introduce the make-up air so it develops a slightly positive pressure in the facility. Heating is often achieved via a direct fired heating using natural gas as the fuel if it is available.

In facilities that handle CNG and LNG vehicles the heating system cannot introduce direct flames or sparking and cannot provide heating surface temperatures that exceed 399⁰C (750⁰F) where natural gas may come in contact. In a CNG facility this means ensuring that the flames, sparking devices and hot surfaces are located more than 455mm (18”) above the floor and below the ceiling. In an LNG facility in the event of a release, the liquid will initially pool and a heavier than air vapour cloud will form around the pool. Eventually the vapour cloud will warm and become natural gas and will then rise and accumulate in the highest possible location so the same open flame, sparking and hot surface restrictions apply.

In these types of facilities it is often difficult to ensure that a natural gas release won't impinge on one of these ignition sources because so much of the floor area is used to park and repair vehicles. A common approach would be to design the HVAC system such that it is indirect fired with all circulation and exhaust fans being Class I, Zone 2, Group IIA (Division 2, Group D) rated.

Another key design element is the ventilation rate. The primary consideration is to detect a combustible gas concentration at 20% of the Lower Flammability Limit (LFL). If this level is detected then the condition must be alarmed. If the percent combustible gas level continues to rise and reaches 50% LFL then the facility must be evacuated, the heating system must be shutdown, all electrical service to the non-life safety systems in the facility is disconnected and the ventilation system is activated to ensure that the combustible gas level does not increase.

An indirect fire heating system coupled with a multi-stage ventilation system is preferred. NFPA 30A states that all electrical wiring and equipment in the facility can be unclassified if the facility has at least 4 air changes per hour in the areas where the vehicles are parked or being repaired. From a capital and operating cost perspective this could be attractive. This ventilation rate is typically higher than the standard design criteria for these facilities so the cost to heat the make-up air under normal conditions may be a concern. Having a 3 stage system may prove useful. Although the capital cost may be higher the operating advantages may be significant, especially if the number of CNG or LNG vehicles serviced by the facility is small relative to the number of diesel vehicles. Regardless of the “normal” ventilation rate, when CNG or LNG vehicles are being parked or repaired it is necessary to ensure that the facility ventilation rate is increased to 4 air changes per hour.

In the event that a level of 20% of LFL or greater is detected, the ventilation system should be increased to a rate that would ensure that the level remains under the LFL. The ASHRAE 2011 Applications Handbook, Chapter 15, recommends 6 air changes per hour (ACH) as the “normal” ventilation rate when servicing CNG/LNG vehicles and that this rate should be doubled to 12 ACH when a level of 20% LFL or greater is detected. NFPA 30A states that the “normal” ventilation rate should be 4 ACH. Based on this recommendation, increasing the ventilation rate to at least 8 ACH is recommended. This may be referred to as the “purge” ventilation rate. Purge ventilation rates are often achieved by opening additional make-up air points and turning on additional fans.

In addition to the number of air changes per hour, another critical factor is where the air changes are introduced and exhausted. The make-up air locations should introduce the purge air at or near floor level and should be designed to ensure that the entire facility floor is “washed” or “deluged” with fresh air and that the air is sent to the purge fans. The purge fans should be Class I, Zone 2, Group IIA (Division 2, Group D) rated and should be located such that the natural gas that rises to the highest point in the ceiling is quickly and safely communicated to the outdoors.

The key to the ventilation strategy is to ensure that enough ventilation is presented such that the combustible gas concentration does not exceed 50% LFL.

CNG and LNG fuel tank systems are susceptible to temperature rise as the ambient temperature acts on the system. Increased temperature results in increased natural gas pressure in the fuel tanks. CNG vehicles are designed to handle this phenomenon through their tank design. This is more of a concern in LNG systems that have a gaseous head space in each tank. As the very cold liquid warms it becomes LNG vapour which, in turn, increases the pressure in the LNG tank. The tank manufacturers have addressed this problem by installing self-seating Pressure Relief Valves (PRV's) that periodically relieve the pressure in the tanks to atmosphere and then close again until the pressure increases and the process is repeated.

A “heat leak” in the tank where the insulation surrounding the LNG tank is compromised results in the rate of heating of the LNG liquid being accelerated even more.

If the ventilation rate in the facility is high enough and the point of exhaust is safe, a periodic release of a small amount of LNG vapour may be acceptable. However, industry norms suggest that installing a flexible connection over the LNG tank vent pipes on each vehicle is preferred. The flexible vent connection would then convey any LNG vapour released through the PRV to a properly designed passive venting system that would naturally communicate any natural gas safely to the outdoors.

All fans that are associated with life safety (i.e. the purge fans) need to be self-monitoring and alarm if they fail.

The HVAC exhaust fans, the purge fans and the PRV vent system must adhere to CAN/CSA B108 for the vent design and termination.

5.8 Combustible Gas, Flame and Fire Monitoring and Detection

In Section 5.6 the ventilation strategy is dependent on knowing the combustible gas % LFL level and then acting on that information.

In facilities where only CNG vehicles are parked or repaired, detecting a leak could be dependent on smell if the natural gas is odorized and the facility is continually occupied. This system of detection is similar to that used as the primary means of leak detection by all natural gas distribution companies in Canada.

However, this system is not effective if the facility is not continuously occupied or if the release is odourless, as is the case with LNG vapour releases as discussed in Chapter 3.0.

NFPA 30A requires the installation of a permanently installed Combustible Gas Monitoring and Alarm (CGMA) for all un-odorized combustible or flammable gases. This system should be installed at the highest point where natural gas could accumulate and should activate when a level of 25% LFL is detected. Industry norms suggest that an alarm level of 20% LFL is preferred.

In the event that 20% LFL is reached the CGMA should be interlocked to a system that initiates an audible and visual alarm and notifies off-site personnel of the problem. This may mean company

personnel during off hours or it could be an alarm monitoring company if one is used at the facility. The 20% LFL alarm should also cause the ventilation system to increase by activating the purge fan system.

In the event that the % LFL level continues to rise, at 50% LFL another audible and visual alarm should be activated that signals the evacuation of the facility, shuts down the heating system, disconnects all non-life safety electrical systems such as unclassified receptacles and permanently wired equipment. This system may also notify the local fire department that this event has occurred but this is at the discretion of the AHJ.

The CGMA system must be self-monitoring and alarm if it fails.

The fire monitoring and alarm system is usually a separate system. A fire system could be activated locally through manual and/or automatic alarm. The alarm could also be local and/or remote. If is remote then it is usually through an approved monitoring company who, in turn, notifies the fire department. The fire alarm system is detecting other elements than combustible gas such as flames, heat and/or smoke. All of these elements are secondary to a natural gas release and will only occur if the primary CGMA and associated purge system cannot contain and rectify the event.

5.9 Fire Suppression Systems

These types of facilities may or may not have a fire suppression system. If a fire suppression system is installed it is likely a water based system that is either a wet or dry system, it is typically zoned and is fusible link activated. This type of system is better suited for a CNG facility. Although it is better to try to contain and rectify the CNG gas release using the CGMA and associated purge fan system, a subsequent fire should be initially handled using the fire suppression system.

This is not without concern though. If a fire is detected the initial response is to eliminate or minimize the elements of the “fire triangle”, specifically the source of ignition, fuel and air. One way to partially accomplish this is by shutting down the ventilation system and shutting all fire doors and dampers. However, if the source of the fire is a CNG system release then the fire suppression system could extinguish the flame. This would change the releasing gas from the products of natural gas combustion (i.e. primarily water vapour and CO₂) back to primarily natural gas (i.e. methane or CH₄). The release may continue until the vehicle fuel tank is empty of natural gas which would result in the build-up of natural gas at the highest point in the room without any means of evacuating it to the outdoors. This is a design trade-off that needs to be addressed by the design team in the HIRA and approved by the AHJ.

