



Natural Gas for Transportation Vehicle Repair Garage Guidelines



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Publication of the State of Wisconsin
Publication Date: September 10, 2013

Wisconsin Department of Administration
Division of Energy Services - State Energy Office
101 East Wilson Street, 6th Floor
Madison, WI 53703

Acknowledgment: This material is based upon work supported by the Department of Energy under Award Number DE-FG26-07NT43169 / 011

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Credits and Acknowledgements

ET Environmental wishes to acknowledge the participation and assistance of several agencies that made this report possible. The collaborative effort helped to provide valuable insight for the development of the guidelines.

Special thanks to:



About the Author:

ET Environmental (ET) is a design/build construction management firm that has extensive experience with the assessment, design, permitting, and construction of repair garage modifications for Natural Gas Vehicle (NGV) compliance. ET's experience with NGV garage and fueling projects spans across many jurisdictions throughout the United States. This experience provided the knowledge and insight to anticipate the complexities that are inevitably encountered when implementing the code requirements into an existing facility and to develop innovative solutions to economically meet those requirements.

Resources

- Wisconsin Administrative Code, Safety and Professionals Services (Admin code SPS sections) <https://docs.legis.wisconsin.gov/code/toc/sps>
- I-Codes can be purchased from the International Code Council online store at <http://shop.iccsafe.org/>
- National Fire Protection Association (NFPA) documents may be purchased online at <http://www.nfpa.org/codes-and-standards/document-information-pages>

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DEFINITIONS AND ABBREVIATIONS

Major Repair Garage – Defined in NFPA 30A 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.”

Minor Repair Garage – Defined in NFPA 30A 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.”

ACH – Air Changes per Hour

AHJ – Authority Having Jurisdiction

CFM – Cubic Feet per Minute

CFM/FT² – Cubic Feet per Minute per Square Foot of Floor Area

CFM/FT³ – Cubic Feet per Minute per Cubic Foot of Room Volume

CNG – Compressed Natural Gas

DSPS – Wisconsin Department of Safety and Professional Services

IBC – 2009 International Building Code

IEBC – 2009 International Existing Buildings Code

IECC – 2009 International Energy Conservation Code

IFC – 2009 International Fire Code

IMC – 2009 International Mechanical Code

LEL – Lower Explosive Limit

LNG – Liquefied Natural Gas

NEC – National Electric Code 2008 (NFPA 70)

NFPA - National Fire Protection Association

NFPA 30A – National Fire Protection Association: Code for Motor Fuel Dispensing Facilities and Repair Garages, 2008

NFPA 52 – National Fire Protection Association: Vehicular Gaseous Fuel Systems Code, 2010

NGV – Natural Gas Vehicle

PSI – Pounds per Square Inch

SEO – Wisconsin State Energy Office

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SECTION 1 – INTRODUCTION

Background

The Wisconsin State Energy Office (SEO) works with policy makers, local energy industry businesses, innovators, and federal agencies to help create clean energy investments that are reliable, balanced, cost effective and environmentally friendly. As part of this effort to encourage the use and adoption of clean energy technologies, the State held several outreach events to educate stakeholders and identify barriers to the growth of the natural gas vehicle market. Through this outreach it was discovered that there is a lot of uncertainty related to repair garage requirements for Natural Gas Vehicles (NGVs). SEO believes that clarifying the code related to natural gas vehicle repair facilities and providing more regulatory certainty will help move the natural gas fueled vehicle industry forward in Wisconsin. This guideline document will address these concerns and provide industry guidance on the subject of repair garage safety and code requirements. The intention is to create more certainty on the subject of garage requirements and to encourage consistent interpretation and enforcement of the code requirements applicable in the state of Wisconsin.

Scope and Purpose

In addition to encouraging the consistency of code interpretations, the document addresses other aspects related to the NGV repair garages including: permitting, recommended practices, training, operations, and budgetary costs. Several case studies detailing the modifications and methods of compliance are also presented to provide a point of reference and to illustrate how others have upgraded existing garages for NGVs.

This document incorporates Wisconsin and applicable national codes related NGV repair garages in effect at the time of publishing. Inevitably, changes will occur in the codes, laws, and regulations following publication. Before relying upon information contained in these guidelines, the reader is advised to check the accuracy of all information with the appropriate official or agency. Wisconsin has adopted and modified national codes to create a unique set of provisions in the State. Every effort has been made to incorporate and specifically reference the current state code modifications related to garage renovations. In some cases, the Wisconsin revisions to the national codes are very significant as they relate to the renovation of repair garages. While this is believed to be a comprehensive summary of applicable codes, the applicability to a specific facility can vary dramatically. A professional engineer with competence in the area of design of repair garages for natural gas vehicles should be consulted and must prepare the final project permit and construction documents.

The scope of these guidelines is specifically focused on the retrofit of existing diesel and gasoline garage facilities for the maintenance of NGVs. The guidelines do not address indoor fueling or new facility construction. Repair shops for both compressed natural gas vehicles (CNG) and liquefied natural gas vehicles (LNG) are discussed. It should be noted that while there are many similarities between these two forms of natural gas fuel, there are also several differences. In general a LNG repair shop will require additional measures above what is required for a CNG repair shop.

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This document is intended to present effective strategies to address code specified minimum measures for NGV repair facilities. Owners may elect to add additional features or functionality to meet their unique requirements. For example, voluntary upgrades of heating or ventilation systems, fire detection/suppression systems, lighting, or energy recovery systems could be incorporated into the project based on owner preference. In some cases, these decisions could be a result of a corporate culture, asset protection, to address deferred maintenance issues, or to increase employee comfort. Section 2 contains a detailed discussion of the code provisions and methods of compliance then separately presents recommended practices that are commonly included with projects of this type.

Properties of Natural Gas

- The primary ingredient of natural gas is methane (CH₄). Methane percentages greater than 90% are typical in the United States distribution systems. Pipeline natural gas is odorized as a safety measure to allow human detection.
- Methane is nontoxic, odorless, colorless, and tasteless.
- Natural gas is lighter-than-air and will rise under normal conditions. It's in a gaseous form at atmospheric conditions.
- The mixture of natural gas in air that will support combustion is between 5% and 15% by volume. Ratios outside this range will not support combustion. Odorized natural gas can typically be detected by smell at approximately 1% natural gas in air.
- The ignition temperature of natural gas is approximately 1100°F
- NGVs are fueled by either compressed natural gas (CNG) or liquefied natural gas (LNG).
- CNG
 - CNG is stored on the vehicle in a gaseous form which has been compressed up to 3,600 PSI nominal pressure (at 70° F). At this pressure the volume of the natural gas is 3.5 times the volume of diesel containing the equivalent energy.
- LNG
 - LNG is a cryogenic liquid with a temperature of approximately -260°F and is typically composed of more than 95% methane.
 - LNG gaseous vapor is initially heavier than air when its temperature is below -170 °F but as the gas temperature quickly rises, it becomes lighter than air.
 - LNG has higher energy density than CNG but is still less than the energy density of diesel; LNG is approximately 1.7 times the volume of diesel containing equivalent energy.
 - LNG is not odorized.

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Hazards of Natural Gas

Natural gas is flammable in air. In the event of a gas escape indoors, natural gas will rise. A large release of the gas may rise in a plume with a concentration greater than the 15% upper limit of ignitable concentrations. Areas around the edges of the plume will contain ignitable concentrations and could be combusted if a source of ignition (heat, flame or spark) is present. Ignitable concentration of gas could also accumulate in the ceiling area and are a potential source of combustion if an ignition source is present.

High concentrations of natural gas can cause asphyxiation by displacing the normal oxygen concentration in air. This hazard is increased in confined spaces.

CNG

There are hazards associated with CNG due to the high pressures. A release could be in the form of a high pressure jet of gas that can cause injury due to the high velocity and cold temperature. Pipes and pipe fittings under high pressure can present significant hazards if damaged or incorrectly serviced.

CNG fuel tanks contain a pressure relief device that is set to open automatically at a specific temperature or pressure. This valve cannot be isolated from the vehicle fuel tank. When the Pressure Release Device (PRD) activates, it remains open until the entire fuel cylinder is depressurized.

LNG

In its liquid form, LNG will pool on the ground and vapors produced could ignite and burn continuously as the pool of LNG vaporizes, creating a high heat environment that could cause burn injury and property damage, i.e., intense fire but not explode.

If skin is exposed to cryogenic liquids such as LNG, it will result in a cold “burn” and can cause serious and permanent damage to the skin.

Permitting

Permitting and plan reviews for commercial facilities in the State of Wisconsin are processed by either the state Department of Safety and Professional Services (DSPS), local authorities having jurisdiction (AHJ), or both depending on the project location and scope of work. Every project should be coordinated with the local AHJ to determine the approval steps and permits required. Refer to Figure 1.1 and 1.2: Commercial Buildings and Fire Alarm/Suppression system permitting flow charts which illustrate the basic approval process.

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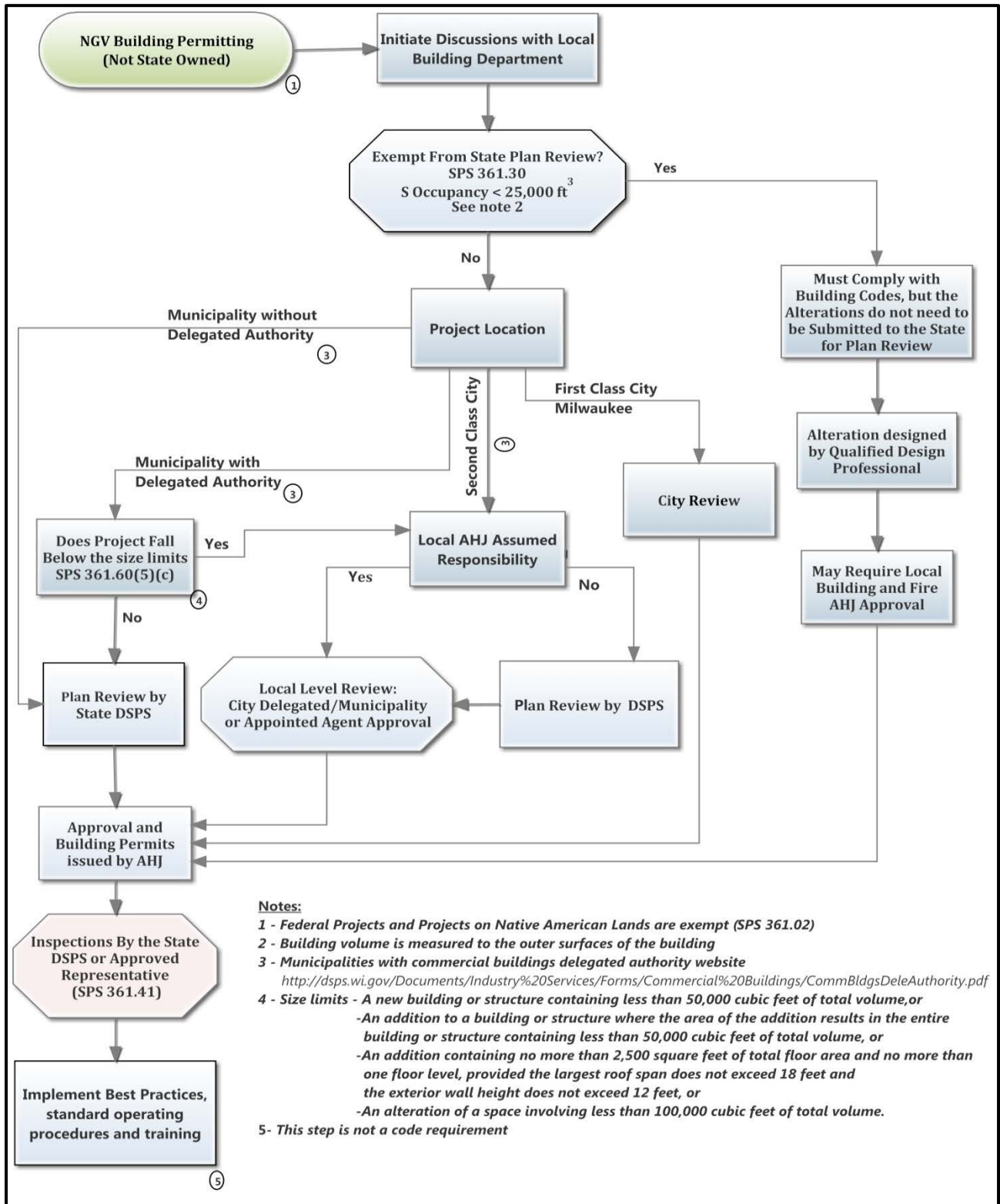


