Wake Transit Plan

Impacts of Alternative Fueled Vehicles

IMPACTS OF ALTERNATIVE FUELED VEHICLES ON EXISTING MAINTENANCE FACILITIES AND THE DESIGN OF NEW MAINTENANCE FACILITIES

INTRODUCTION

In conjunction with the assessment of facility conditions and space needs, staff from each Transit Partner requested specific input with regards to the potential for parking and maintaining CNG-fueled vehicles at the existing facilities and any new facilities being recommended. The major issues and needs have been noted:

- The 18-inches of space below the ceiling or roof structure where CNG vehicles are present is classified as a Class 1, Division 2 hazard, requiring all equipment in the 18-inch zone to be spark resistant or removed from the zone. This includes light fixtures and detectors.
- While not required when using odorized CNG, most facilities install a methane detection system to sense the presence of dangerous levels of methane and activating an emergency exhaust/purge system. The detectors must be explosion-proof.
- Skylights allow for the collection of CNG/methane gas and must be individually exhausted.

The following document presents a detailed review of existing code requirements for compressed natural gas (CNG) and liquefied natural gas (LNG) for vehicle maintenance facilities. This technical memorandum includes steps that should be considered when determining the modification that may be required, including basic questions that should be addressed in order to begin development of facility modification plan.

EXISTING NATIONAL CODE REQUIREMENTS

The national codes that cover vehicle maintenance facilities based on Michigan's code adoption at the time of this report are the:

- International Fire Code (IFC 2012)
- International Mechanical Code (IMC 2012)
- International Building Code (IBC 2012)
- NFPA 30A (2012) Code for Motor Fuel Dispensing Facilities and Repair Garages
- NFPA 52 (2010) Vehicular Gaseous Fuel Systems Code
- NFPA 88A (2011) Standards for Parking Structures.

It is important to note that the ICC code series and NFPA 30A, 52 and 88A are codes that, if adopted, are adopted voluntarily by states (they usually do not adopt the latest edition) and enforced by the local Authority Having Jurisdiction (AHJ). The local AHJ may enforce additional requirements beyond the national codes and, therefore, they should at least be consulted directly before final design of any modifications, preferably they should be part of the initial evaluation discussions.

EXISTING CODE REQUIREMENTS BY FACILITY ACTIVITY

The codes discussed below only apply to major repair facilities. Both NFPA 30A and the IFC exempt minor repair facilities from all of the code requirements specific to CNG and LNG.

- IFC 2311.7 exempts garages that do not work on the vehicle fuel system or do not use open flames or welding from all additional requirements.
- By definition NFPA 30A exempts garages that do not perform engine overhauls, painting, body and fender work and any repairs requiring draining vehicle fuel tanks from all additional requirements. The maintenance work that can be done without any modifications to the facility include lubrication, inspection, engine tune-ups, replacement of parts, fluid changes, brake system repairs, tire rotation and similar routine maintenance work.

When a maintenance facility is considering adding CNG and /or LNG vehicles to their operations, an analysis of maintenance tasks by type as a percentage of the overall activities should be done. The analysis can help determine if the facility could be divided into 'major repair' and 'minor repair' areas. With proper physical separation, the codes require only that those areas of the facility designated as 'major repair' areas to be subject to the additional requirements for CNG and LNG.

EXISTING CODE REQUIREMENTS BY CATEGORY

The sections below discuss the existing national code requirements for liquid and gaseous fuels (CNG and LNG) repair garages or maintenance facilities. There are seven main areas to consider when reviewing the existing codes: ventilation, pits or basement ventilation, gas detection, heating equipment (sources of ignition), electrical classification, vehicle preparation for entering repair garage and maintenance, and decommissioning of fuel containers. In each area, the requirement for each fuel are shown side by side for comparison. Table A provides an overview of code references for each of the seven categories.