Similarly for LNG, the final state of LNG is natural gas so the preceding paragraph may apply. However, a liquid LNG release would first be a very cold combustible liquid pooled at the floor level and surrounded by a heavier than air vapour cloud, also at the floor level. This pool of liquid would be subject to Rapid Phase Transition (RPT) as described in Chapter 3.0 if water is introduced into the area.

A chemical based system may be preferable to a water based system. This is a design decision that needs to be addressed by the design team in the HIRA and approved by the AHJ.

5.10 Emergency Shutdown Device (ESD) Systems

The Emergency Shutdown Device (ESD) system is the heart of the active life safety systems. It operates similarly to a programmable logic controller (PLC) and coordinates all of the input and out signals that the various life safety systems need to operate. It controls the CGMA system, the alarms and annunciation, the purge fans and associated make-up air, the interlocks between the CGMA and fire alarm system and the emergency lighting.

The ESD system should be self-monitoring and alarm if it fails.

5.11 Defuelling Facility Design

The Defuelling Facility is a necessary system if the Repair Garage is going to perform major repairs. Defuelling is generally the process of removing any residual fuel from the fuel tanks and on board fuel delivery system prior to commencing a major repair. A defuelling system should meet the requirements of a CNG or LNG fuelling system as described in CAN/CSA B108 and NFPA 52, including defuelling indoors.

Defuelling can take the form of transferring the CNG or LNG from the vehicle's fuel system that needs a major repair to an approved vehicle fuel system on another vehicle. It can also take the form of allowing the CNG to escape to atmosphere or the LNG fuel to vapourize and then escape to atmosphere.

Capturing the CNG or LNG in a system that can send it to a CNG or LNG fuelling station storage facility for reuse is the most environmentally responsible and cost effective, at least from an operating perspective.

Defuelling can take two forms.

- i) The first option is to relieve the pressure from the CNG tank or remove the LNG from the tank such that only residual LNG vapour remains. Typically both systems would have nominally 689kPa (100 psig) on board in gaseous pressure when the system is "defuelled" according to the vehicle manufacturer. Defuelling to 100 psig is acceptable if none of the repairs involves the CNG / LNG equipment on the vehicle. If the repair involves the fuel system in any way it is necessary to defuell and purge; described as follows.
- ii) The second option is to remove all of the fuel from the vehicle including the residual fuel and replace it with an inert gas such as nitrogen. The objective is to completely purge the system of all combustible gas. In order to complete the operation, the entire system should be purged with the inert gas 3 times to a pressure of at least 689kPa (100 psig). Approximately 70kPa (10 psig) of residual inert gas pressure should be left on the system during the major repair if possible.

Recharging the fuel system CNG or LNG is equally critical. The inert gas must be scavenged from the system in a similar manner as the inert gas was introduced. Specifically, the entire system should be charged 3 times with approximately 689kPa (100 psig) of natural gas.

6.0 OPERATIONS AND MAINTENANCE

This chapter will deal with the Operations and Maintenance (O&M) of each facility type. Similar to Facility Design, the O&M for each facility type and each fuel type varies but there are common elements.

6.1 Facility Operations

All of the systems described in Section 5.1 through 5.11 need to be complemented by specific operating and maintenance procedures. In Parking Structures or Cargo Handling facilities CNG and LNG vehicles will be intermingled with gasoline and diesel powered vehicles. They may even be intermingled with hybrid electric vehicles that feature high voltage DC buses to transmit power from the prime mover or fuel cell to the battery and eventually to the drive motors. The key element is that the function that the facility is providing needs to be carried out with as much commonality as possible while still recognizing the differences in the characteristics of each fuel type.

Similarly for Repair Garages, they will likely concurrently handle all types of fuelled vehicles in adjacent service bays. They too need to function with as much commonality as possible while recognizing the differences in the characteristics of each fuel type.

Operating Procedures must be put in place that define the additional tasks that trained and knowledgeable technicians and drivers will be required to do when working with CNG and LNG fuelled vehicles in these facilities.

In a Repair Garage the least risky of the repair types is a major repair. This is due to the fact that a CNG or LNG vehicle will need to be defuelled before this type of repair can proceed. Therefore, it doesn't have the fuel on board and can be treated similarly to a typical diesel or gasoline repair under most situations. However, even if it is defuelled, the CNG or LNG tank will likely still contain some residual natural gas vapour unless it is fully purged with an inert gas.

A minor repair of a CNG or LNG vehicle is more risky because the technician will bring the vehicle with potentially a full load of fuel on board into the facility. A subsequent release would primarily be handled by the CGMA system and the associated systems as controlled by the ESD system. However, this automatic response is less preferred than a manual response by the technician if they are working on the vehicle. The CGMA sensors will be located at the highest point of the ceiling so a release would have to occur and then the vapour would have to find its way to the sensor at a concentration equal to or greater than 20% LFL.

This may be acceptable for CNG but what if the leak was LNG in liquid form? That means that the release would have to have spilled on to the floor, pooled, formed the vapour cloud and then vapourized to become natural gas as we know it before it is detected. A more timely response can be initiated by having repair technicians be alert for visual signs of leaks. They may also carry portable CGMAs so that. If the alarm is triggered; it will require a manual response from the technician.

This situation is similar for Parking Structures and Cargo Handling facilities. The common element is that CNG and LNG fuelled vehicles will be brought indoors for a purpose other than working on the CNG or LNG fuel system and may develop a fuel leak that will have to be handled quickly and correctly. Procedures and training are the best way to ensure that this occurs.

A few common elements that may prove useful in these procedures are:

- Only trained and qualified personnel should be allowed to repair a CNG or LNG vehicle.
- Prior to bringing a CNG or LNG vehicle into the facility, conduct a visual check as well as a check with a portable CGMA device to prove that the vehicle has no fuel leaks.

- As per the vehicle manufacturer's instructions, perform a manual venting of the fuel tank PRV(s).
- Once the vehicle is inside the facility, deploy temporary spill containment for LNG fuelled vehicles, attach the grounding cable and connect the CNG or LNG vent stacks on the vehicle to the permanent venting system.
- If conducting a minor LNG repair, use a portable CGMA device to constantly monitor the area under and around the vehicle so that a leak can be spotted and reacted to long before natural gas reaches the permanent CGMA system at the ceiling.
- Prior to starting a CNG or LNG vehicle, particularly if it's been parked inside for an extended period of time, conduct a visual check, as part of the vehicle "circle check" and conduct an "on-board" vehicle system check to ensure that the vehicle has not developed a fuel leak. The operator may also use a portable CGMA device to ensure that the vehicle hasn't developed a fuel leak.
- All major and minor repairs should be carried out according to the vehicle OEM's procedures for each make and model serviced in the facility. The specific repair instructions should be referenced in the facility's Operating and Maintenance procedures, preferably as a "controlled document" set under the facility's O&M document system.
- For major and minor repairs, develop facility specific procedures, job plans and work permits that complement the vehicle OEM procedures. These facility specific procedures should define how repairs on a CNG or LNG vehicle will proceed. These procedures and job plans should consider the hazards associated with a specific activity and the mitigation strategies that need to be implemented to ensure that the job is safe. This philosophy must be extended to the entire repair garage because a task being done on a non-CNG or non-LNG vehicle in an adjacent service bay could very easily affect the safety of the CNG or LNG work taking place (e.g. welding or open flame torch). This concern is extended to spark resistant tools. Explosion proof equipment is preferable for all situations throughout the repair facility; however, if open flames or sparking tools or equipment are required then a job plan and risk assessment should be required before allowing the operation to proceed.
- In the event that the repair activity is one that is undertaken infrequently, a job plan should be developed including a hazard identification and risk assessment and a work permit issued to the senior technician responsible for the repair. This may include issuing additional permits such as "hot work" or reinforcing procedures such as how to handle, store and secure CNG or LNG fuel tanks before installation or after removal.