FIGURE 1.1 – Commercial (Building, HVAC, Lighting) Permit Flow Chart

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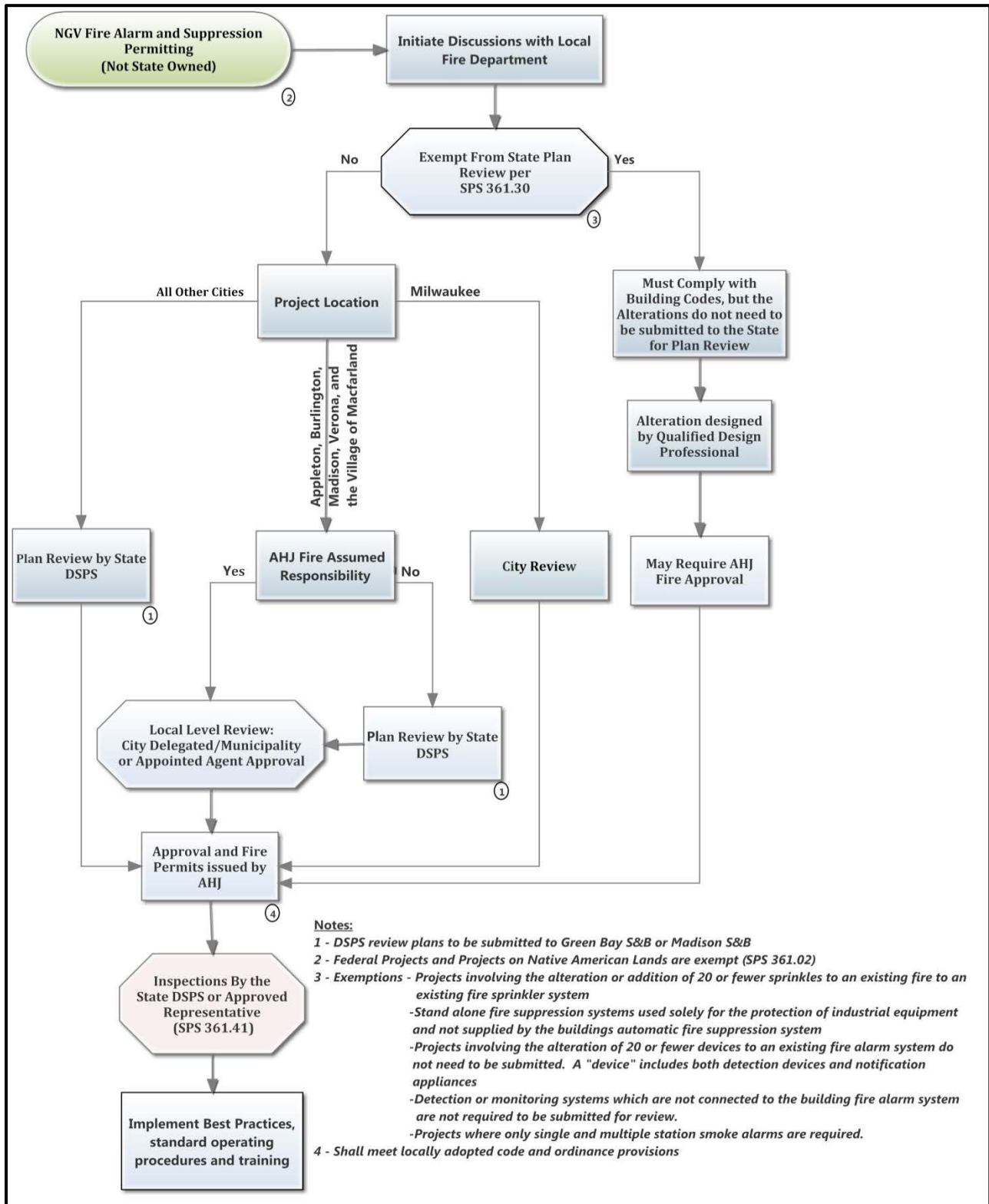


FIGURE 1.2 – Fire alarm and Suppression Permit Flow Chart

SECTION 2 –NGV GARAGE CODE COMPLIANCE SUMMARY

Introduction

Repair garages that service NGVs are subject to several hazards that do not exist in gasoline and diesel vehicle garages, but these hazards can be effectively mitigated with building design, operations and training. These hazards exist due to the properties of natural gas and the conditions at which NGVs operate. Some of the code provisions specifically related to NGV repair garages include:

- Ventilation systems,
- Gas detection systems,
- Maximum heater surface temperatures and open flames, and;
- Electrical installations and electrically classified areas.

This section presents a closer look at the code requirements for garages maintaining both CNG and/or LNG vehicles. Specific code requirements are identified and methods of compliance proposed. Additionally, this section identifies several areas of non-code driven ideas that we have termed recommended practices. The recommended practices are provided to identify elements that could guide decisions and influence the design approach.

The Wisconsin DSPS provided numerous code interpretations which are incorporated throughout the document. While the content of this document was coordinated with DSPS, it has not been produced or approved by DSPS. Individual interpretations may differ from those presented in this document.

Many other code requirements are applicable to vehicle repair garages; however this document is specifically focused on the additional requirements that are required for NGV maintenance. Experienced design professionals should be consulted to evaluate existing facilities.

Minor Repair Garages

Repair garages that perform limited services are subject to fewer code requirements than those that provide heavy maintenance services. This distinction can result in significant differences in the application of the code provisions and significantly affect the facility renovation costs.

“Major Repair Garages” are defined in 2008 National Fire Protection Association (NFPA) 30A as those garages that perform major repairs on vehicles, such as engine overhauls, painting, body and fender work, and repairs that require draining of the motor vehicle fuel tank.

“Minor Repair Garages” are defined in NFPA 30A as those garages that perform minor repairs on vehicles such as engine tune-ups, replacement of parts, fluid changes, brake repairs, tire rotation and similar routine maintenance work.

See below for an analysis of the code requirements for minor repair garages.

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Electrical Installations – Minor Repair Garages

A minor repair garage does not have a classified area within 18” of the ceiling, and would be exempt from the electrical requirements associated with this area. Reference 2008 National Electric Code (NEC) 511.3 (D) and NFPA 30A 8.2.1.

Heaters – Minor Repair Garages

Heaters having open flames or surface temperatures in excess of 750°F are not permitted in major repair garages servicing CNG- or LNG- fueled vehicles. This requirement does not apply to minor repair garages. Reference NFPA 30A sec 7.6.6.

Purge Ventilation – Minor Repair Garages

The 2009 International Mechanical Code (IMC) section 502.16 requires a ventilation rate of 1 CFM/12 ft³ (5 ACH) of room volume in repair garages servicing NGVs. This ventilation system must operate continuously with two exceptions: it may be interlocked with a gas detection system, or if the garage only services vehicles fueled by odorized gases, it may be interlocked with the lighting circuit. This requirement does not distinguish between major or minor repair garages and it is applicable in both cases. Reference the major repair garage ‘Ventilation’ section for further information.

For reference, 2009 International Fire Code (IFC) 2211.7 has a similar and nearly identical provision for ventilation; however, it contains an exception for garages that do not perform work on the fuel system and limited to maintenance that does not require open flames or welding. The state of Wisconsin has not adopted chapter 22 of the IFC and therefore it does not apply to projects under state jurisdiction. Reference SPS section 361.03(14). A project specific “petition for variance”, form SBD-9890X, could be filed with DSPS in an effort to be granted an exception to the ventilation requirement for a minor maintenance facility.

Gas Detection – Minor Repair Garages

CNG – CNG repair garages are not required by codes to install a flammable gas detection system, however, gas detection may be used in CNG repair garages to comply with IMC ventilation requirements (section 502.16).

LNG - The 2009 International Building Code (IBC) and NFPA 30A require a flammable gas detection system to be provided in repair garages fueled by non-odorized gases such as LNG. This requirement does not differentiate between major and minor garages, so it would apply in both cases. Reference IBC section 406.6.6 and NFPA 30A 7.4.7.

Reference the ‘Gas Detection for Major Repair Garages’ section for further information.

For reference, IFC 2211.7.2 has a similar and nearly identical provision for gas detection of non-odorized fuels (LNG) however it’s charging section of 2211.7 contains an exception for garages that do not perform work on the fuel system and limited to maintenance that does not require open flames or

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welding. The state of Wisconsin has not adopted chapter 22 of the IFC and therefore it does not apply to projects under state jurisdiction. Ref SPS section 361.03(14).

Ventilation for Major Repair Garages

Overview

The ventilation system design is perhaps the most complicated/confusing design element for a garage maintaining NGVs as many different codes and provisions are connected to the ventilation system. The ventilation system will need to satisfy two distinct mechanical code venting criteria:

- 1) The venting necessary to purge natural gas from garage should a leak occur; and
- 2) The normal air quality ventilation for occupied spaces.

In addition to the IMC ventilation requirements, the ventilation rate and configuration is also tied to the electrical system design and its rating for hazardous environments. Ventilation can be used to declassify areas, and thus allow for less expensive electrical wiring and equipment. The electrical requirements are discussed further in that section. Care should be exercised in the selection of the ventilation rates considering the higher operational costs associated with the electric fan motors and subsequent impact on heating loads. The up-front cost can be reduced by the selection of a high ventilation rate system, but the long term operational costs could be much higher.

This section will discuss the ventilation necessary to comply with the provisions of the IMC for garages maintaining NGVs. More specifically, it will discuss the provisions related to NGV maintenance that are in addition to those required for gasoline and diesel vehicle garages. There are other ventilation provisions that must be satisfied for repair garages that are not related to NGVs and an experienced design professional should be used to assess the existing conditions of a facility.

Ventilation and exhaust requirements in NGV repair garages are different than those in a gasoline or diesel repair garage. In the abnormal condition of a natural gas leak or spill, an approved mechanical ventilation system capable of evacuating the gas is required by the IMC. IMC section 502.16 and IFC section 2211.7 have nearly identical provisions to address this purge ventilation.

Design of Purge Ventilation System

Per the IMC, the mechanical ventilation system must be capable of achieving a ventilation rate of 1 CFM/12FT³ (5 Air Changes per Hour, ACH). An exception to the ventilation requirement allows natural ventilation to be used in lieu of mechanical ventilation, but this approach must be approved by the AHJ and would require documentation of equivalency. In almost all cases, a mechanical ventilation system will be required because natural ventilation equivalency is difficult to achieve in a building.

The air movement in the shop should be as uniform as possible (or practical) from the floor to the ceiling to effectively purge natural gas because it is lighter than air and rises under normal conditions. Inlets are required to be located on exterior walls near floor level and outlets are required to be located at the high point of the ceiling. Roll up garage doors can be used as an alternative to inlet louvers provided that

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they are interlocked with the gas detection system and programmed to open automatically in the event of a gas detection alarm (see recommended practices).

Operation of Purge Ventilation System

The IMC Section 502.16 provides three options for the operation of the ventilation system. The ventilation system may either operate continuously, it may be interlocked with a gas detection system, or it may be interlocked with the lighting circuit (only for CNG).

Continuous Operation

Continuous operation of the ventilation system is permitted as a means of compliance with the requirements of the IMC. This method is simple to implement, but it can lead to increased energy costs associated with continuously heating makeup air during winter months.

Interlock Ventilation with a Gas Detection System

A continuously monitoring gas detection system which is interlocked with the emergency ventilation system is permitted as a method of compliance by the IMC in lieu of continuous ventilation. The gas detection system must be programmed to activate the exhaust fans, activate the audible alarm and deactivate the heat when it senses a gas accumulation of 25% of the lower explosive limit. Reference the gas detection section for further guidance on the design and operation of the gas detection system. When the purge ventilation system is interlocked to the gas detection system, the makeup air is not usually heated (tempered).