Table A: Code References by Category

Modification Category	Code Reference
Ventilation	IFC (2012) 2311.7.1. 2311.7.1.2 IMC (2012) Table 403.3 NFPA 30A (2012) 7.4.7.2, 7.4.7.3, 7.5.1, 7.5.3 NFPA 88A (2011) 6.3.1

Ventilation in Pits	IFC (2012) 2311.4.3 NFPA 30A (2012) 7.4.5.4
Gas Detection	IFC (2012) 2311.7.2, 2311.7.2.1, 2311.7.2.2, 2311.7.2.3 NFPA 30A (2012) 7.4.7, 7.4.7.1, 7.4.7.2, 7.4.7.3, 7.4.7.4
Sources of Ignition	NFPA 30A (2012) 7.6.6
Electrical Classification	NFPA 30A (2012) 8.2.1
Preparation of Vehicles for Maintenance	IFC (2012) 2311.5
Maintenance of Containers and Discharge from Containers	NFPA 52 (2010) 6.14

NOTE: While the various codes have similar requirements, there are a few discrepancies that should be considered. They are noted in the tables for each individual category, provided in the following sections.

Code Requirements for Ventilation (General)

The International Mechanical Code (IMC 2012) Table 403.3 requires all vehicle repair garages, regardless of fuel type or maintenance performed, to have a ventilation rate of 0.75 cfm/sq ft of floor area. Any ventilation rates required for CNG or LNG maintenance facilities would simply increase this base rate. As noted above, there are no requirements for ventilation rates over-and-above the base rate for CNG or LNG minor repair garages (see “Existing Code Requirements by Facility Activity” in the previous section).

NFPA 88A (2011), Article 6.3.1 requires a ventilation rate of 1 cfm/sq ft of floor area for enclosed parking garages housing liquid and gaseous-fueled vehicles. Based on this requirement, it should be considered that the base rate for all repair garages would be at least 1 cfm/sq ft, as even in minor repair garages, vehicles could be parked waiting for repairs for a period of time.
Where mechanical ventilation is required by IFC (2012), Article 2311.7.1, it must operate continuously except when it is either interlocked with a gas detection system for LNG or electrically interlocked with the lighting circuit for CNG applications.

The codes state the ventilation rate using three different formats. Conversions for each format are shown in Table B.

Table B: Ventilation Rate Conversions

Rates	CFM/Sq Ft	CFM/12 Cu Ft	Air Changes/Hour
CFM/sq ft	1	1/12 ft	60/room height (ft)
CFM/12 cu ft	12 ft	1	5
Air Changes/Hour	Room height (ft)/60	1/5	1

There is a discrepancy between NFPA 30A and IFC 2311.7.1 in the requirements for mechanical ventilation. NFPA requires mechanical ventilation for fuel dispensing areas but the IFC requires it for the CNG maintenance areas as well. NFPA 7.5.1 – 7.5.4 only requires ventilation for fuel dispensing areas within the maintenance facility, where IFC 2311.7.1 – 2311.7.1.2 uses similar language for CNG repair facilities assuming that indoor fueling will always be part of the repair facility even to the point of requiring the "system shall shut down the fueling system" if the ventilation fails. NFPA separates indoor dispensing from repair facility requirements.

Table C: General Ventilation

Subject	Liquid Fuels	CNG	LNG
Ventilation, General	NFPA 30A: 7.5.1, 7.5.2, 7.5.3 and 7.5.4 – Provides for ventilation systems service a fuel dispensing area inside a building or repair garage. IFC – No specific requirements for liquid fuels but does reference the IBC for general ventilation requirements. IMC: Table 403.0 – General ventilation requirements for all repair garages of 0.75/cfm per sqft of floor area. NFPA 88A: 6.3.1	NFPA 30A: No specific requirements for CNG IFC: 2311.7.1, 2311.7.1.1 and 2311.7.2 – Requires approved mechanical ventilation systems for CNG repair garages at 1 cfm/sf	NFPA 30A: 7.4.7.2 and 7.4.7.3 – Requires that the operation and failure of gas detection systems be interlocked with an existing mechanical ventilation system for garages repairing LNG engine fuel systems.- IFC: 2311.7.1, 2311.7.1.1 and 2311.7.1.2