6.2 Facility Maintenance

Maintenance procedures are equally important. The operator of a facility that handles CNG and LNG fuelled vehicles indoors is depending on very sophisticated systems to keep the facility safe. These systems need to be tested and maintained at regular intervals. Manufacturer's recommended inspection, testing and maintenance should be adhered for each component in each system.

7.0 HAZARD IDENTIFICATION AND RISK ASSESSMENT (HIRA)

This chapter will deal with the need and methodology to consider the hazards and associated risks affiliated with the Facility Design and Operations and Maintenance for handling CNG and LNG vehicles.

A Hazard Identification and Risk Assessment (HIRA) is a way to first identify the hazards and resulting risks that are associated with handling CNG and LNG vehicles in Repair Garages, Parking Structures and Cargo Handling facilities. There are several ways to conduct a HIRA but the general principles are the same.

First, the risk formula is: Risk = Frequency X Consequence

CNG and LNG releases are typically very infrequent but can have very significant consequences.

The way to quantify the various events that may occur due to a CNG or LNG release is to identify each of the events then assign a frequency and consequence score to the factor. The scoring scales typically range from 0 to 5 or 0 to 10.

The next step is to plot these scores in a matrix type of chart that segments them into high, medium and low risks. For example, if the event is deemed to have a low consequence and a low frequency then the risk is scored low and is likely deemed acceptable by management. Conversely, if a risk is deemed to be low frequency but high consequence then it could be deemed to present a high risk.

High risk events are usually re-examined to determine if there is a way to reduce the risk. Typical solutions could be to re-engineer / re-design the system and “engineer” the risk out of the design. Another strategy is to implement physical barriers that protect the public, employees and the property from being harmed if the event takes place. The third method to reduce risk is to implement operating and maintenance procedures that cause the technicians and drivers to be aware of the risk, respect the risk and then act to avoid the consequences of the risk.

Designing out the risk is the preferred method followed by implementing physical barriers to isolate the hazard followed by implementing operating and maintenance procedures to manage the risk associated with the hazard.

The HIRA should be conducted with as many of the parties participating including the facility operator, the engineers overseeing the design, the mechanics and drivers who will operate the system, and the maintenance mechanics for the systems that will be put in place.

Where the HIRA is more focused on the design of the system as it relates to the operation and maintenance of the system, other methods of risk assessment are often used such as Failure Modes and Effects Analysis (FMEA) and Mean Time Between Failure Analysis (MTBF). Both of these methods are more quantitative in their approach and focus on the engineering design of the system and the sub-assemblies and components that comprise the system to determine how they will behave under certain operating and failure conditions. Both methods are more time consuming and expensive to conduct than the more common HIRA.

The HIRA is typically a very critical document to present to the AHJ's.

An example of the specific risks that may be considered for CNG and LNG fuelled vehicles in Repair Garages, Parking Structures and Cargo Handling facilities are:

- Potential for a CNG or LNG release and the mitigation strategies that are in place to handle the event.
- Failure of a critical life safety system component such as a CGMA sensor or the ESD system.
- Potential for a task being conducted in one service bay adversely affecting the task being conducted in an adjacent service bay where at least one of the vehicles involved is a CNG or LNG vehicle.

8.0 SYSTEM SAFETY MANAGEMENT

This chapter deals with the need for, and elements of, a Safety Management System (SMS) when handling CNG and LNG vehicles.

An SMS is a set of written documents that define how the organization will conduct its operations and maintenance activities so the work proceeds safely. The SMS essentially captures all of the elements discussed in Chapter 6.0 in a consistent format that is formally accepted by senior management.

The SMS typically consists of the following elements:

8.1 Written Policies and Procedures

An organization's policies define what the organization believes in and how it will generally conduct its operations relative to those beliefs.

An organization's procedures layout how the various tasks that comprise the organization's operations and maintenance activities will be carried out so the work is completed safely each time.

They are written in a consistent format and are endorsed by senior management.

8.2 Safe Work Procedures

Procedures can be written for many things such as quality, the environment and financial control. When dealing with high energy systems like those on CNG and LNG vehicles safety is a major concern.

Procedures are generally repetitive activities that have been completed several times in the past and represent the organization's cumulative experience of how best to complete that task. They are often driven by equipment manufacturer's procedures of how to operate or maintain a piece of equipment used at the facility. This includes the original vehicle equipment manufacturer (vehicle OEM).

Each written procedure typically addresses the scope of the activity, the reference documents including other procedures that may be required, the step-by-step activities that comprise the task and the documentation necessary when the task is completed.

8.3 Job Plans and Safety Analyses

There are often cases, especially in a Repair Garage, when a procedure is not available for the task at hand because it is not used frequently enough. In this case the organization would rely on a Job Plan and Safety Analysis to anticipate the risks that may be encountered and then put barriers and restrictions in place to mitigate the risk. If a Job Plan is completed several times it may become a procedure.

A Job Plan and Safety Analysis are typically initiated by the senior person responsible for actually completing the activity (i.e. the lead technician). This may be the repair of a major component of a vehicle or the periodic inspection and maintenance of a critical system in the Repair Garage, Parking Structure or Cargo Handling facility. Whatever the task, the Job Plan should address all of the elements that need to be completed, in sequential order, and in sufficient detail to satisfy those that review the plan.

Once the Job Plan is completed the preparer should conduct a Safety Analysis. This is essentially a "mini" HIRA as defined in Chapter 7.0. Using the Job Plan's sequential steps the HIRA should address

the unique risks that may encountered in competing this task and offer mitigating strategies to reduce the risk if it is deemed to be high or medium.

Once the Job Plan and Safety Analysis is completed it should be reviewed and approved by at least the preparer's immediate supervisor and others if the task is sufficiently complex and/or presents a substantial potential risk.

8.4 Work Permitting

After the Job Plan and Safety Analysis have been approved, the supervisor should issue a Work Permit that formally allows the work to proceed. Work Permits typically have the Job Plan and Safety Analysis attached to them. The Work Permit will define the person responsible for the work, in most cases the Work Plan preparer. It will often put a time limit on the Work Permit itself, such as, that it must completed within that shift.

Work Permits may have other permits associated with it such as Lock Out and Tag Out if a system needs to de-energize during the task or Hot Work if open flames or other sources of ignition such as sparking tools must be used around systems containing flammable or combustible gases.

Work Permitting should be used throughout the entire facility, especially in a Repair Garage. As discussed in Chapter 7.0, the potential exists for a task conducted in one service bay affecting the task being conducted in an adjacent service bay. Even though a given activity may be following an established procedure controlling the whole shop environment may best be handled through a Work Permit system.

8.5 Change Control

When new systems are being proposed whether it's for the facility itself or the vehicles being handled, major changes require an analysis to ensure that the change doesn't adversely affect the procedures that are already established. The Change Control analysis addresses this issue.

Changes may be significant such as a major change to the HVAC system. Changing old or worn out equipment may be the main driver for the change, but ensuring that the new equipment meets the needs of the life safety system requirements is also a key consideration.

Changes may also be less significant such as a minor re-design of a CNG or LNG fuel system vapour vent stack on the vehicle. Will the vehicle modification change the systems or procedures needed to handle that element? In the case of the vent stack, will the temporary attachment to the facility's permanent venting system still reach and fit over the vent stack?

Regardless of the change, the Change Control procedure should cause the organization to consider the change relative to the established procedures and systems and determine if subsequent changes need to be made to other procedures or system in the organization to ensure a high level of safety.