Interlock Ventilation with the Lighting Circuit

Interlocking the ventilation system with the lighting circuit is an approved method of compliance only in repair garages that service vehicles with odorized gases. Pipeline natural gas is odorized, but liquefied natural gas is odorless and would not be permitted to use this method of compliance.

Air Quality Ventilation for Occupied Spaces

The IMC provisions in chapter 4 require 0.75 CFM/FT² exhaust airflow for repair garages. However, the Wisconsin amendments of SPS section 364.0403(5) only require 0.5 CFM/FT². Since state amendments govern over the national codes, repair garages in Wisconsin only require 0.5 CFM/FT². This requirement does not differ between repair garages of gasoline and diesel fueled vehicles and gaseous-fueled vehicles, so it should not affect an NGV repair garage conversion project.

The air quality ventilation must operate continuously during the period that the building is occupied. Typically the exhausted air is removed from floor level in a gasoline or diesel repair garage in accordance with NFPA 30A 7.5.4 and IMC 502.1.1 because those vapors are heavier than air and accumulate at floor level. The floor ventilation is opposite to the goal of exhausting of the highest concentrations of lighter than air natural gas. The natural gas purge ventilation is required to flow from the floor to the ceiling. To satisfy both the natural gas and liquid fuels ventilation criteria in a single garage, a dual system may need to be installed. In many cases, the method of compliance for a garage servicing vehicles with

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multiple fuels is achieved by satisfying the liquid fuels floor ventilation during normal operations and switching to the ceiling ventilation only during a gas detection event.

Gas Detection for Major Repair Garages

Overview

Gas detection systems are commonly used in NGV repair garages. A typical gas detection system consists of gas detectors located throughout the ceiling of a garage, each wired to a central control panel that is capable of receiving signals from each detector and activating emergency systems if threshold concentrations of natural gas are detected. Gas detectors require regular maintenance and calibration. Detector manufacturers should be consulted for the calibration methods and frequency.

Applicability to CNG and/or LNG garages

The use of gas detection is required in all LNG vehicle repair garages per the IBC Section 406.6.6 and NFPA 30 A section 7.4.7 because LNG is a non-odorized gas. Gas detectors are required to be installed at ceiling level and also in lubrication or chassis pits in LNG vehicle repair garages.

Gas detection is not a requirement in CNG repair garages because the gas is odorized, but it is commonly used as a means of compliance with mechanical ventilation requirements. Detection can be used in combination with the ventilation system to satisfy the provisions of the IMC without using continuous ventilation thus, avoiding energy costs associated with the continuous heating and conditioning of makeup air.

Design of the Gas Detection System

Ceiling Detection

Gas detectors should be installed at the highest points of the ceiling, where natural gas is most likely to collect. A specific evaluation of every facility is required to accurately determine the number and location of detectors required such that large isolated pockets of gas cannot form in the ceiling structure.

Detection in Pits

The IBC section 406.6.6.1 and NFPA 30A Section 7.4.7.1 requires gas detection in lubrication and chassis pits located in repair garages used for repairing non-odorized (LNG) fueled vehicles.

Detection Integration with Other Equipment

The gas detection central control panel should automatically activate a series of events upon gas detection at 25% LEL or a system failure. Upon detection or system failure, the system shall activate audio and visual alarms, activation of purge ventilation, and deactivation of heating devices. Reference IBC 406.6.6 and NFPA 30A 7.4.7

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Ventilation is not always required to be interlocked to the gas detection system (i.e. continuous ventilation in CNG garages). Reference the section entitled “Purge Ventilation” for further information.

Gas detection often triggers additional events as well as those required by the code provisions such as opening the garage doors for fresh air intake, shunt tripping the welding circuits, and disabling other potential sources of ignition.

The local AHJ may require that a notification be sent to the approved fire alarm monitoring company during all gas detection events. Consult the AHJ to determine if this is required.

Heating & Sources of Ignition for Major Repair Garages

Overview

Heating systems and other sources of ignition are subject to code restrictions that can require modification of existing systems in garages for NGV maintenance. NFPA 30A Section 7.6.6 prohibits open flame heaters or heating equipment with exposed surfaces exceeding 750°F in areas subject to ignitable concentrations of gas within a major CNG/LNG vehicle repair garage. It has been common practice to assume that the entire garage is subject to “ignitable concentrations of gas”, however in special situations it is possible that specific areas may not be exposed to this environment. The AHJ and the design professional should carefully evaluate the areas subject to ignitable concentrations of gas prior to adopting a strategy of anything other than 100% compliance throughout the entire shop.

Design of Heating Systems

Heating systems in natural gas repair garages must be designed to operate below the 750°F maximum surface temperature requirement. This is typically achieved using infrared tube heaters or a forced air heating system from an exterior air handling unit. See the recommended practices section for more details.

Wisconsin has amended IMC section 309 with SPS section 364.309. The Wisconsin amendments require a repair garage to be maintained at an inside temperature of 60 °F at 3 feet above the floor. The national code requires the space to be maintained at 68 °F unless your facility qualifies for an exception.

Electrical for Major Repair Garages

Overview

The NEC Section 511.3 specifies a Class I Division 2 area within 18” of the ceiling in major repair garages that work on lighter-than-air gaseous fuels. In a NGV repair garage conversion project, all electrical equipment located within the classified area will need to comply with the provisions associated with this area.

The Wisconsin DSPS is currently proposing an amendment to section SPS 316.511(2) that would allow for the declassification of the Class I Division 2 ceiling area if the building is equipped with a ventilation system that exhausts air from within 18” of the ceiling and is in accordance with the provisions of the IMC section 502.16.

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If approved as a code revision in Wisconsin, this method of compliance could be used to avoid rework of the existing electrical equipment at the ceiling. Although the ceiling classified area could be eliminated, it is highly recommended that the exhaust fans are still rated for a Class I Division 2 area because they will come in contact with natural gas in the unlikely event of a gas leak.

Applicability to CNG and/or LNG Garages

Both CNG and LNG vehicles contain lighter-than-air gaseous fuels, and are therefore subject to the code requirements provided in the NEC.

Design of Electrical Systems

All electrical equipment that is installed within the Class I Division 2 area in a NGV repair garage must be rated for use in a Class I Division 2 area. It is common for existing equipment such as lights, fans and electrical conduit to be located in this area. This equipment along with all other equipment not in compliance will either need to be replaced with rated equipment or relocated below the electrically classified area. It is generally more cost-effective to reuse or replace non-rated equipment below the classified area rather than replace it with rated equipment.

Existing Conditions

Existing buildings undergoing renovations or alterations may be required to upgrade parts of the building to comply with current codes. The 2009 International Existing building Code (IEBC), as adopted by the Wisconsin DSPS, determines what upgrades need to be made during construction projects involving existing buildings. A repair garage will not usually be required to bring systems into compliance that are not directly related to the project. This section summarizes requirements that existing garages may or may not need to conform with if they do not already.

The IEBC details several methods of compliance for the alteration or change in occupancy of existing buildings. The three methods of compliance are defined as “Prescriptive Compliance Method”, “Work Area Compliance Method”, and “Performance Compliance Method”. Wisconsin has eliminated the “Prescriptive Compliance Method” of IEBC section 101.5.1 with Administrative code section 366.0101 and section 366.0300. This document details the requirements of the Work Area Compliance Method however designers may choose to show compliance via the Performance Compliance Method. The two main categories that are applicable to the renovation on an existing garage are “Alterations” and “Change of Occupancy”, each is discussed below.

Alterations

Building alterations are classified in 3 levels. Modifications to an existing repair garage for NGV compliance would generally be classified as Alteration – Level 2 or Level 3. Therefore as required by the IEBC Chapters 6, 7, and/or 8 will apply to the alterations. A qualified design professional should provide a detailed evaluation of the existing facility to determine the applicability of all IEBC requirements but

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several of the key aspects that may be applicable to a repair garages undergoing an alteration for NGV compliance are detailed below.

Alteration – Level 1

Alteration - Level 1 changes are limited to the removal and replacement of elements that serve the same purpose.

Section 602: Materials and Methods - All new work must comply with the materials and methods requirements of the IBC, IECC, IMC, and IPC as applicable. Reference IEBC 602.4.

Section 606: Structural – refer to Alteration level 2 section 707 for more information.

Section 607: Energy Conservation - IEBC Energy Conservation provisions have been amended by SPS Section 366.0607. Wisconsin requires any additions, alterations, renovations or repairs to comply with the IECC as they relate to new construction. Unaltered portions of the building are not required to be brought into compliance with the IECC and are permitted to be maintained in their existing conditions. For more information refer to SPS 366. For example, the addition of heating load to an existing building for NGV compliance will not require the building to be re-insulated.

Alteration – Level 2

Garage modifications for NGVs are usually considered Level 2 alterations because they involve “the reconfiguration or extension of any system, or the installation of any additional equipment”. Level-2 alterations shall comply with the provisions of Level 1 alterations, as well as the provisions for Level 2 alterations

Section 704 Fire Protection - Automatic sprinkler systems shall be provided in accordance with section 704.2.2 for S1 occupancies. Triggers for the automatic sprinkler protection include exits shared by more than one tenant or with an occupant load greater than 30 where all of the following conditions occur:

- 1) The garage would be required by the IBC to have a sprinkler system if it were new construction;
- 2) The work area exceeds 50% of the floor area; and,
- 3) The building has sufficient water municipal water supply without the installation of a fire pump.

To satisfy item 1) above, the IBC Section 903.2.9.1 requires the installation of an automatic fire sprinkler system in a repair garage if any of the following conditions are met:

- Buildings having two or more stories above grade plane with a fire area containing a repair garage exceeding 10,000 square feet.
- Buildings no more than one story above grade with a fire area containing a repair garage exceeding 12,000 square feet.
- Buildings with repair garages servicing vehicles parked in basements.

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- A group S-1 fire area used for the repair of commercial trucks or buses where the fire area exceeds 5,000 square feet.

The Wisconsin DSPS defines commercial trucks, as referred to in the IBC, as of September 1, 2011, as follows:

- Semitrailer trucks;
- Trucks having a gross vehicle weight over 26,000 pounds; and
- Passenger vans or buses with a seating capacity of 16 or more.

Section 707: Structural - Alterations are not permitted to reduce the capacity of existing gravity load-carrying structural elements or add additional loads to elements unless it can be demonstrated that the stress on any structural member is not increased by more than 5 percent, per the IEBC Section 707.4. If the stress on a structural element is increased by greater than 5 percent, then it will need to be retrofitted to withstand the additional load. If rooftop equipment is added, the structural loads shall consider snow drifting. This requirement often applies in NGV repair garage conversions when new rooftop mechanical systems are installed to meet ventilation requirements. The installation of new rooftop exhaust fans or any other structural alterations should be designed by a qualified professional.

Section 709: Mechanical - Reconfigured or converted spaces intended for occupancy are required to be provided with ventilation in accordance with the IMC, per IEBC section 709.1. However, the requirements of the IEBC Section 709.2 do not apply in the State of Wisconsin because this section has been omitted from the Wisconsin State Codes by SPS Section 366.0709.

Alteration – Level 3

In most cases the systems alterations required for NGV garage modifications will not trigger the Level 3 (chapter 8) requirements. Individual cases should be reviewed by the AHJ to determine the applicability of IEBC chapter 8. Level 3 alterations shall comply with the provisions of Level 1 and 2 alterations, as well as the provisions for Level 3 alterations. Even if an alteration is classified as Level 3, it will not usually trigger additional provisions beyond those identified above in level 1 and level 2 alterations.

Change of Occupancy without Change in Classification

A NGV repair garage upgrade does not typically alter the building's occupancy classification according to the IBC (it will remain an S-1 classification) however, a change in the application of the code requirements will occur when natural gas vehicles are serviced within a garage. This change is described by the IEBC as a change in occupancy with no change of occupancy classification, and should not be confused with a change of occupancy classification. Buildings undergoing a change of occupancy are required to comply with any special provisions of sections 902 through 911.

- **Section 902: Special Use and Occupancy: Not Applicable.** Section 902 requires buildings that are changed to a special use or occupancy category per the IEBC to comply with the

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requirements of that special category. Both Liquid fuels and CNG/LNG garages are categorized as 'motor vehicle-related occupancies' by the IBC, so no change has been made.