Code Requirements for Ventilation in Pits or Basements

Ventilation requirements for pits, lower level work areas, and below grade and subfloor work areas are part of the basic requirements for liquid fuels where flammable vapors may accumulate. This requirement should already be met by the existing maintenance facility. However, the codes are not harmonized as to the ventilation rate. IFC requires 1.5 cfm/sq ft, while NFPA requires 1.0 cfm/sq ft. The local AHJ should specify the rate for each facility. The codes have no requirements specific to CNG or LNG. While experience has shown that there is a very low probability of a release of LNG liquid, the release of a cold vapor may initially be heavier than air and migrate to a subgrade area, where it would quickly become buoyant and rise as a CNG release. The existing ventilation requirement for liquid fuels should be adequate for the addition of LNG to major repair facilities with approval of the local AHJ.

Table D: Ventilation of Pits

Subject	Liquid Fuels	CNG	LNG
Ventilation of Pits, Below-grade Work Areas and Subfloor Work Area	**IFC:** 2311.4 **NFPA 30A**: 7.4.5.4	**IFC and NFPA 30A** – No requirements specific to CNG	**IFC and NFPA 30A** – No requirements specific to LNG

Code Requirements for Gas Detection

There are no requirements for gas detection in repair garages (major or minor) where odorized CNG or LNG vehicles are maintained. However, IFC 2311.7.2 and NFPA 30A 7.4.7 both require approved gas detection systems for major repair garages servicing LNG vehicles. Specific requirements under these codes for gas detection installation and operation are similar and may require the expertise of a gas detection design engineer for optimal performance.

Table E: Gas Detection

Subject	Liquid Fuels	CNG	LNG
Gas Detection	**IFC and NFPA 30A** - No requirements	**IFC and NFPA 30A** – No requirements for gas detection for odorized CNG or odorized LNG.	**IFC: 2311.7.2, 2311.7.2.1, 2311.7.2.2, and 2311.7.2.3 –** Requires an approved gas detection system for major repair garages for LNG vehicles where (work is done on the fuel system and the work may require open

			flames or welding **NFPA 30A: 7.4.7,7.4.7.1, 7.4.7.2, 7.4.7.3 and 7.7.4.4 -**The requirements are essentially the same in NFPA except that it is limited to facilities where "repair of vehicle engine fuel systems" takes place

Code Requirements for Sources of Ignition

The IFC does not have any specific requirements for CNG and LNG repair garages with respect to sources of ignition. IFC does provide requirements for liquid fuels in section 2311.4 restricting ignition sources from the space within the 18 inches of the floor. This is the standard requirement in the IBC, IMC and NFPA 70. These requirements already should be met by the existing facility.

In NFPA 30A 7.6.6, the restrictions on heating equipment in major repair garages only apply to areas where ignitable mixtures may be present. The accepted practice at this time is to assume that there will be an ignitable mixture present in some areas of major repair garages. The identification of these areas is based on the expected volume of fuel released and its concentration in the facility.

Table F: Sources of Ignition

Subject	Liquid Fuels	CNG	LNG
Preparation of vehicles for repair	**IFC and NFPA 30A -** No requirement	**IFC 2311.5** Close cylinder valve prior to repairing any portion of the vehicle fuel system. Where the fuel system has been damaged it shall be inspected and evaluated for fuel system integrity prior to	**IFC 2311.5** Close LNG tank valve prior to repairing any portion of the vehicle fuel system. Where the fuel system has been damaged it shall be inspected and evaluated for fuel system integrity prior to being brought into the repair garage. Test

		being brought into the repair garage. Test the entire fuel system for leakage. **NFPA 30A** – No requirement	the entire fuel system for leakage. **NFPA 30A** – No requirement

ELECTRICAL CLASSIFICATION CODE REQUIREMENTS

The IFC does not have any specific requirements on electrical classifications for CNG and LNG repair garages. NFPA 30A Chapter 8 includes requirements for electrical classification areas for liquid fuel vehicles that primarily address electrical classifications for pits and the space within 18 inches from the floor of the repair garage. NFPA 30A 8.2.1 classifies the area 18 inches from the ceiling for major garages that repair CNG vehicles as Class 1, Division 2. The exception to this classification is that, when an area below the ceiling has ventilation of at least 4 air changes per hour, the area is considered unclassified. While NFPA 30A is silent on classified areas for LNG in major garages, in practice LNG would see the same requirements as liquid fuels in pits and the same requirements as CNG in the 18-inch space below the ceiling.