Similar to Job Planning and Safety Analysis, Change Control usually involves a mini HIRA once the elements of the risk are identified. The outcome is a written proposal for additional changes to the organization that should be implemented to safely accommodate the change.

8.6 Deficiency (Non-conformance) and Incident Reporting

Deficiencies or Non-conformances are negative unexpected outcomes of a procedure or Job Plan. These outcomes may result from such things as a Job Plan's sequential steps not anticipating everything that was required in sufficient detail (i.e. a deficiency) to a required step in a procedure being missed (i.e. a non-conformance).

Under certain circumstances a deficiency or a non-conformance could result in an undesirable outcome such as a lost time injury or damage to property (i.e. an Incident).

Regardless of the exact event, the organization should have a system in place to track these events. Not only is it important when handling the specific event in terms of insurance claims and performance evaluation, it also begins to develop a body of historical data that is auditable and can provide key insights into how the organization as a whole needs to change to better deal with its business.

Another very important concept is that of "near misses". Near misses are those events that could have easily resulted in an Incident if the exact events had been slightly different. In Chapter 7.0 we discussed the concept of risk and that it is the product of frequency and consequence. Most organizations understand this concept and strive to limit the number of incidents because, when dealing with CNG and LNG, the frequency is small but the consequences are large. However, if we just rely on infrequent incident reporting how do we know if we're "really good" or "really lucky"? Deficiency, non-conformance and near miss reporting can provide a very valuable set of data to allow the organization to improve without relying exclusively on a small set of after-the-fact incident data.

8.7 Corrective and Preventive Action

A Corrective Action is required when a procedure or Job Plan results in an undesirable outcome and must be corrected. This may mean fixing a repair on a CNG or LNG vehicle or it may mean modifying the procedure itself because it is found to be deficient.

A Preventive Action is taken to avoid an anticipated undesirable event or to improve an existing procedure or system.

In Section 8.6 we discussed how the collection of data can help the organization establish trends in how it does business and how to improve. Corrective and Preventive Actions are the action steps that result from doing this analysis. These trends and the subsequent actions are often uncovered during internal or external audits.

8.8 Signage and Other Barriers

Like procedures and Job Plans, signs and physical barriers are designed to increase the safety effectiveness of the organization.

CNG and LNG signage is set out in NFPA 30A and CAN/CSA B108. The signs clearly define the critical elements of behaviour in and around these systems. Signage is an important element of the safety system that constantly reminds both experienced and inexperienced individuals what is acceptable and what is not. Signage should be posted in conspicuous places throughout the facility.

Barriers are another important element of the safety system. A barrier could range from a door that restricts access to an area to a portable welding partition that isolates the welding activity taking place in one service bay from the activities in adjacent service bays. A barrier could also be a lock that prevents

access to an area of the facility or the energization or de-energization of a system as in a lock out tag out situation.

8.9 Material Safety Data Sheets and Personal Protective Equipment

Material Safety Data Sheets (MSDS) define the types of materials that are present in the facility and their properties. MSDS' are a common element of each workplace's safety system. The set needs to be expanded to include CNG and LNG.

Personal Protective Equipment (PPE) is also a common element of each workplace's safety system. The PPE requirements need to be expanded to include CNG and LNG. This is particularly true regarding face shields for high pressure CNG systems and face shields and gloves and protective clothing for cryogenic LNG.

8.10 Integrated Management System

An Integrated Management System (IMS) combines the common elements of several management systems to establish one system that addresses several elements using one common format. In technical organizations such as Repair Garages, the management systems that are often combined are quality (ISO 9001), environment (ISO 14001) and health and safety (OHSAS 18001).

All of these systems require policy statements endorsed by leadership, work procedures, reporting, audits and continuous improvement. Best practice is to have one management system that addresses all of these elements in a consistent format.

The IMS should be a "controlled document" according to the ISO definition. This means that each policy and procedure is valid and has an issue date and method to ensure that the most up-to-date procedure is being used. Often these systems are issued "on line" so it is essential that the date and time is shown on the document if it is printed and it must be clear on the printed document that the policy or procedure is only valid at the time of printing.

Changes to the policies and procedures must follow an ISO Change Management procedure that defines who can change a procedure and how they must go about implementing that change.

Implementation of an IMS is a best practice that would benefit operators of facilities where CNG/LNG vehicles are repaired, stored and / or loaded.

9.0 EMERGENCY RESPONSE PLAN

This chapter deals with the need for, and elements of, an Emergency Response Plan (ERP) when handling CNG and LNG vehicles.

Emergencies are another name for significant incidents. As discussed in Chapter 9.0, incidents are usually infrequent but the consequences can be significant. Emergencies can be described in a similar manner except that the consequences can involve significant damage to property, serious injury or health issues and possibly death. Regardless of the outcome, emergencies are usually not predictable so an ERP is essential in handling this event quickly and effectively.

An ERP can take many forms but common elements include:

9.1 Written Policies and Procedures

It is essential to have written ERP procedures. The task of writing them helps to focus the organization on the possible risks and associated outcomes that various events may present. Also, a written ERP provides a base document that will help in personnel training, including emergency drills. The ERP will also help to identify key responders that your organization can contact in the event of an emergency. The ERP will also pre-establish tasks and responsibilities for the individuals in the organization such as directing first responders, AHJ liaison, media liaison, employee liaison and working with your insurer to initiate recovery tasks.

The ERP procedures should address specific events that may occur such as an evacuation due to an alarm condition, a fire or explosion, an intruder, severe weather, an environmental spill or a power failure.

9.2 Key Contact List

In an emergency having a list of Key Contacts and the duties or services that they will provide is vital document. This document will also provide an essential checklist of the things that need to be considered given the type of emergency.

The list should range from key company notifications such as the President and CEO, the Chief Operating Officer and the Chief Financial Officer as well as emergency first responders such as fire, police and ambulance.

However, the list should also include secondary responders such as your insurer, any AHJ's that need to be informed of the incident, a pre-selected restoration company to begin damage mitigation, your telecommunication provider and your business machine/services provider for voice and data continuity and a pre-selected building services contractor to begin the process of facility re-building if necessary.

Each internal contact should include the person's name and title, telephone number(s) and e-mail as well as a summary of the key responsibilities that they are assigned in an emergency.

Each external contact should include the organization's name, telephone number(s), e-mail and key people in charge of your account as well as a summary of the services they will provide.

Each contact should be listed in the order that they should be contacted. For example, emergency first responders precede company personnel who precede secondary responders.

9.3 Crisis Communication and Management

If the emergency is serious and causes significant damage, the emergency event may require several hours or even days to resolve. If this is the case having a pre-established plan in place to deal with the intermediate term issues such as site interaction with AHJ's, interaction with company personnel and their families, interaction with the media, interaction with off-site senior management and shareholders and interaction with your insurer would be very useful.

An emergency of this scale may mean that whole operation may need to be relocated to a secondary location. This is referred to as Business Continuity Planning and involves a pre-established plan that defines how the critical functions of the organization will continue, how telecommunications will be re-routed, where the temporary facility will be located and in what time frame will it be up and running.

Every organization may not need this level of planning, but elements of the plan are essential, especially if the organization uses on-site computing and owns its own routers and network controllers.

9.4 Exercises

Best practice suggests that for the ERP to be effective in times of crisis it needs to be practiced so the remedial components of the plan are well known to all participants when an actual emergency occurs. Practice is typically achieved through conducting exercises that simulate an emergency event and measuring how the organization responds against an expected outcome.