- **Sections 903 through 906: Not Applicable.** Sections 903: Building Elements and Materials, 904: Fire Protection, 905: Means of Egress, and 906: Accessibility. These sections are not applicable because they only apply to buildings undergoing a change in occupancy classification, which does not occur in a NGV repair garage conversion.
- **Section 907: Structural: Not Applicable** Section 907 requires projects that change the basic gravity, snow, wind and seismic loading requirements of a building to comply with the new requirements. NGV repair garage conversions do not change these loading requirements, so this section would not apply.
- **Section 908: Electrical: Applicable if the AHJ Determines an Existing Electrical Installation is a Safety Hazard.** SPS section 316.003(3) allows electrical installations to be maintained without conforming to current codes if they were installed in compliance with the governing codes that were in place at the time of installation. The AHJ may require an electrical installation to be repaired or reinstalled if it presents a safety hazard, but otherwise electrical installations are permitted to remain as they are.
- **Section 909: Mechanical: Not Applicable.** Section 909 requires a new occupancy to comply with the ventilation requirements of the International Mechanical Code for the new occupancy. NGV repair garages are subject to the same basic occupancy ventilation requirements as a diesel or gasoline vehicle garage. Note that NGV garages are still subject to the additional provisions for the purge ventilation of IMC 502.16
- **Section 910: Plumbing: Not Applicable.** SPS 366.0912 replaces IEBC 910 and only requires plumbing fixtures to be updated when the occupant load is increased by more than 20%.
- **Section 911: Other Requirements: Applicable.** This section requires the light and ventilation to comply with the requirements of the International Building Code for the new occupancy. Lighting requirements would not change for NGV repair garages and would not present any new requirements. There are additional ventilation provisions for a NGV garage. Garage ventilation systems should be modified or replaced to meet those provisions. (see Ventilation for Major Repair Garages section)

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Recommended Practices

Ventilation

Energy Recovery Systems - If using an Air Handling Unit with high exhaust rates, consider the use of an energy recovery system. SPS section 364.0514 allows the use of energy recovery ventilation systems, provided that corrosion, cross contamination and fouling are addressed by the engineered system. The use of energy recovery systems is normally not allowed by the IMC Section 514.2, but is permitted by the Wisconsin DSPS.

Gas Detection

Battery Backup - Provide a battery backup to power the gas detection system in the event of a power failure. Minimum backup of 12 hours is recommended.

Location of Central Control Panel - The gas detection central control panel should be located in a safe area close to the means of egress. In the event of an emergency, it should be easily accessible.

Exterior gas detection indicator lights - Provide exterior indicator lights showing the status of the gas detection system. This system provides a means to assess the gas concentration levels without entering the building.

Calibration of Gas Detectors - Gas detectors need to be periodically calibrated (usually every 6 to 12 months depending on the manufacturer) to maintain accurate readings. To calibrate some detectors, natural gas must be introduced directly to each detector at a known concentration. Calibration can be facilitated with tubing routed from each gas detector to a central location, thus eliminating the need for a man lift and disruption to the garage operations.

Relay Panel - An auxiliary relay panel can be used to allow the gas detection controller to activate or deactivate circuits required for other equipment. A signal from the gas detection controller can activate the relays within this panel to control other equipment in the event of an alarm such as, heaters, ventilation, garage doors, welding circuits, alarm indication lights, etc.

Heating

Infrared Heating - Infrared tube heaters are often used in NGV repair garages to comply with the requirements of NFPA 30A. Consult infrared heater manufacturers for more information and specific products that are capable of meeting the code requirements. Many existing infrared heaters are not compliant for use in a NGV garage.

Forced Hot Air Heating – An air handling unit located outside of the repair garage can be a compliant ventilation solution in NGV garages. It can be cost-effective to reuse an existing forced hot air heating system rather than install a new heating system, but it may need to be relocated outside of areas subject to ignitable concentrations of gas. Motor controlled dampers may be used to prevent the migration of natural gas to the heating elements.

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Electrical

Shunt Trip Breakers - Certain equipment is not required to be deactivated by the codes in the event of a gas alarm, but it is a recommended practice to do so. Electrical equipment such as welding outlets and heating equipment in areas that are not subject to ignitable concentrations of gas such as pressure washers, used oil burners, and ducted roof top air handlers can be deactivated in the event of a gas alarm using shunt trip breakers.

Lowering Conduits and Equipment – Relocating equipment that is not rated for the Class I Division 2 area within 18” of the ceiling of a repair garages is often the most cost-effective means of compliance with the requirements of the NEC section 511.3.

Backup Power – consider a generator for backup power if the garage will remain operational in an extended power outage. If the garage will be occupied during an outage, generator power should be provided to the gas detection and ventilation systems in addition to the lights and equipment required to perform maintenance on the vehicles.

Defueling

Although there is not a code provision that allows defueled natural gas vehicles to enter a non-code-compliant garage for NGV maintenance, it has been allowed in rare instances. Approval by the AHJ for defueling as a means of compliance would most likely be applicable to a fleet with a proven track record of fire code compliance, safety programs, established written procedures, qualified personnel, and appropriate equipment.

In many cases, defueling a NGV requires specialized equipment. LNG vehicles require specialized equipment to offload fuel. Truck to truck transfers can be used as a method to defuel CNG vehicles but requires several vehicles with empty tanks, a transfer hose, and the vehicle to be equipped with a defueling port. The transfer can take many hours and will not completely depressurize the tank. Venting CNG tanks to atmosphere is not a recommended practice and may be prohibited by some jurisdictions. Methane is a powerful greenhouse gas and venting it to atmosphere is contrary to the environmental benefits that NGVs represent.

LNG Vehicle Facilities

Floor Drains - In garages servicing LNG Vehicles, care should be taken to prevent a LNG spill from entering a floor drain system. Liquid LNG can undergo a rapid phase transition from a liquid to a gas when it is in contact with water. This phase transition can resemble an explosion and would certainly be dangerous to the building occupants. The simplest method of mitigating for this condition is to permanently plug the floor drains with concrete. In cases where the floor drain system must be maintained, a cryogenic valve can be added. The valve can automatically close with input from a temperature sensor in the drain. The valves, controls, under slab work, and electrical costs associated with a cryogenic valve make it prohibitively expensive in some cases.

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LNG Pressure Release Venting Capture - Liquefied natural gas must be stored at cryogenic temperatures to remain in its liquid state. As its temperature rises in a closed cylinder, it reverts to its gaseous state, building internal tank pressure. LNG vehicles that are regularly driven will use the fuel such that the tank internal pressure is maintained at a low pressure. Vehicles that are not driven for extended periods of time will gain pressure over several days before eventually venting to relieve the tank pressure. The pressure relief valves on LNG vehicles are different from CNG vehicles because they are set at a lower pressure and normally open to vent a small plume of gas, rather than the entire tank.

Although not a specific code requirement, some designers have chosen to provide a positive means of exhausting a LNG tank pressure release. This could be done using a tube with a fitting to the LNG tank vent and terminating outside the building. Other designers have chosen to use the building gas detection and ventilation systems as a means of evacuating a LNG tank pressure release. Shop operations, Owner preference, and AHJ approval will also play role in the configuration selected.

For more information about LNG tank venting refer to Section 3 – Training and Operations.

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**Table 2.1 – Applicable Codes
Wisconsin Codes (as of July 2013)**

Code	Title	Adopted by	Comments
2009 IBC SPS 362	International Building Code Modifications, additions, & deletions to IBC	SPS 361.05	
2009 IECC SPS 363 Subchapter II	International Energy Conservation Code Changes, additions, & omissions to IECC	SPS 361.05	
2009 IMC SPS 364 Subchapter II	International Mechanical Code Changes, additions, & omissions to IMC	SPS 361.05	
2009 IFGC SPS 365 Subchapter II	International Fuel Gas Code Changes, additions, & omissions to IFGC	SPS 361.05	
2009 IEBC SPS 366	International Existing building Code Changes, additions, & omissions to IEBC	SPS 361.05	
NFPA 1 – 2009	Fire Code	SPS 314.001	NFPA 1 applies only to Inspection, Testing, and Maintenance (see 314.01 (1) (a)(2))
SPS 314 Subchapter II	Modifications to NFPA 1	SPS 314.01 (2) (1) SPS 314.01 (6) (b)	Design is excluded except as noted in sec 314.01 (2) (1) Design provisions of NFPA 1 may be adopted by local Municipality
2009 IFC	International Fire Code	SPS 314.001 SPS 361.03 (14)	2009 IFC as adopted by a local Municipality IFC as referenced by codes adopted in 361.05 does NOT apply accept as indicated Some of the relevant sections for Garages: - IFC chapter 22 "Motor Fuel Dispensing Facilities and Repair Garages" is excluded by SPS 361.03(14) - IFC chapter 30 "Compressed Gasses" is excluded by SPS 361.03(14) - IFC chapter 32 "Cryogenic Fluids" is included by SPS 361.03(14) --> NFPA 59A
			Continued

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Code	Title	Adopted by	Comments
NEC 2008 (NFPA 70) SPS 316 Subchapter III	National Electric Code Modifications to the NEC	SPS 316.014	
NEC 2011 (NFPA 70) SPS 316 Subchapter III	National Electric Code Modifications to the NEC	SPS 316.014 - The NEC 2011 is pending adoption by the state of WI	
NFPA 30A – 2008	Code for Motor Fuel Dispensing Facilities and Repair Garages	SPS 310 Table 310.200-6 & SPS 362.3500 & SPS 362.0401	
NFPA 52 – 2010	Vehicular Gaseous Fuel Systems Code	NFPA 1 sec 2.2 & sec 30.2.3 (If Adopted by Municipality) IFC 2009 sec 3001.1 (if adopted by Municipality)	
Note SPS 340.40 only adopts NFPA 52-2010 as it related to "fueling purposes" ref 340.11, 340.42, 340.61, 340.71			
NFPA 59A – 2010	Production, Storage, and Handling of Liquefied Natural Gas	SPS 361.03 (1)(b) SPS 361.03 (14)	2009 IBC 406.6.1--> reference to 2009 IFC .. sec 3201.1 --> Ref to NFPA 59A Note IFC chapter 32 "Cryogenic Fluids" is included by SPS 361.03(14) --> NFPA 59A NFPA 1 sec 2.2 (If Adopted by Municipality)
NFPA 59A is generally not applicable to Vehicle Maintenance Facilities per section 1.1. However it does provide some guidance on best practices, for example: Spill and Leak Control, Fire Safety, and Training			
Note SPS 340.40 only adopts NFPA 59A-2009 as it related to "fueling purposes" ref 340.11, 340.61			

Table 2.1 – Applicable Codes, continued

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TABLE 2.1 Notes:

Code Hierarchy/Conflicts Ref SPS 361.03(3) and 361.03(5)

The Wisconsin Administrative Code including Wisconsin amendments to the National level codes (I-Codes and NFPA) have the highest code authority and will govern in the case of conflicts between codes

SPS 361.03 (3)

(3) CONFLICTS. (a) Where any rule written by the department differs from a requirement within a document referenced in this code, the rule written by the department shall govern.

(b) Where rules of the department specify conflicting requirements, types of materials or methods of construction, the most restrictive rule shall govern, except as provided in pars. (a) and (c). Note: If the most restrictive of two or more conflicting requirements is not readily apparent, a determination of which is more restrictive can be obtained from the department.

(c) Where a rule prescribes a general requirement and another rule prescribes a specific or more detailed requirement regarding the same subject, the specific or more detailed requirement shall govern, except as provided in par. (a).

Note that the State code requirements are considered a minimum and local Building and Fire jurisdictions have the authority to enforce more restrictive requirements than the State.

SPS 361.03 (5)

(5) LOCAL ORDINANCES. (a) 1. Except as provided in par. (b), pursuant to s. 101.02 (7), Stats., a city, village, town or local board of health may enact and enforce additional or more restrictive standards for public buildings and places of employment, provided the standards do not conflict with this code.