As noted in the previous section on 'Hazard Analysis', the existing code requirements for CNG were based on the release of 150% of the contents (NFPA 30A - Annex A.8.2.1) of the largest cylinder of the vehicles in the repair facility. This release hazard was selected because of the failure of specific pressure relief devices (PRD) in service in the 1990s. The PRDs have been through several design generations since then and the last cases of premature release were over 15 years ago.

Table G: Electrical Classification

Subject	Liquid Fuels	CNG	LNG
Electrical Installations	**IFC Section 2211 –** No specific requirements. **NFPA 30A Chapter 8** - Multiple electrical classifications for liquid fuel repair garages.	**IFC Section 2211 –** No specific requirements. **NFPA 30A 8.2.1*** In major repair garages where CNG vehicles are repaired or stored, the area within 18 in. of the ceiling shall be designated a Class I, Division 2 hazardous location.	**IFC Section 2211 –** No specific requirements. **NFPA 30A 8.2.1*** Only covers CNG but would expect the AHJ to extend the requirement to LNG as well. See note in CNG column on assumption made for extent of hazard.

		Exception: This requirement shall not apply where the ventilation rate is not less than 4 air changes per hour. **Note 3** The assumption made by the code committee, as stated in Annex A.8.2.1, was that the release of CNG in the facility would be equal to 150% of the largest CNG cylinder. Since the assumption defines the hazard expected, any change in this assumption may result in future code changes.	

PREPARATION OF VEHICLE FOR REPAIR CODE REQUIREMENTS

IFC 2211.5 is the only code requirement that addresses mitigation of the assumed hazards from releases of natural gas by:

- Isolating the CNG cylinders and LNG tanks from the balance of the fuel system by valve closures prior to maintenance. This reduces the quantity of fuel that could be released in fuel system piping and components due to damage or error during maintenance operations.
- Operating the NGV until it stalls due to low fuel pressure in the system can further reduce the possible release volume with the cylinder valves closed.

IFC 2211.5 also requires that the fuel system on the NGV be tested for leakage by appropriate methods if there is a concern that the fuel system has experienced any damage. If damage is suspected the vehicle may need to be de-fueled prior to any maintenance.

Table H Preparation of Vehicles for Repair

Subject	Liquid Fuels	CNG	LNG
Preparation of vehicles for repair	**IFC and NFPA 30A** - No requirement	**IFC 2211.5** Close cylinder valve prior	**IFC 2211.5** Close LNG tank valve prior to

		to repairing any portion of the vehicle fuel system. Where the fuel system has been damaged it shall be inspected and evaluated for fuel system integrity prior to being brought into the repair garage. Test the entire fuel system for leakage. **NFPA 30A** - No requirement	repairing any portion of the vehicle fuel system. Where the fuel system has been damaged it shall be inspected and evaluated for fuel system integrity prior to being brought into the repair garage. Test the entire fuel system for leakage. **NFPA 30A** - No requirement

MAINTENANCE AND DECOMMISSIONING OF VEHICLE FUEL CONTAINERS

These code requirements are not found under repair garages but are part of the maintenance requirements for vehicle mounted fuel storage containers. NFPA 52 (2010) should be consulted for the specific requirements. The 2013 edition of NFPA 52 incorporates several critical safety related changes for CNG cylinder maintenance. These changes are lessons learned from incidents involving CNG cylinder maintenance operations and are included in the table below. These requirements call for the development of written maintenance procedures along with certain modifications to the maintenance facility to accommodate defueling of fuel containers for fuel system maintenance and end of life decommissioning of CNG cylinders.