There is no set formula for how many exercises an organization should run per year. A common frequency is 4 per year where 2 would be Table Top exercises that are conducted in a "classroom" type setting, 1 would be a measured response exercise that includes only internal resources (e.g. a fire drill that doesn't include the local fire department) and 1 would be a measured response exercise that includes internal and external resources (e.g. a fire drill that includes the local fire department). The frequency and type of emergency exercises should be defined in the Integrated Management System (IMS) discussed in Chapter 8.0.

9.5 Integrated Management System

Best practice suggests that the ERP should be part of the Integrated Management System (IMS) discussed in Chapter 8.0.

10.0 PERSONNEL TRAINING AND EXPERIENCE DOCUMENTATION

This chapter deals with the need for, and elements of, a Personnel Training and Experience Documentation (PTED) system when handling CNG and LNG vehicles.

A PTED system can take many forms but common elements include:

10.1 Written Policy and Procedures

Written PTED procedures are very useful in ensuring that the facilities personnel are competent to complete the assigned tasks in a safe and responsible manner. As with the ERP procedures discussed in Chapter 10.0, the task of writing the PTED helps to focus the organization on the key elements that each person needs to be trained in to allow them to complete their assigned tasks safely and competently. It also develops a set of documents that the organization can reference to establish trends for new or refresher training as well as allowing the organization to demonstrate its “due diligence” in providing the services that it offers.

Training may take the form of class room training and/or computer based learning. It may also involve hands on competency tests and informal observation by supervisors that all comprise the Training documentation set.

10.2 Experience Documentation

Another important element of an individual’s competency is the amount of experience that a person has in the area of interest. Having completed a procedure several times as part of their daily work is very different than receiving training on that procedure once and never having used it since.

Similar to the formal Training discussed in Section 10.1, documenting experience is another critical element that will help define future training needs and the effectiveness of the entire Training system.

10.3 Attendees

Attendees should include the technicians and drivers that handle the vehicles on a daily basis. They should also include supervisors and management who have a direct responsibility for the services being provided.

A focused version should be given to all employees so they understand the ERP and their responsibilities under it. An even more focused version may be given to emergency first responders so they understand the hazards that they may face if they are asked to attend the facility.

10.4 Training Topics

Training topics should include all procedures that govern the facility and in the case of CNG and LNG vehicles should include:

- The fuel properties.
- Safe handling of the fuel and the vehicles with the fuel on board primarily based on the procedures from the vehicle OEM’s.

Critical facility design features such as the ESD system, the CGMA system and the ventilation system.

- All O&M procedures concerning the fuels.
- The ERP, MSDS & PPE documentation including emergency evacuation and emergency drills.

10.5 Documentation

Each entry for each individual in the Training documentation set should reference a date and time when the training or observation was completed.

Internal audits should be conducted on the Training that each individual receives and also on the overall Training system that is in place to develop trends for further improvement.

10.6 Integrated Management System

Best practice suggests that the PTED should be part of the Integrated Management System (IMS) discussed in Chapter 8.0.

Attachment 1 LIST OF CODES AND STANDARDS, CLAUSES / PARAGRAPHS / SECTIONS RELATED TO GENERAL REQUIREMENTS

Description	Reference CSR
1.0 GENERAL REQUIREMENTS	
1.1 Scope	
	CAN/CSA B108:99
1.	
1.1	
	NFPA 52:2010
1.1	
1.1.1	
1.1.2	
1.1.3	
1.1.4	
1.1.5	
1.1.6	
1.1.7	
1.1.8	
	NFPA 30A:2008
1.1	
1.1.1	
1.1.2	
	NFPA 88A:2011
1.1	
1.2 Purpose	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
1.2	
	NFPA 88A:2011
1.2	
1.3 Retroactivity	
	B108:99

Description	Reference CSR
	NFPA 52:2010
1.3	
1.3.1	
1.3.2	
1.3.3	
	NFPA 30A:2008
1.4	
1.4.1	
1.4.2	
1.4.3	
	NFPA 88A:2011
1.3	
1.3.1	
1.3.2	
1.3.3	
1.4 Equivalency	
	B108:99
	NFPA 52:2010
1.4	
1.4.1	
1.4.1.1	
1.4.1.2	
1.4.2	
1.4.3	
1.4.4	
1.4.4.1	
1.4.5	
	NFPA 30A:2008
1.5	
1.5.1	
1.5.2	
	NFPA 88A:2011

Description	Reference CSR
	1.4
1.5 Enforcement	
	B108:99
	2.1
	NFPA 52:2010
	1.6
	NFPA 30A:2008
	1.6
	NFPA 88A:2011
	3.2.2
1.6 Definitions	
	B108:99
	2.1
	NFPA 52:2010
	3.0
	3.2.2
	3.3.4
	3.3.4.1
	3.3.17
	3.3.32
	3.3.63
	3.3.64
	NFPA 30A:2008
	3.0
	3.3.9
	3.3.9.1
	3.3.9.2
	3.3.12
	3.3.12.1
	3.3.12.2
	3.3.18
	NFPA 88A:2011
	3.0
	3.3.2
	3.3.2.3
	3.3.2.4

Attachment 2 LIST OF CODES AND STANDARDS, CLAUSES / PARAGRAPHS / SECTIONS RELATED TO FACILITY DESIGN

Description	Reference CSR
2.0 FACILITY DESIGN	
2.1 Geometry of the Space	
	B108:99
	Appendix B
	B4.1
	B4.1.1
	NFPA 52:2010
	NFPA 30A:2008
	7.4.2
	NFPA 88A:2011
	5.1
	5.1.1
	5.1.2
	5.1.3
	5.1.4
2.1.1 Roof / Ceiling Shape	
	B108:99
	Appendix B
	B4.5.1
	B4.5.2
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
2.1.2 Beam and Girder Construction Type	
	B108:99
	Appendix B
	B4.5.1
	B4.5.2

Description	Reference CSR
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
2.2 Fire Rating	
	B108:99
	Appendix B
	B3.1.2
	NFPA 52:2010
	12.2.4.1.1
	NFPA 30A:2008
	7.4.1
	7.4.1
	NFPA 88A:2011
2.2.1 Ceiling	
	B108:99
	NFPA 52:2010
	12.2.4.1.1
	NFPA 30A:2008
	7.4.1
	7.4.2
	NFPA 88A:2011
	5.1.1
2.2.2 Exterior Walls	
	B108:99
	B8.3
	B8.3.1
	B8.3.2
	NFPA 52:2010

Description	Reference CSR
	12.2.4.1.1
	12.2.4.5
	NFPA 30A:2008
	7.4.1
	7.4.2
	NFPA 88A:2011
	5.1.1
	5.2.1
	5.2.2
	5.2.3
2.2.3 Interior Walls / Partitions	
	B108:99
	B8.3.2
	NFPA 52:2010
	8.4.3.4
	8.4.3.4.1
	8.4.3.4.2
	12.2.4.1.1
	12.2.4.5
	NFPA 30A:2008
	7.4
	7.4.1
	7.4.2
	NFPA 88A:2011
	5.1.1
	5.2.1
	5.2.2
	5.2.3
2.3 Flooring	
	B108:99
	Appendix B
	NFPA 52:2010
	NFPA 30A:2008
	7.4.4
	NFPA 88A:2011

Description	Reference CSR
2.3.1 Drains	
	B108:99
	NFPA 52:2010
	12.2.3.2
	NFPA 30A:2008
	7.4.4.2
	NFPA 88A:2011
2.3.2 Service Pits	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	7.4.5
	7.4.5.1
	7.4.5.2
	7.4.5.3
	7.4.5.4
	NFPA 88A:2011
2.4 Means of Egress	
	B108:99
	4.8
	4.8.1
	4.8.2
	6.14
	NFPA 52:2010
	9.3.3.4
	9.3.3.4.1
	9.3.3.4.2
	9.3.3.4.3
	9.3.3.4.4
	9.3.3.4.5