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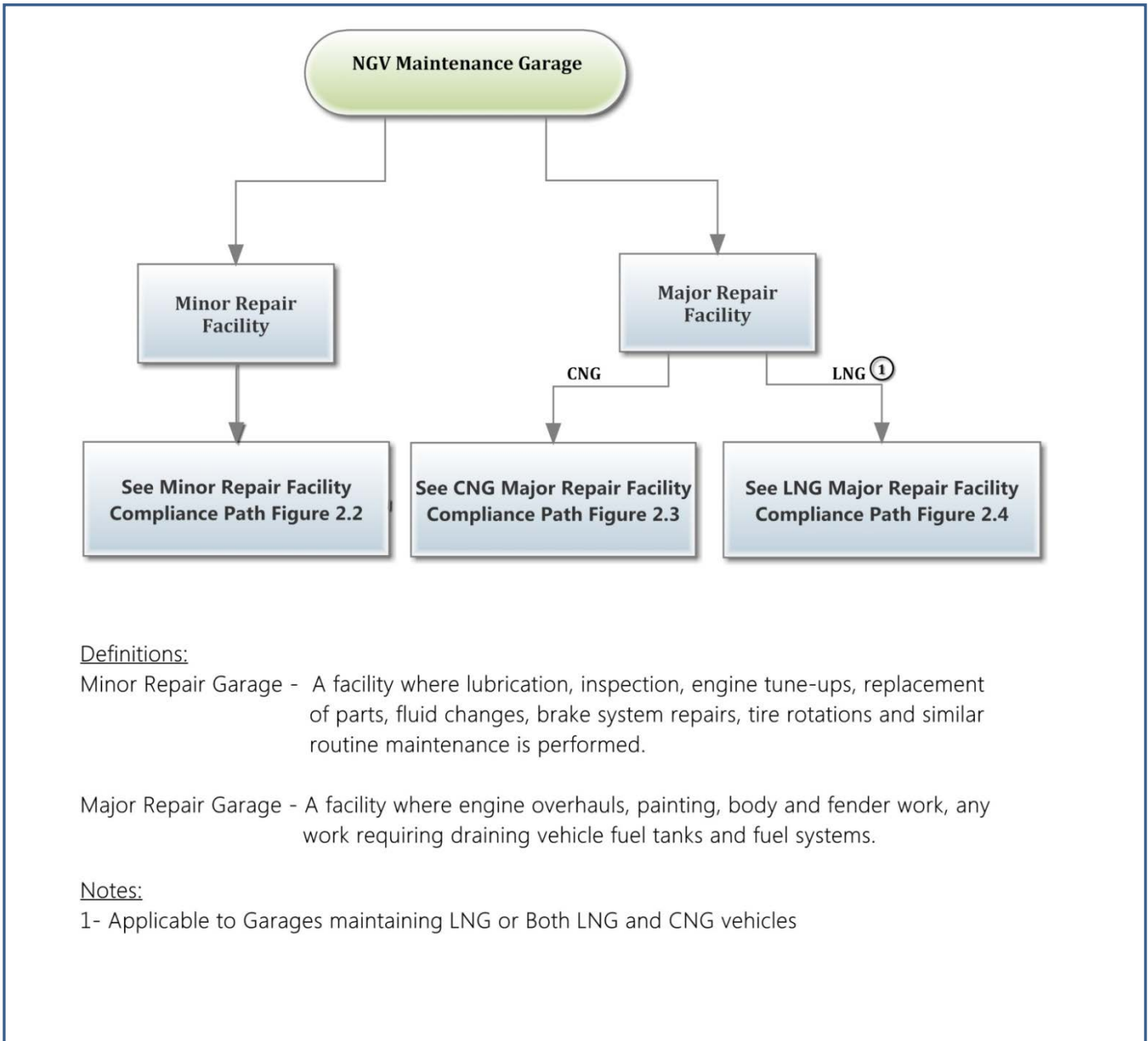


FIGURE 2.1 - NGV Facility Compliance Path

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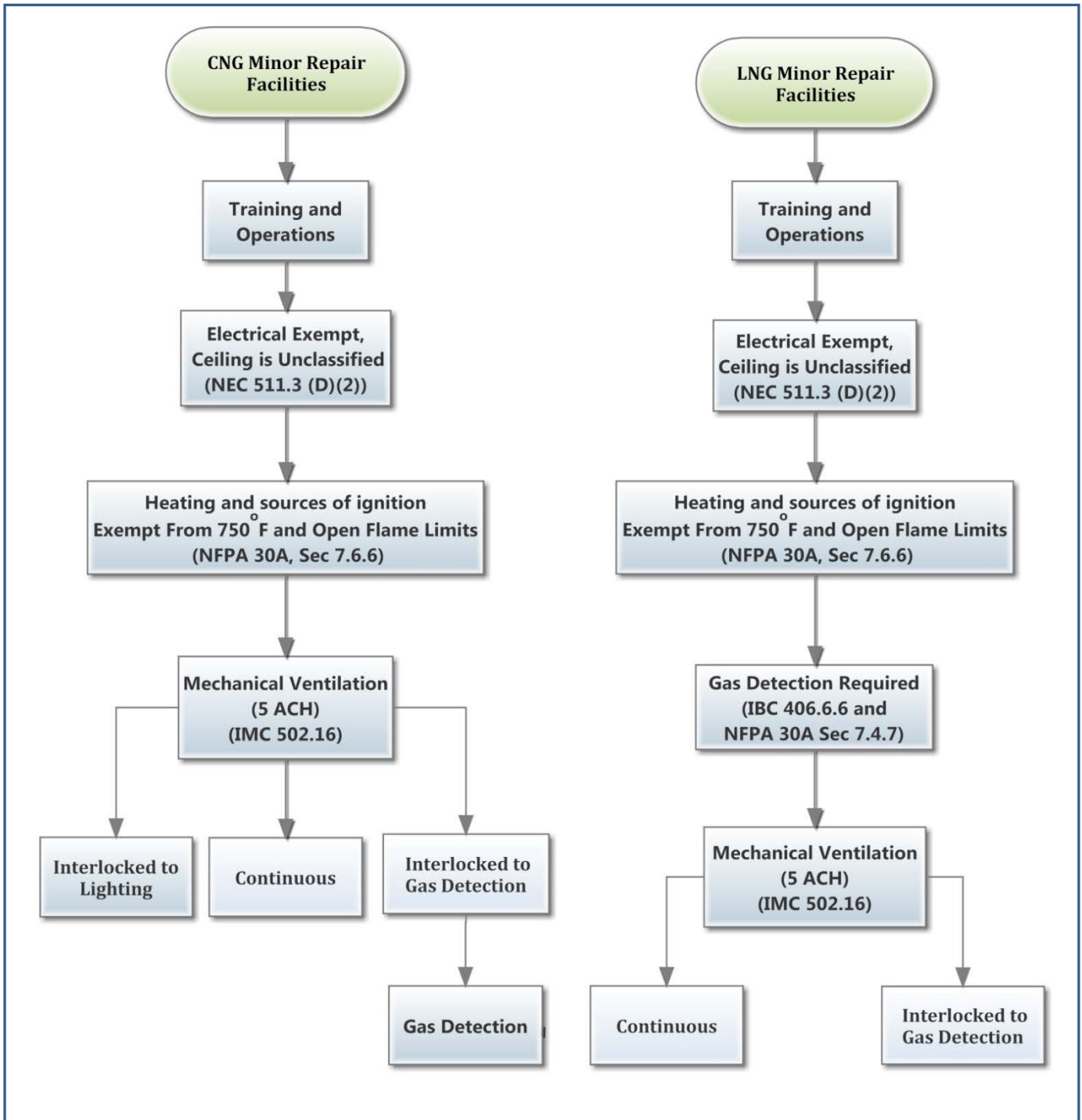


FIGURE 2.2 - MINOR Repair Facility Compliance Path

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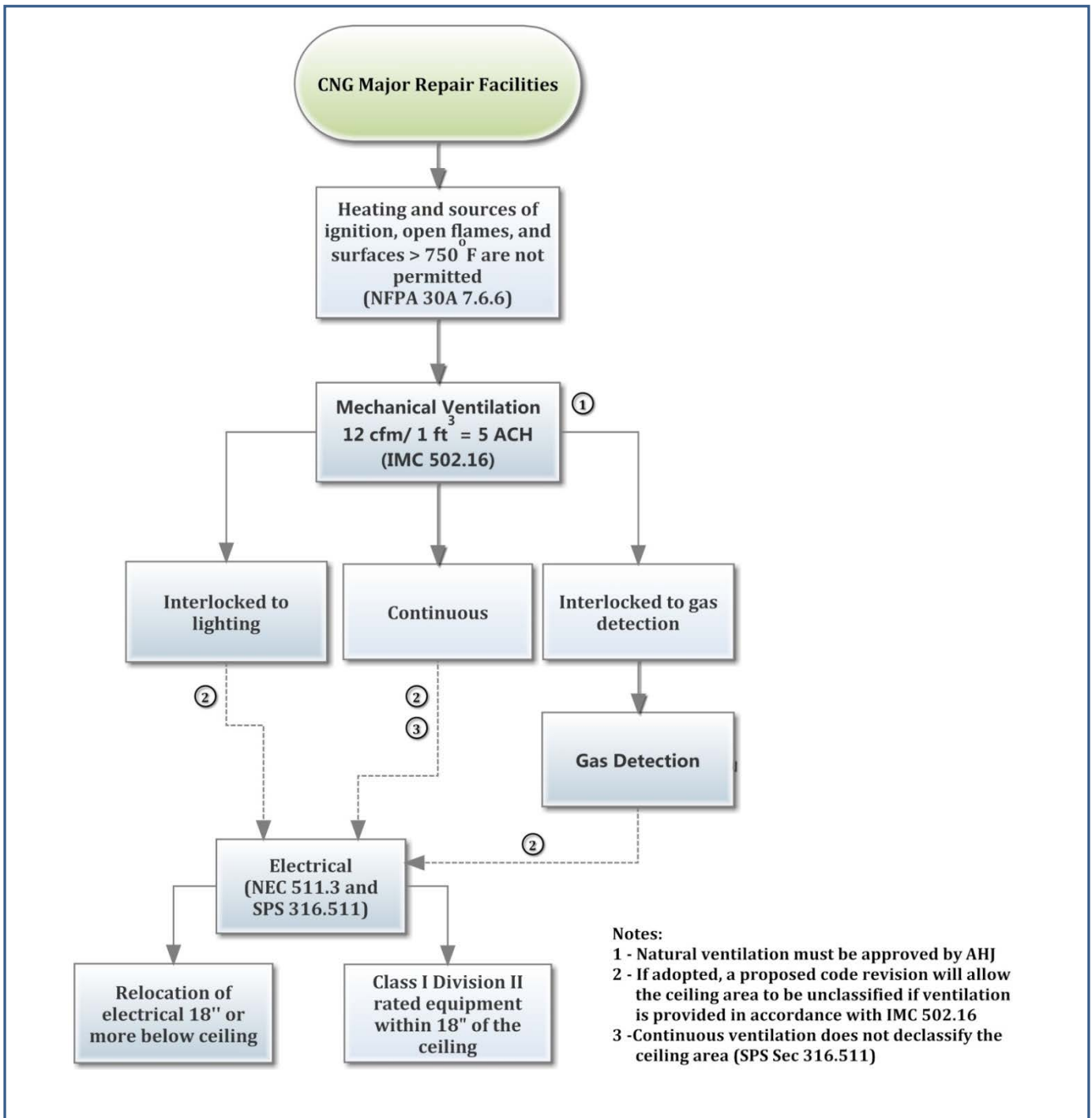