Table I Maintenance and Decommissioning of Vehicle Fuel Containers

Subject	Liquid Fuels	CNG	LNG
Fuel system maintenance	No specific requirements	**NFPA 52** – 2012 6.13 Repair facilities should have specific written procedures for inspection and decommissioning CNG cylinders. This set of requirements depends on properly trained personnel and the use of procedures as recommended by the	The codes do not provide specific requirements for maintaining or venting LNG fuel tanks. It is recommended that the repair garage develop written procedures and training material based on the LNG

		cylinder and/or cylinder valve manufacturer.	tank manufacturer's instructions.
Decommissioning & defueling of fuel cylinders/tanks	No specific requirements	**NFPA 52** - 2012 6.14 Each major repair garage should install the proper defueling facility as outlined by this section of NFPA 52. Designs for fuel recovery systems and direct atmospheric venting systems should be approved by the AHJ as required. If the CNG cylinders have reached their end of life or are damaged, the cylinder should be purged with an inert gas, made unusable and scrapped according to the cylinder manufacturer's instructions.	The codes do not have specific requirements for decommissioning LNG fuel tanks. It is recommended that the repair garage develop written procedures and training material based on the LNG tank manufacturer's instructions.

GUIDELINE FOR MODIFICATIONS

This section discusses steps that should be considered when determining the modifications that may be required for maintenance facilities to service CNG and /or LNG vehicles. It is important to note that each individual existing maintenance facility must be evaluated to determine any necessary modifications, since the building design and activities preformed in the facility can have a significant impact on the modifications required. Just as the codes are performance documents - not design documents - this document does not provide specific design guidelines but does provide the steps needed for basic decisions on the modifications required to meet code and provide for safe operations.

NOTE: If the garage is designed to accommodate LNG vehicles then no additional modifications should be needed to also service CNG vehicles. If the garage is modified specifically for CNG vehicles meeting the basic code requirements, then additional modifications may be required to service LNG vehicles.

Plan Development and Coordination with AHJ's

There are several basic questions that should be answered in order to begin development of the facility modification plan. These include

- Does the facility meet existing code requirements for liquid fuels?
  - If not, what remedial action may be required? (i.e. ventilation etc.)
- What type of NGV will the facility maintain; CNG, LNG or both?
- Will the facility provide minor repairs, major repairs or both?
- Will the minor repair area be physically separated from the major repair area?
  - If not the entire facility may be classified as a major repair facility.
- Will the facility procedures include the venting and decommissioning of cylinders?
- Will the facility include an indoor or outdoor fueling station?
  - Note: this document does not include guidelines for fueling stations, but if a station will be installed at the same times as the facility modifications, then the overall plan should include that design and its possible interconnection with cylinder defueling.
- Will the facility include indoor parking for NGVs?

The answers to the questions above will help determine the scope of the potential facility modifications and the operating procedures for the facility. Before taking the next step in plan development, an inquiry should be made to the local AHJ(s) to determine the specific code documents that have been adopted and will be enforced.

Analysis of Existing Maintenance Facilities

When modifications are anticipated for existing maintenance facilities, a review of the facilities compliance with the existing codes may be necessary. Since the existing maintenance facilities may have been built under older editions of the codes, and codes are generally not retroactive, any new modifications may require bringing the facility up to the codes now enforced for liquid fuels.

Code Compliance of Maintenance Facility for Class I and Class II Fuels

The general primary concerns and consideration for code compliance for the existing transit Partners' facilities are:

- Ventilation rate in general garage area should be between 0.75 (IMC) and 1.0 (NFPA) cfm/sq ft with inlet at least 18" above the floor.
- Ventilation rate for below grade areas (pits or basement) should be between 1.0 (NFPA) and 1.5 (IFC) cfm/sq ft with exhaust air taken within 12" of the floor.
- Review the IFC and NFPA documents for requirements for sources of ignition including heating appliances since their design and placement may have a significant influence on the modifications for the CNG/LNG garage.

- When the AHJ tours the facility in the initial review process, they may determine that some remedial modifications are needed to the existing facility to come into compliance with the code editions now in place.