Description	Reference CSR
	9.3.3.4.6
	NFPA 30A:2008
	7.4.3
	NFPA 88A:2011
	4.1
	4.1.1
	4.1.2
	4.1.3
	4.1.4
	4.1.5
2.5 Electrical Systems	
	B108:99
	Table 4.1
	Table 5.1
	Table 6.2
	Table 7.1
	Appendix B
	B5.1
	B5.2
	B5.2.1
	B5.2.2
	NFPA 52:2010
	Table 12.2.2.4
	12.12
	12.12.1
	12.12.1.1
	12.12.2
	12.12.3
	12.12.4
	12.12.4.1
	12.12.5
	12.12.5.1
	12.12.6
	12.12.7
	12.12.8
	NFPA 30A:2008

Description	Reference CSR
	Table 8.3.1
	8.1
	8.2
	8.2.1
	8.3
	8.3.1
	8.3.2
	8.3.3
	8.3.4
	NFPA 88A:2011
	6.1
	6.1.1
	6.1.2
2.5.1 Lighting	
	B108:99
	NFPA 52:2010
	14.3.1.3
	14.3.1.3.1
	NFPA 30A:2008
	NFPA 88A:2011
	6.1.1
	6.1.2
2.5.2 Power	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
	6.1.1
	6.1.2
2.5.3 Heating	

Description	Reference CSR
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
2.5.4 Service Pits	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	Table 8.3.1
	NFPA 88A:2011
2.6 HVAC Systems	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	7.5
	7.5.1
	7.5.2
	7.5.3
	7.5.4
	NFPA 88A:2011
2.6.1 Heating Systems	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008

Description	Reference CSR
	7.6
	7.6.1
	7.6.2
	7.6.3
	7.6.4
	7.6.5
	7.6.6
	7.6.7
	7.6.8
	7.6.9
	NFPA 88A:2011
	6.2
	6.2.1
	6.2.2
	6.2.3
	6.2.4
2.6.2 Ventilation Systems	
	B108:99
	B4.4.1
	B4.4.2
	B4.4.3
	B4.4.4
	B4.4.4.1
	B4.4.4.2
	B4.4.4.3
	B4.4.4.4
	NFPA 52:2010
	12.2.4.2.3
	12.2.4.2.4
	12.2.4.2.5
	12.2.4.2.6
	NFPA 30A:2008
	8.2.1
	NFPA 88A:2011
	6.3
	6.3.1

Description	Reference CSR
	6.3.2
	6.3.3
2.6.3 Venting Systems	
	B108:99
	7.6
	7.14
	7.15
	Table 7.1
	NFPA 52:2010
	5.5.2
	5.5.2.1
	12.6
	12.6.1
	12.6.2
	12.6.3
	12.6.4
	12.6.4.1
	12.6.4.2
	NFPA 30A:2008
	5.6
	5.6.1
	5.6.2
	5.6.3
	NFPA 88A:2011
2.7 Spill Containment	
	B108:99
	NFPA 52:2010
	12.2.3
	12.2.3.1
	12.2.3.1.1
	12.2.3.2
	12.2.3.3
	12.2.3.4
	12.2.3.5

Description	Reference CSR
	12.2.3.5.1
	12.2.3.5.2
	12.2.3.6
	12.2.3.7
	12.2.3.8
	12.2.3.8.1
	12.2.3.8.2
	12.2.3.8.3
	NFPA 30A:2008
	NFPA 88A:2011
	7.1.3
2.8 Gas & Flame Detection Systems / Fire Alarm Systems	
	B108:99
	Appendix B
	B6.1
	B6.1.1
	B6.1.2
	B6.2
	B6.2.1
	NFPA 52:2010
	15.1
	15.2
	15.2.1
	15.2.1.1
	15.2.1.2
	15.6
	NFPA 30A:2008
	7.4.7
	7.4.7.1
	7.4.7.2
	7.4.7.3
	NFPA 88A:2011
	6.6
	6.6.1

Description	Reference CSR
	6.6.2
	6.6.3
	6.6.4
2.9 Fixed Fire Protection Systems	
2.9.1 Automatic Sprinkler Systems	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	7.4.6
	NFPA 88A:2011
	9.2.4.1
2.9.2 Automatic Water-Free Fire Suppression System	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
2.10 Storage of Liquids	
	B108:99
	NFPA 52:2010
	12.2.2.3
	16.3.1
	Table 14.3.2.1.1
	NFPA 30A:2008
	4.1
	4.2
	4.2.1
	12.3.1
	12.3.3

Description	Reference CSR
	12.3.4
	12.3.5
	NFPA 88A:2011
	7.1.1
	7.1.3
2.11 Piping for Liquids	
	B108:99
	NFPA 52:2010
	12.5
	16.9
	16.9.1
	16.9.2
	16.9.3
	16.9.4
	16.9.5
	16.9.6
	16.9.7
	16.9.8
	16.9.9
	16.9.10
	16.9.11
	NFPA 30A:2008
	5.1
	5.2
	5.2.1
	5.2.2
	5.2.3
	5.2.4
	5.2.5
	5.2.6
	5.2.7
	NFPA 88A:2011
2.12 Service Tools and Equipment	
	B108:99

Description	Reference CSR
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
2.12.1 Dynamic Automotive Emissions Testing Equipment	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	7.7
	NFPA 88A:2011
2.12.2 Welders / Open Flame Tools	
	B108:99
	NFPA 52:2010
	12.13.4.1
	NFPA 30A:2008
	9.7.2
	9.7.2.1
	9.7.2.2
	9.7.2.3
	9.7.2.4
	9.7.2.5
	9.7.2.6
	NFPA 88A:2011
2.12.3 Spray Painting / Undercoating / Drying / Baking	
	B108:99

Description	Reference CSR
	NFPA 52:2010
	NFPA 30A:2008
	9.7.3
	9.7.3.1
	9.7.3.2
	9.7.3.3
	9.7.3.4
	9.7.4
	NFPA 88A:2011
2.12.4 Parts Cleaning	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	9.7.6
	9.7.6.1
	9.7.6.2
	9.7.6.2.1
	9.7.6.3
	9.7.6.4
	NFPA 88A:2011
2.12.5 Chassis Cleaning	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	9.7.7
	9.7.7.1
	9.7.7.2
	NFPA 88A:2011

Description	Reference CSR
2.13 Safety / Emergency Systems	
	B108:99
	7.19
	B3.3.1
	B3.3.2
	B3.3.3
	B3.3.4
	B4.4.4.1
	B4.4.4.2
	B4.4.4.3
	B4.4.4.4
	B6.1
	B6.1.1
	B6.1.2
	B6.2
	B6.2.1
	B6.2.2
	B6.2.3
	B6.2.4
	NFPA 52:2010
	8.4.3.5.4.1
	8.4.3.5.4.2
	8.4.3.5.5
	8.4.3.5.6
	8.4.3.6
	8.4.3.7
	12.2.4.2.3
	12.2.4.2.4
	12.2.4.2.5
	12.2.4.2.6
	12.2.4.3
	12.2.4.4
	12.2.4.4.1
	12.2.4.4.2
	12.13.3
	12.3.4

Description	Reference CSR
	12.3.4.1
	NFPA 30A:2008
	4.3.3.6
	4.3.3.7
	4.3.3.7.1
	4.3.3.7.2
	4.3.3.7.3
	4.3.3.7.4
	4.3.3.7.5
	4.3.3.7.6
	4.3.6.3
	7.4.7
	7.4.7.1
	7.4.7.2
	7.4.7.3
	NFPA 88A:2011
2.13.1 Annunciation	
	B108:99
	B6.3
	B6.3.1
	B6.3.2
	B6.3.3
	B6.3.4
	B6.3.5
	NFPA 52:2010
	8.4.3.6
	12.2.4.4
	12.2.4.4.1
	NFPA 30A:2008
	7.4.7.2
	NFPA 88A:2011
2.13.2 Safety Interlocks	
	B108:99
	6.15