FIGURE 2.3 – CNG MAJOR Repair Facility Compliance Path

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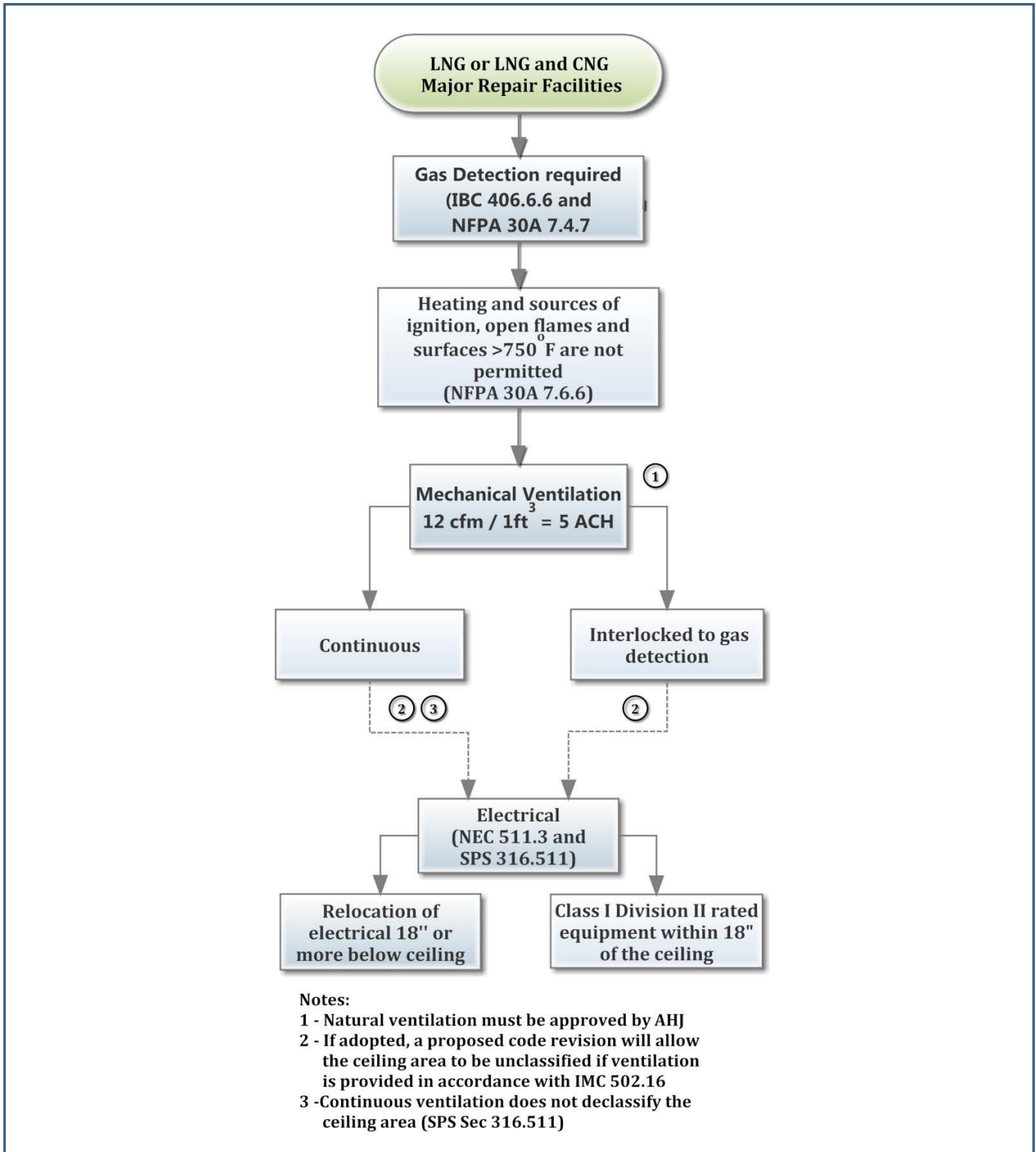


FIGURE 2.4 – LNG MAJOR Repair Facility Compliance Path

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SECTION 3 – TRAINING AND OPERATIONS

Training and operations are an essential part of any NGV maintenance program. Although a detailed discussion on the topic is outside the scope of this document, several important aspects are noted below. NGVs have a proven record of safety but they will introduce new hazards into a maintenance garage. As with any new hazards introduced into existing operations, training will play a key role to identify and mitigate the hazards.

Training

Training courses and education programs are available through NGV industry groups and organizations, Original Equipment Manufacturers (OEM), NGV engine manufacturers, automotive service training programs, local colleges, and others. Training should be conducted for all new employees and on a regular basis thereafter. All training programs should explore the following as a minimum:

- Properties of CNG and LNG
- Hazards of CNG and LNG
 - High pressure
 - Risk of ignition, flammability
 - Asphyxiation
 - Cryogenic (LNG)
- Vehicle fueling procedures (including Personal Protective Equipment for LNG fueling)
- Vehicle fuel system training
- Vehicle fuel tank maintenance, inspections, defueling, and decommissioning
- Mitigation of hazards (inspections & standard operating procedures)
- Facility equipment including (as applicable): Gas detection system calibration and testing; heating and ventilation systems maintenance, maintaining fire protection systems including detectors, alarms and fire suppression systems.

Operations

Operations play a vital role in the safety of a repair garage. Properly constructed and equipped facilities will help to mitigate a natural gas hazard in the unlikely case of a release, but training and operations can prevent the hazard from ever occurring. Several factors to consider when maintaining NGVs are indicated below. While this is certainly not an exhaustive list and only partially code driven, it's intended to be a starting point for individual facility programs.

- Preparation for vehicles for maintenance
 - Confirm fuel shutoff valve is closed prior to maintenance on the vehicle fuel system (IFC 2211.5) or for added protection, close the valves prior to any maintenance on an NGV. NFPA 52 section 6.13.6 requires that the engine is isolated from the fuel supply lines unless engine operation is required.

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- Inspect the fuel system integrity prior to bringing a vehicle into the garage if the fuel system has been damaged or damage is suspected (IFC 2211.5). An additional layer of safety could be voluntarily provided by inspecting all NGVs prior to entering a garage. This can be accomplished with the use of a hand held gas detector.
- Create standard operating procedures for the maintenance of NGVs.
- Welding and Hot Work on NGVs – Use a hand held leak detector prior to starting work and protect fuel system from potential damage from sparks or flame. Tanks should be defueled prior to hot-work within six feet of the tank. Prohibit torches, welding, or grinding equipment on or near fuel lines and fuel tanks. Reference NFPA 52 6.13.6.
- Establish NGV defueling procedures and protocol in accordance with all code provisions. Defueling of a CNG container shall be performed only by trained personnel using written procedures. Reference NFPA 52 6.14. NFPA requires controlled release away from primary buildings when defueling.
- Fuel tanks/cylinders require periodic inspections. Follow OEM and code required procedures for maintenance, inspection, and decommissioning. Personnel performing the maintenance and inspections on the fuel tanks/cylinders will need to be trained and certified.
- Properly maintain periodically calibrate the garage gas detection system per the Manufacturer’s instructions.
- Use hand held gas detectors to inspect the fuel system for leaks
- Prepare an emergency response plan
- LNG Vehicles
 - LNG vehicles should be run prior to entering a garage to reduce the internal pressure of the fuel tank. LNG tanks are designed to vent when the internal pressure of the tank builds due to the normal warming of the LNG. If the vehicles are run prior to entering the garage, the LNG tank will have a longer “hold time” to build pressure prior to venting. LNG tanks are designed to hold pressure without venting for several days under normal conditions. The minimum design hold time of a properly functioning LNG tank is 72 hours at 70 ° F (NFPA 52 sec 11.3.5) with typical hold times of about 1 week.
 - Limit the time an LNG vehicle is the garage for maintenance. Extended maintenance increases the chances of the LNG tank venting into the shop. Consider defueling the vehicle or the use of a simple vent capture system to direct vented gas to a safe outdoor location if LNG vehicles will be in the garage for long periods of time. Reference NFPA 52 15.7.
 - Protective clothing, face shield, and gloves should be worn for anyone dispensing or handling LNG.

SECTION 4 – CASE STUDIES

Frito Lay Case Study

Summary

In August of 2012, Frito Lay commissioned facility improvements to accommodate a new fleet of compressed natural gas (CNG) vehicles with an initial roll-out of 12 CNG vehicles. Facility modifications to accommodate the fleet conversion included the upgrade of a repair garage to safely accommodate the maintenance of natural gas vehicles and the modification of the existing diesel fueling bay to also include indoor CNG fueling.

The existing fleet facility was constructed seven years ago. The facility includes a 3 bay repair garage along with an attached fueling bay. The building has concrete masonry unit walls with a combination of open bar joist and concrete plank roof structure. There is also an administrative office space attached on the side opposite the fueling bay. The interior partition wall appears to be a fire rated assembly, presumably a 2 hour wall based on building codes in effect at the time the facility was built.

One of the key aspects of this facility upgrade was the early coordination with state and local building and fire authorities. The facility modifications were designed, permitted, and constructed in approximately 6 months using a design/bid/build project delivery. The 3 maintenance bays are set up for normal preventive maintenance within the normal scope as outlined in NFPA codes. Dealership and third party maintenance providers will support repairs beyond the allowable scope outline in NFPA for the facility.

Facility Modifications for Natural Gas Vehicles (NGV)

The facility upgrades are separated into the two distinct areas; the Repair Garage and the Fueling Bay. These areas have been retrofitted differently for compliance with their specific code requirements and hazards.

The scope of the improvements that were made to the facility to support the introduction of NGV in the fleet was based on several factors:

- Code driven requirements;
- Corporate culture with respect to safety and asset protection; and,
- Maintaining a consistent experience for operations and maintenance staff in the transition from diesel to gas fueled vehicles.

Summary of improvements provided in the Minor Repair Garage (3 bays):

- Ventilation – The garage has been modified with equipment to increase the rate of ventilation for compliance with mechanical code. The ventilation system is designed to introduce fresh air low, exhaust air high, and is interlocked to the lighting circuits to provide continuous ventilation whenever occupied.

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- Heating System – The rooftop mechanical air handling system was replaced with a larger unit in order to be able to adequately heat the increased volume of make-up air. The heating is thermostat controlled however the fan is interlocked to the lighting and will operate continuously when the building is occupied. The air handling unit has no open flame in the garage and no elements with surface temps over 750 degrees F.
- Gas Detection – A gas detection system is not installed in the repair garage and is not required for code compliance. Fleet technicians are equipped with handheld methane detectors for use as needed when working on or inspecting vehicle fuel systems.
- Electrical – Because minor repair garage ceiling areas are considered “unclassified”, the existing electrical systems in the repair garage ceiling were not relocated or modified for classified locations.
- Migration of hazardous vapors – measures have been taken to prevent the migration of hazardous vapors from the different operational areas of the building (indoor fueling, repair garage, and administrative areas). Mechanical systems are isolated, doors have seals and self-closers, and verification of seals and fire ratings between areas has been performed.



Summary of improvements provided in Fueling Bay:

- Ventilation – Provided additional purge ventilation interlocked to gas detection. Purge ventilation is activated in the event of gas detection.
- Heating System – Heat is provided by a rooftop air handling unit.
- Gas Detection – Gas detection is provided in the fueling bay and interlocked to the purge ventilation system. The gas detection system is monitored by a monitoring company. In a gas detection event, the heating unit will be disabled, the ventilation system will be activated, and an alarm will sound.



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- Electrical – electrical within 18” of the ceiling was relocated or replaced with electrical systems rated for the class 1 division 2 classification area.

Operations and Training

In addition to the facility upgrades, operational procedures have been put in place and personnel have been trained to safely work on the NGVs. Mechanics and others have attended several training classes related to NGV systems and maintenance. Frito Lay has several personnel who are certified and/or trained for CNG cylinder inspections.

In summary, the facility has been modified for the maintenance of CNG vehicles in its 3 bay Minor Repair Garage and for indoor CNG fueling. By the classification of the 3 bay garage as “minor repair”, significant savings were achieved because the electrical systems in the ceiling did not need to be modified for hazardous areas. The impact to winter operational cost has not been determined however heating cost is expected to increase slightly due to continuous ventilation air supply.

Waste and Recycling Vehicle Maintenance Facility Case Study

Summary

A national waste and recycling company is currently operating more than 2,000 NGVs and is in the process of a fleet wide transition of its heavy duty vehicles to run on CNG. The program is being implemented on a national level and includes vehicle purchases, CNG fueling infrastructure, and maintenance garage upgrades. The existing maintenance garage located in Milwaukee County was selected for upgrades to accommodate the major repair of CNG vehicles. The garage was built circa 1970 and consists of 10 vehicle maintenance bays, 1 wash bay, and administrative office areas. Facility modification to accommodate major maintenance of heavy duty natural gas vehicles was completed in 2013.

With existing conditions similar to many repair garages, the metal building was heated by gas fired unit heaters and had most of the electrical conduit attached to the ceiling. The building does not have a fire sprinkler system. One of the vehicle bays has a lube pit. The lube pit has existing exhaust ventilation.

Facility Modifications for Natural Gas Vehicles (NGV)

Summary of improvements provided in Repair Garage:

All 10 bays were upgraded to meet the requirements of a Major Repair garage for CNG vehicles.