Description	Reference CSR
	6.16
	B6.2.1
	NFPA 52:2010
	12.2.3.8.1
	NFPA 30A:2008
	7.4.7
	7.4.7.1
	7.4.7.2
	7.4.7.3
	NFPA 88A:2011
2.13.3 Emergency Shutdown Devices (ESD)	
	B108:99
	B6.2.2
	B6.2.3
	B6.2.4
	NFPA 52:2010
	8.4.3.12.1
	8.11.1
	8.11.5
	8.11.5.1
	8.11.5.2
	12.11.3
	12.11.3.1
	12.11.3.2
	NFPA 30A:2008
	NFPA 88A:2011
3.0 DEFUELLING FACILITY DESIGN	
	B108:99
	NFPA 52:2010
	8.14.6

Description	Reference CSR
	NFPA 30A:2008
	9.7.5
	9.7.5.1
	9.7.5.2
	9.7.5.3
	9.7.5.4
	NFPA 88A:2011
3.1 CNG Defueling System	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
3.1.1 Vent Back System	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
3.1.2 Compressor Inlet System	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
3.1.3 Vehicle to Vehicle System	

Description	Reference CSR
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
3.1.4 Atmospheric Venting System	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
3.1.5 Flaring System	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
3.2 LNG Defuelling System	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
3.2.1 Atmospheric Venting System	

Description	Reference CSR
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
3.2.2 Flaring System	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
3.2.3 Vehicle to Temporary Storage	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011

Attachment 3 LIST OF CODES AND STANDARDS, CLAUSES / PARAGRAPHS / SECTIONS RELATED TO OPERATIONS AND MAINTENANCE

Description	Reference CSR
4.0 OPERATIONS & MAINTENANCE	
	B108:99
	4.8.1
	B3.2.4
	B3.3.3
	B3.3.4
	B4.3.3
	B4.3.4
	B4.4.4.2
	B4.4.4.3
	B4.4.4.4
	B6.2.4
	NFPA 52:2010
	1.7
	8.4.3.7
	8.4.3.12.2
	8.10.2
	8.11.7
	12.2.1.1
	12.2.1.2
	12.2.1.3
	12.2.1.4
	12.2.4.3
	12.2.4.4.2
	12.11.3.2
	NFPA 30A:2008
	7.4.7.2
	7.4.7.3
	9.2.8
	9.4
	9.4.1
	9.4.2

Description	Reference CSR
	9.4.3
	9.4.3.1
	9.4.4
	9.5
	9.5.1
	9.5.2
	9.5.3
	9.5.4
	9.5.5
	9.5.6
	9.7.9
	9.7.9.1
	9.7.9.2
	9.7.9.3
	9.7.9.4
	9.7.9.5
	9.7.9.6
	9.7.9.7
	NFPA 88A:2011
4.1 Vehicle Storage Facilities Operations	
	B108:99
	NFPA 52:2010
	15.7
	NFPA 30A:2008
	NFPA 88A:2011
4.1.1 Designated Parking Lanes	
	B108:99
	8
	8.1

Description	Reference CSR
	8.2
	B4.2.1
	NFPA 52:2010
	NFPA 30A:2008
	6.3.7
	7.3.6.6
	NFPA 88A:2011
4.1.2 Activity Restrictions: Smoking, Cell Phones, etc.	
	B108:99
	5.17
	6.10
	NFPA 52:2010
	8.4.3.11.1
	12.2.4.7
	NFPA 30A:2008
	9.2.5.4
	9.7.9.7
	NFPA 88A:2011
4.1.3 Portable Leak Detection	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
4.1.4 No Idling	
	B108:99
	6.10
	NFPA 52:2010
	8.14.12

Description	Reference CSR
	NFPA 30A:2008
	9.2.5.4
	NFPA 88A:2011
4.1.5 No Repairs	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	9.7.1
	NFPA 88A:2011
4.1.6 Time Limit	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
4.2 Vehicle Storage Facilities Maintenance	
	B108:99
	NFPA 52:2010
	12.13
	12.13.1
	12.13.1.1
	12.13.1.2
	12.13.1.3
	12.13.2
	12.13.3
	12.13.4
	12.13.4.1

Description	Reference CSR
	12.13.5
	12.13.6
	12.13.7
	12.13.8
	12.13.9
	NFPA 30A:2008
	5.4.3
	5.5
	6.3.6
	9.2.6
	9.2.6.1
	9.2.6.2
	9.2.7
	9.2.8
	NFPA 88A:2011
	6.4
	6.4.5
	6.6
	6.6.4
	8.0
	8.1
	8.2
	8.3
	8.4
	8.4.1
	8.4.2
	8.5
4.2.1 Gas / Flame Detection Calibration	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011

Description	Reference CSR
4.2.2 Ventilation System	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
4.2.3 Annunciators	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
4.3 Service Facilities (Repair Garages) Operations	
	B108:99
	NFPA 52:2010
	12.2.1.3
	NFPA 30A:2008
	7.4.7
	7.4.7.1
	7.4.7.2
	7.4.7.3
	7.5.2
	7.5.3
	7.5.4
	9.7.1
	12.0
	12.1
	12.2

Description	Reference CSR
	12.2.1
	NFPA 88A:2011
4.3.1 Defuelling	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	9.7.5
	9.7.5.1
	9.7.5.2
	9.7.5.3
	9.7.5.4
	NFPA 88A:2011
4.3.2 Leak-Free	
	B108:99
	9.0
	9.1
	9.2
	NFPA 52:2010
	8.10
	8.10.1
	8.10.2
	NFPA 30A:2008
	5.4
	5.4.1
	5.4.2
	5.4.3
	5.4.4
	5.5
	NFPA 88A:2011
4.3.3 Electrical Isolation	
	B108:99

Description	Reference CSR
	B4.1.1
	B5.1
	NFPA 52:2010
	NFPA 30A:2008
	6.7
	6.7.1
	6.7.2
	8.1
	8.2
	8.2.1
	8.3.4
	8.3.5
	8.3.6
	8.4
	NFPA 88A:2011
	6.1
	6.1.1
	6.1.2
4.3.4 Fuel Isolation (On board LNG Vehicle)	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	4.0
	4.1
	4.2
	4.2.1
	4.3.9
	4.3.9.1
	4.3.9.1.1
	4.3.9.1.2
	4.3.9.1.3
	4.3.9.2

Description	Reference CSR
	4.3.9.3
	NFPA 88A:2011
	7.0
	7.1
	7.1.1
	7.1.2
	7.1.3
4.3.5 Hot Work	
	B108:99
	NFPA 52:2010
	8.14.11
	12.3.6
	12.13.4.1
	NFPA 30A:2008
	9.7.1
	9.7.2
	9.7.2.1
	9.7.2.2
	9.7.2.3
	9.7.2.4
	9.7.2.5
	9.7.2.6
	NFPA 88A:2011
4.3.6 Portable Fire Extinguishers	
	B108:99
	NFPA 52:2010
	8.15
	NFPA 30A:2008
	9.2.5.3
	NFPA 88A:2011
4.3.7 Emissions Testing	
	B108:99

Description	Reference CSR
	NFPA 52:2010
	NFPA 30A:2008
	7.7
	NFPA 88A:2011
4.3.8 Fire Doors	
	B108:99
	B8.1.2
	B8.5
	B8.5.1
	B8.5.2
	B8.5.3
	B9.2.2
	NFPA 52:2010
	12.2.4.1.1
	12.2.4.1.2
	12.2.4.6
	NFPA 30A:2008
	7.3.6
	7.3.6.1
	7.3.6.2
	7.3.6.3
	7.4
	7.4.2
	9.2.8
	NFPA 88A:2011
	4.1
	4.1.1
	4.1.2
4.3.9 Welding / Open Flames	
	B108:99
	NFPA 52:2010
	8.14.11

Description	Reference CSR
	12.3.6
	12.13.4.1
	NFPA 30A:2008
	9.7.1
	9.7.2
	9.7.2.1
	9.7.2.2
	9.7.2.3
	9.7.2.4
	9.7.2.5
	9.7.2.6
	NFPA 88A:2011
4.3.10 Spray Painting / Undercoating / Drying / Baking	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	9.7.3
	9.7.3.1
	9.7.3.2
	9.7.3.3
	9.7.3.4
	9.7.4
	NFPA 88A:2011
4.3.11 Fuel Tank Repairs	
	B108:99
	NFPA 52:2010
	16.8
	16.8.1
	16.8.1.1
	16.8.1.2

Description	Reference CSR
	16.8.1.3
	16.8.1.4
	16.8.2
	16.8.3
	16.8.3.1
	16.8.3.2
	16.8.4
	NFPA 30A:2008
	9.7.5
	9.7.5.1
	9.7.5.2
	9.7.5.3
	9.7.5.4
	NFPA 88A:2011
4.3.12 Parts Cleaning	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	9.7.6
	9.7.6.1
	9.7.6.2
	9.7.6.2.1
	9.7.6.3
	9.7.6.4
	NFPA 88A:2011
4.3.13 Chassis Cleaning	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	9.7.7

Description	Reference CSR
	9.7.7.1
	9.7.7.2
	NFPA 88A:2011
4.3.14 Vehicle Fuel System Leak Testing – CNG	
	B108:99
	Table B2
	NFPA 52:2010
	NFPA 30A:2008
	6.12
	6.12.1
	6.12.2
	6.12.3
	6.12.4
	6.12.5
	6.12.6
	NFPA 30A:2008
	NFPA 88A:2011
4.3.15 Vehicle Heat Leak, Cold Test and Pressure Test – LNG	
	B108:99
	NFPA 52:2010
	11.3.5
	11.3.5.1
	11.3.5.2
	11.3.5.3
	16.8
	16.8.1
	16.8.1.1
	16.8.1.2
	16.8.1.3

Description	Reference CSR
	16.8.1.4
	16.8.2
	16.8.3
	16.8.3.1
	16.8.3.2
	16.8.4
	NFPA 30A:2008
	NFPA 88A:2011
4.4 Service Facilities Maintenance	
	B108:99
	NFPA 52:2010
	8.16
	8.16.1
	12.13
	12.13.1
	12.13.1.1
	12.13.1.2
	12.13.1.3
	12.13.2
	12.13.3
	12.13.4
	12.13.4.1
	12.13.5
	12.13.6
	12.13.7
	12.13.8
	12.13.9
	NFPA 30A:2008
	5.4
	5.4.1
	5.4.2
	5.4.3
	5.4.4

Description	Reference CSR
	5.5
	9.7.9
	9.7.9.1
	9.7.9.2
	9.7.9.3
	9.7.9.4
	9.7.9.5
	9.7.9.6
	9.7.9.7
	NFPA 88A:2011
4.4.1 Gas / Flame Detection Calibration	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
4.4.2 Ventilation System	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
4.4.3 Annunciators	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008

Description	Reference CSR
	NFPA 88A:2011

**Attachment 4 LIST OF CODES AND STANDARDS, CLAUSES / PARAGRAPHS /
SECTIONS RELATED TO HAZARD IDENTIFICATION AND RISK**

Description	Reference CSR
5.0 HAZARD IDENTIFICATION AND RISK ASSESSMENT (HIRA)	
	B108:99
	NFPA 52:2010
	9.2.3
	9.2.3.1
	9.2.3.2
	14.3.1
	NFPA 30A:2008
	NFPA 88A:2011

Attachment 5 LIST OF CODES AND STANDARDS, CLAUSES / PARAGRAPHS / SECTIONS RELATED TO SAFETY MANAGEMENT

Description	Reference CSR
6.0 SAFETY MANAGEMENT SYSTEM	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
6.1 Safety Policy	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
6.2 Safety Program Overview (Master Safety and Health Plan)	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
6.3 Change Control	
	B108:99
	NFPA 52:2010

Description	Reference CSR
	NFPA 30A:2008
	NFPA 88A:2011
6.4 Safe Work Procedures	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
6.4.1 Risk Assessment	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
6.4.2 Job Procedure	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
6.4.3 Deficiency Reporting	
	B108:99

Description	Reference CSR
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
6.4.4 Incident Investigation & Reporting	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
6.4.5 Corrective & Preventive Action	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
6.4.6 Contractor Safety	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
6.4.7 Hazardous Materials Management (MSDS & PPE)	

Description	Reference CSR
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
6.4.8 Work Permit	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
6.4.9 Equipment Lockout	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
6.4.10 Hot Work	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
6.4.11 Confined Space Entry	

Description	Reference CSR
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
6.4.12 Audit	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
6.4.13 Personnel Qualifications & Training	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
6.5 Signage	
	B108:99
	5.17
	5.18
	6.10
	7.20
	B4.3.1
	NFPA 52:2010
	8.4.3.11
	8.4.3.11.1

Description	Reference CSR
	8.4.3.11.2
	8.14.5
	8.14.12
	8.14.12.1
	8.14.12.2
	8.14.12.3
	8.14.12.4
	12.2.4.7
	NFPA 30A:2008
	9.2.5.4
	9.5.3
	NFPA 88A:2011

Attachment 6 LIST OF CODES AND STANDARDS, CLAUSES / PARAGRAPHS / SECTIONS RELATED TO EMERGENCY RESPONSE

Description	Reference CSR
7.0 EMERGENCY RESPONSE PLAN	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
7.1 Emergency Response Procedure	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
7.2 Phone List	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
7.3 Crisis Communications	
	B108:99
	NFPA 52:2010

Description	Reference CSR
	NFPA 30A:2008
	NFPA 88A:2011

Attachment 7 LIST OF CODES AND STANDARDS, CLAUSES / PARAGRAPHS / SECTIONS RELATED TO PERSONNEL TRAINING

Description	Reference CSR
8.0 PERSONNEL TRAINING	
	B108:99
	B3.3.4
	NFPA 52:2010
	1.7
	8.16.7
	NFPA 30A:2008
	NFPA 88A:2011
8.1 Attendees	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
8.1.1 Vehicle Operators	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
8.1.2 Mechanics	
	B108:99
	NFPA 52:2010

Description	Reference CSR
	NFPA 30A:2008
	NFPA 88A:2011
8.1.3 Management / Supervisory / Other Staff	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
8.1.4 Emergency First Responders	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
8.1.5 Other	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
8.2 Training Topics	
	B108:99

Description	Reference CSR
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
8.2.1 Physical / Chemical Properties of the Fuel	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
8.2.2 Safe Handling Procedures	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
8.2.3 Facility Safety Features	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011

Description	Reference CSR
8.2.4 Fire Detection / Suppression Features	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
8.2.5 Vehicle Safety Features	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
8.2.6 Safe Work Procedures	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
8.2.7 Fire Prevention	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011

Description	Reference CSR
8.2.8 Emergency Notification Procedures	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
8.2.9 Emergency Evacuation Procedures	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
8.2.10 Emergency Drills	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011
8.2.11 Personal Protective Equipment	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011

Description	Reference CSR
8.2.12 Defuelling Procedures	
	B108:99
	NFPA 52:2010
	NFPA 30A:2008
	NFPA 88A:2011