- Heating System – The existing unit heaters were non-compliant for NGV garages because they had both open flames and temps above 750 degrees F. The heating system was replaced with a radiant tube heating system that was specifically selected for compliance with the code requirements. The new heating system is supplied with ducted outside combustion air.
- Ventilation – Four new rooftop exhaust fans were added that are compliant for the ceiling classified area. The exhaust fans are interlocked with the gas detection system and activate in the event of gas detection. In addition to the roof top exhaust fans, a rooftop make-up air unit was added to correct the existing condition of deficient ventilation rates while the building is occupied. The unit is equipped to provide heated make-up air using 100% outside supply air and has a motorized damper to prevent the back flow of garage air to the heating element.



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- Gas Detection – A gas detection system was added to the facility. Upon gas detection the alarms activate, ventilation fans activate, and several garage doors open. Also the heating system and welding outlets are disabled. The gas detectors have Tygon calibration tubing run to each of the five detectors to facilitate the detector calibration without the use of a scissor lift or disruption of normal maintenance operations.
- Electrical – All of the electrical conduits in the ceiling were re-built for compliance with the classified area. In most cases this was done using conduit rated for the classified area because there was insufficient headroom in the garage to lower them. Electrical equipment was moved below the ceiling classified area.
- Migration of vapors – the maintenance garage is located between the wash bay and the administrative offices. Both separation walls were sealed to prevent the migration of natural gas to those areas.
- Fire protection – The building modifications triggered local fire department requirements for the addition of a fire alarm system. The fire alarm system was required throughout the building including the administrative offices. The gas detection system was tied into the fire alarm system.
- Other – A used oil burner was removed from the garage and a permanent roof access ladder was added.

Permitting

The site has added on-site CNG fueling as well as the garage modifications. Because of the on-site fueling, the project first went through a planning phase with the city and then the building permits phase. The garage alterations exceeded the permissible limits for a local level building plan review, therefore the design drawings were submitted to the state Department of Safety and Professional Services (DSPS) for plan review. After state approvals the plans were then submitted to the local AHJ for review and building permits. The building permitting phase was approximately 3 months including both the state and local reviews. In addition, the local ordinances triggered the installation of a fire alarm system which required additional reviews by the state and local AHJ. The fire alarm system design, reviews, and permitting phase took approximately 2 months beyond the building department reviews.

Operations and Training

A national level training program has been created to educate their personnel on the maintenance and operation of natural gas vehicles. The training program is initiated with each facility adopting NGVs and includes both in-house training and training provided by outside consultants. The training program has been developed over the years through a long history of operating alternative fueled vehicles, particularly on the west coast. Their first CNG vehicles were operational in the early 90's.

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Kwik Trip Case Study

Summary

Kwik Trip has truly been a leader in the adoption of Natural Gas Vehicles (NGV) and development of fueling infrastructure in the state of Wisconsin. To that end they have modified their own repair garage for the maintenance of their NGV fleet. Kwik Trip/ Convenience Transportation LLC operate a fleet of 36 CNG and LNG vehicles with plans to continue their fleet conversion to NGVs. The existing repair garage was built in the late 80's with several phases of more recent additions. The facility consists of 11 vehicle maintenance bays, wash bays, parts room, and administrative office areas. In 2012, the facility underwent a retrofit for code compliant maintenance of NGVs and simultaneously integrated standard operating procedures and training related to NGVs.

In a successful effort to meet their repair garage needs and develop an economical solution for the building modifications, Kwik Trip converted one wash bay into a "major repair" bay for NGVs and is using its 11 existing maintenance bays as "minor repair" areas for CNG vehicles and any repairs on defueled NGVs. No significant facility modifications were made to the 11 bay garage. It should be clearly noted that minor repair of CNG vehicles in a major repair garage and vehicle defueling are not standard methods of compliance with code provisions and they were thoroughly vetted with the building officials, fire authorities, and have strictly enforced standard operating procedures associated with them. The method of compliance in the 11 bay garage was, in part, facilitated by the specialized



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experience and operations that Kwik Trip does at the facility. The facility performs inspections and maintenance on fuel tanker trailers and thus has robust safety, training, and operational procedures.

The garage upgrade design and permitting was completed by a design build contractor with significant owner contributions and coordination with the building and fire officials. Permitting and plan review was provided by the Wisconsin Department of Safety and Professional Services (DSPS), local building officials, and fire officials. Total project timeline from conceptualization to completion was approximately 1 year.

Facility Modifications for Natural Gas Vehicles (NGV)

Summary of improvements provided in the Major Repair Garage (1 isolated bay):

The existing single wash bay was retrofitted for the maintenance of LNG and CNG vehicles.

- Heating System – the heating system was replaced with a unit heater meeting the requirements for NGV garages. The heater has no open flames and surface temperatures less than 750 °F. 100% fresh outside air was used for combustion air and the exhaust was ducted to the outside.
- Ventilation – Additional ventilation was provided and interlocked with the gas detection system. The ventilation system is a push/pull type system which has unheated outside air ducted to near the floor level and exhausts from the ceiling.
- Gas Detection – a gas detection system was installed and is monitored by their corporate security. The gas detection system is interlocked to the ventilation system and the heating system.
- Electrical – All electrical conduit and equipment was moved outside of the 18” classified area in the ceiling. The garage door opener was lowered such that it was outside the 18” classified area. Conduits within 18” of the floor were encased in concrete to mitigate the classified area at the floor.
- Migration of hazardous vapors – The maintenance bay construction prevents gas vapors from migrating to other areas of the building. Self-closing man doors are used to prevent gas migration through the door openings.
- Other – Because the service bay was going to be servicing LNG vehicles, the floor drain was plugged to prevent liquid LNG from running down the drain and interacting with water in the drainage system. Lighting was added/upgraded in the repair bay as part of the facility modification.

Operations and Training

Operations and training play a critical role in the safety of any vehicle maintenance facility and Kwik Trip has invested considerable effort into both. The maintenance shop is occupied 24/7/365. As part of the standard operating procedures, NGVs are removed from the shop in the case of an unscheduled closing of the shop. Many other standard operating procedures are enforced with several notable ones as follows:

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- Hand held leak detectors are used regularly;
- CNG vehicle fuel cylinders are manually closed before entering the shop;
- Vehicles are identified with signage to indicate their status;
- No hot work on/near Natural Gas Vehicles in the minor repair area; and,
- Cylinder inspections are performed by in-house certified CNG cylinder inspectors.

CNG vehicle defueling is accomplished with truck to truck transfers. For this to be possible, all vehicles are equipped with a defueling port. Truck to truck transfers require several vehicles with empty tanks and transfer the fuel using pressure equalization. Defueling a CNG vehicle may take up to 2 man hours and 4 transfers depending on the amount of fuel in the tank.

LNG vehicle defueling is accomplished with a specialized tank system design to defuel LNG vehicles. The fuel transfer is accomplished by using the existing tank head pressure to push the fuel out of the tank. The system is then used to re-fuel the LNG vehicle in the same manner. Fuel transfer is accomplished in minutes.

In summary, Kwik Trip has developed an economical system to safely provide maintenance to their NGV fleet with the use of facility modifications, training, and standard operating procedures. Systems like this may not work for every fleet or facility but demonstrate that ingenuity and customization of the solution to individual fleet needs is possible.

City of Milwaukee Case Study

Summary

The existing City of Milwaukee fleet facility located on Lincoln Avenue includes an existing compressed natural gas fueling facility. The City has a design prepared for the maintenance shop conversion. The shop conversion was bid as an alternate to the CNG fueling facility construction project in 2011, but due to budgetary concerns was not awarded or constructed at that time. The City anticipates that as their CNG vehicles start to go out of warranty period and their maintenance need increases they will perform the facility upgrades for CNG compliance, likely in 2013 or 2014.

Currently there are 21 CNG vehicles based at two facilities with approximately 20 additional CNG vehicles anticipated to be added to the fleet within the year.

The existing Lincoln Avenue maintenance shop is a steel frame and Concrete Masonry Unit building. The building has a flat roof with membrane roofing and insulation over metal deck. Because this is a large facility, the City of Milwaukee has elected to isolate an area of the shop and convert that area for CNG vehicle repair rather than modify the entire facility.

The maintenance shop modification project is within the jurisdiction of the City of Milwaukee. The design has not yet been submitted for permit application and plan review.

Facility Modifications for Natural Gas Vehicles (NGVs)

The proposed design for the City of Milwaukee Lincoln Avenue Repair Garage NGV modifications isolates and upgrades only a portion of the shop, limiting the scope of work required for improvements. The proposed scope of improvement includes:

- Partition walls – Design isolates an area in the southeast corner of the shop which is 120' x 52' (approx. 6240 sf) for the repair of CNG vehicles. This area will create a 6 bay garage that is compliant for CNG vehicles without the cost associated with upgrading the entire garage. The CMU partition wall is sealed at the top of wall to the existing metal roof deck. The main area of the shop is accessed via internal coiling overhead doors and man doors. An additional pedestrian door was added in the main shop area to meet code related exiting requirements with the modified facility.
- Heating System – The existing facility is heated with gas fired forced air system made up of two air handling units (AHU). The design modifies the ducting of the existing system to maintain heat in the diesel vehicle shop via the two existing AHU. The design calls for a new roof mounted AHU to service the CNG repair area.

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- Ventilation –
 - NGV purge ventilation - roof mounted fans, interlocked to operate in the event of a detection, provide the 1cfm/12cf of building volume required by mechanical codes. In this case ventilation is by (4) 2,500 cfm fans. Unheated makeup air is provided by a rooftop intake hood and fan during a detection event. Intake ventilation air is ducted to the floor level and exhausted at the ceiling.
 - Base occupancy ventilation – normal ventilation is provided for the CNG vehicle maintenance area with (2) up blast exhaust fans (4,750 cfm each). This ventilation rate is approximately 1.5 cfm/sf which exceeds the state required occupancy ventilation rate of 0.5 cfm/sf (ref SPS 364.403) but matches the 2006 IMC required rates (ref 2006 IMC 403.3).
- Gas Detection – Gas detection and heat detectors are provided in the new CNG vehicle maintenance area. Gas detection is interlocked to exhaust and intake fans as noted above. Gas detection is also interlocked to the welding receptacles to disable welding circuits in the event of gas detection.
- Electrical – Space at the ceiling is classified Class 1, Division 2 per NEC.
 - Lighting – height of shop from floor to ceiling varies from 18'-8" to 19'-1", to ensure minimum overhead clearance to lights of 17' clear AFF, the design specifies fixtures rated for CL 1, Div 2 location.
 - Design spec requires that 18" envelope at ceiling and at floor is Cl 1, Div 2 per NEC so would allow installer to choose path of compliance, either relocation of electrical in those areas, or installation of explosion proof equipment rated for the classified location (typically relocation would be most economical).
- Fire protection – a modified fire alarm system is included in the design for the CNG vehicle maintenance area.

Operations and Training

City of Milwaukee has initiated NGV training programs including training through the Milwaukee Area Technical College.

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SECTION 5 – GARAGE UPGRADE COSTS

Purpose and Goals of the Cost Information

The purpose of this section is to provide some means for potential NGV stakeholders to very roughly assess the costs of a shop upgrade for code compliance maintenance of NGVs. It is understood that the costs associated with the adoption of a NGV fleet of vehicles will be a major driving force in the decision making process and thus should be addressed. The basic premise for the cost structure is the same as it is for the rest of this document in that we are starting with an existing vehicle maintenance facility that is in compliance with codes for the maintenance of diesel and gasoline vehicles and then doing a renovation for code compliant maintenance of NGVs. Not all cost line items will be required for projects, applicability of line items in the table below will be based on the an assessment of the facility, identification of the upgrades required, and the method of code compliance selected.

Every shop provides unique challenges and no two shops will have identical solutions. The costs indicated reflect inherent assumptions of the existing conditions and our experience working with existing buildings. The intent of the costs presented is to provide some measure of the potential costs associated with a repair garage retrofit; however projects will fall outside of these ranges depending on existing conditions and many other factors. For decision making purposes, more accurate costs estimates should be generated based on a detailed facility assessment, design, and contractor estimates.

Refer to the end of this section for an “Initial Assessment Checklist” to guide the evaluation of existing conditions. In order to work through the cost information below, a concept plan should first be developed. The concept plan should address the method of compliance for ventilation, heating, gas detection, and electrical.

Costs by Scope of Work

Costs indicated reflect the total installed costs including overhead and fee. July 2013.

Item	Unit	Unit price	Notes
Engineering Assessment and Design	Lump sum	\$25,000 - \$40,000	Engineering for the development of project scope, design, permitting, and construction support. Costs will vary widely depending on the facility size and scope of work.
Ventilation			
Exhaust fans rated for classified locations	each	\$8,200 - \$9,200	Ventilation required for 5 ACH (usually wall or roof mounted) Includes Mechanical, Electrical, Roof Framing & Roofing Work.
Ducting if required	Lf	\$45 - \$60	Exposed non-insulated interior duct & fittings

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Item	Unit	Unit price	Notes
Gas Detection			
Gas Detector system. Detectors and control system	1	\$30,000 - \$45,000	Includes equipment, installation and electrical. Number of detectors and complexity of the control system can have a significant cost impact.
LNG – Pit detectors	each	\$3,500 – \$5,000	Costs will be highly dependent on the floor slab and underground scope of work.
Heating			
Air handling unit (AHU)	\$/SF	\$3.00 - \$7.50	Assumes AHU is pad mounted direct fired unit. Includes installation and electrical. Heat exchangers or cooling systems are not included.
Added costs for Rooftop mounted AHU	each	Varies	Roof penetrations and structural framing. Structural design costs and retrofit can vary significantly depending on existing conditions.
Ducting	See Ventilation	See Ventilation	
Infrared tube heaters	SF	\$12 - \$17	Includes electrical
Electrical			
New electrical conduit at the ceiling for gas detection and heating	--	Included in item pricing above	Included in item pricing above
Retrofit of electrical conduit in the ceiling classified area	SF	\$1.50 - \$2.50	Garage Doors, Lights, Misc. Includes Conduit and Conductors.
Retrofit of power feeders in the ceiling classified area		Varies	Dependent on quantity, size, and complexity.
Retrofit of Data and Communications in the ceiling classified area		Varies	Dependent on quantity, complexity.
Shunt trip 30A breakers	each	\$525 - \$650	Assumed that space is available in the existing panel. Otherwise a new panel may be required.
Shunt trip 200A panels	each	\$1,300 - \$3,500	Assumes existing panel type can be retrofitted for 200A Shunt Trip Breaker. Cost varies depending on the AIC rating of the breaker.
Other			
Misc. mechanical and electrical demolition	SF	\$0.50 - \$2.00	

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Item	Unit	Unit price	Notes
Lighting	each fixture	\$350 – \$600	Optional lighting upgrades are often included in the garage retrofit (assume 4 bulb T5-HO fixtures). Cost Depends on desired lighting levels and complexity of lighting control system and sensors.
LNG – plug floor drains	each	Varies	Concrete plug will be a very low cost solution but may require other parts of the floor drainage to be reconfigured.
LNG – floor drains controlled by cryogenic valves	each	\$10,000 - \$15,000	Assume a 3” cryogenic valve. Includes installation, temperature sensor, floor slab cut and repair, control panel, and electrical.
Roof Access Ladder	each	\$3,000 - \$5,500	19 foot, steel, non-caged, exterior mounted. Does not include interior mounted and/or cost associated with retrofitting building roof structure for access through roof. OSHA requires a cage or other safety devices for ladders greater than 20’.
New Separation wall	Sq ft of wall area	\$18 - \$25	6” metal stud with metal panel ea side, sealed.
Special Conditions	--	Varies	Existing facilities may have additional scope of work depending on specific conditions.
Correction of deficient / unsafe existing conditions	--	Varies	
Project Management Costs	Design Management	5% - 10%	Project schematic design, AHJ coordination, design contracting and management, design coordination, permitting, permit fees, design team construction support.
	Construction Management	20% - 50%	Bidding, contingency, construction supervision, overhead, fee, insurance, closeout.

Costs Assumptions and qualifications:

- Conversion of an existing major repair garage that is compliant for diesel and gasoline vehicle maintenance to one that is also compliant for maintenance of NGVs.
- Garage is privately owned (not a municipality, state, or publically owned facility)
- The costs are representative of a maintenance garage that is 4 to 10 truck bays. Smaller or larger shops will influence the cost.

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- Existing electrical supply is adequate for the proposed loads.
- Existing gas supply is adequate for the proposed loads.
- Construction duration of 10-14 weeks.

Costs can vary widely. In an overly simplistic model, it's possible to have project cost variations from \$0 to over \$125,000 per vehicle bay. Many projects end up in the range of \$40,000 to \$75,000 per vehicle bay.

Potential factors influencing costs:

- Existing building construction materials, condition, workmanship, configuration, etc.;
- Facility size (economy of scale);
- Local construction climate and competitiveness;
- Owner requirements such as asset protection and/or cooperate culture can increase the scope of work;
- Role of consultants vs. the role of the owner/operator. In some cases the entire process from conceptualization through the facility commissioning will be managed and directed by a paid consultant or contractor. In other cases the owner may take on a much more active role. The costs to the owner could vary significantly depending on the project management and delivery approach;
- Project delivery method (Design/Bid/Build, Design/Build, etc);
- Accuracy of bidding documents;
- Construction schedule;
- Availability of experienced contractors and subcontractors;
- Local AHJ and Fire official's interpretations of codes and adoption of more restrictive codes;
- Plan review and permitting costs;
- Design approach and methods of compliance related to the initial capitol compared to the long term operating costs; and,
- Facility operations and flexibility to accommodate construction activities (overtime, off hours, phased construction approach, etc.).

Recommended Cost Savings Strategies

- Hire experienced design professionals and contractors. Conservative design assumptions and contractor uncertainties increase costs.
- Use a sealed partition wall to separate NGV repair areas thus limiting the extent of garage renovations. This method of compliance may be used to upgrade a section of an existing repair garage without requiring the entire repair garage to comply with applicable codes for NGV repair garages. Separation walls should effectively prevent the transition of vapors from one side of the wall to the other and do not need to be a fire rated. The separation would eliminate the need for the heating, electrical, ventilation, and gas detection upgrades on the conventionally fueled vehicle side of the wall.

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- Select ventilation and heating systems that considers operational costs as well as up front capital. Beware of systems that offer reduced capital investment but have higher ventilation rates because those systems may have significantly increased long term operational costs.
- Financial incentives are available through the Wisconsin “Focus on Energy” Program. Focus on Energy is Wisconsin utilities’ statewide energy efficiency and renewable resource program. The program offers special incentives to businesses that install energy efficient equipment. Of particular relevance to NGV garage retrofits are the programs related to HVAC equipment and lighting. Additionally, other incentives are available for Variable Frequency Drives (VFDs), compressed air equipment, and other energy efficient upgrades.
Contact Focus on Energy at: www.focusonenergy.com/about/contact
Applications and more information can be found online at:
<http://www.focusonenergy.com/business/efficient-equipment>.
- Replace the lighting with high efficiency lighting such as fluorescent T5 HO high bay lighting. The additional upfront capital can pay for itself with energy savings.
- Minimize non-code required upgrades.
- Relocate equipment in electrically classified areas rather than replace with equipment rated for the classified areas (i.e. garage door openers).
- Don’t duplicate existing mechanical/electrical systems (i.e. supplement existing air handlers if they are compliant instead of demo and replace with an entirely new system).
- Shunt trip air handling units and pressure washers heated with natural gas in areas not subject to ignitable concentrations of gas rather than replace or remove them. AHJ and the design professional should carefully evaluate the areas subject to ignitable concentrations of gas prior to adopting this strategy.

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CNG/LNG Repair Garage Initial Assessment Checklist

This checklist was developed for potential NGV stakeholders to roughly assess the existing conditions and identify potential deficiencies related to the upgrades necessary for NGV repair facilities. Each facility provides unique challenges and no two will have identical solutions. It is recommended that for final decision making purposes a more accurate assessment be generated with the help of NGV experienced designers and contractors.

Item	Description of Existing Building Conditions	Yes	No
<i>Existing Ventilation</i>			
	Mechanically ventilated facility		
	Existing ventilation rate 1 CFM/ 12 CF (5 ACH)		
	Lubrication or chassis repair pits ventilated		
<i>Existing Gas Detection</i>			
	Gas detectors, control panel, and notification devices		
	Lubrication or chassis repair pits detectors (required for LNG vehicles)		
<i>Existing Heating and Sources of Ignition</i>			
	Heaters or equipment with a surface temperature greater than 750 degrees		
	Heaters or Equipment with open flames (i.e. pressure washer, used oil burner, water heater, etc.)		
<i>Existing Electrical</i>			
	Lights and lighting conduits within 18" of the ceiling		
	Primary power feed located within 18" of the ceiling		
	Electrical conduits, wiring, or electrical equipment within 18" of the ceiling (i.e. garage door motors, ceiling fans, vehicle tailpipe exhaust systems, fire detection equipment, data, phone lines)		
	Overhead crane electrical equipment within 18" of the ceiling		
	Welding receptacles		
<i>Other</i>			
	Sealed separation wall between occupancies (i.e. separation of repair garage from offices or wash bays)		

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APPENDIX A – DETAILED CODE PROVISIONS SUMMARY

Definitions

Code Section	Code Verbiage
Definitions	
2008 NFPA 30A 3.3.12.1	Major Repair Garage: 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
2008 NFPA 30A 3.3.12.2	Minor Repair Garage: 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.
2009 IFC 2211.7 IFC “Minor” definition	Exception: Repair garages where work is not performed on the fuel system and is limited to exchange of parts and maintenance requiring no open flame or welding. (Note IFC 22 is excluded by WI SPS sec 361.03 (14) but may be adopted by local jurisdictions)
2009 IEBC 202: Definitions	Change of Occupancy: A change in the purpose or level of activity within a building that involves a change in application of the requirements of this code.
2009 IEBC 403	Level 1 Alteration: Level 1 alterations include the removal and replacement or the covering of existing materials, elements, equipment, or fixtures using new materials, elements, equipment, or fixtures that serve the same purpose
2009 IEBC 404	Level 2 Alteration: Level 2 alterations include the reconfiguration of space, the addition or elimination of any door or window, the reconfiguration or extension of any system, or the installation of any additional equipment.
2009 IEBC 405	Level 3 Alteration: Level 3 alterations apply where the work area exceeds 50 percent of the aggregate area of the building.

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Minor Repair Garages

Code Section	Paraphrase	Notes
Electrical 2008 NFPA 30A 8.2.1 2008 NEC 511.3(D)	Ceiling Areas: In Minor repair garages where lighter-than-air gaseous fuels will not be transferred, such locations shall be unclassified.	In a Minor Repair Garage the area at the ceiling is unclassified.
Heating 2008 NFPA 30A 7.6.6	Minor repair garages are exempt from the limitations of open flame heaters or surfaces > 750°F.	Minor garages for NGVs have no additional requirements for heaters beyond the heating provisions for diesel and gasoline vehicle garages.
Purge Ventilation 2009 IMC 502.16	NGV repair garages shall have a mechanical ventilation system in accordance with sections 502.16.1 and 502.16.2	NGV Minor repair garages have the same purge ventilation requirements as Major garages; refer to the Ventilation Code Summary.
Gas Detection – CNG 2009 IMC 502.16	Gas detection may be interlocked to the purge ventilation systems in CNG repair garages per 2009 IMC 502.16.2 (1)	
Gas Detection – LNG 2009 IBC 406.6.6 2008 NFPA 30A 7.4.7	Repair garages used for repair of vehicles fueled by non-odorized gases such LNG shall be provided with a flammable gas detection system.	Gas detection is required at the ceiling and in service pits for Minor garages servicing LNG vehicles.

Ventilation Code Summary

Code Section	Paraphrase	Notes
Ventilation for air quality in occupied spaces		
SPS 364.0403(5)(a)	An exhaust rate of 0.5 CFM/FT ² is required in repair garages of any vehicle fuel type.	Table 364.403 prescribes a 0.5 CFM/FT ² exhaust rate for repair garages. This ventilation rate is not dependent on the vehicle fuel type.
2009 IMC 403.3	An exhaust rate of 0.75 CFM/FT ² is required in repair garages of any fuel type.	Amended by WI DSPS: This requirement is reduced to 0.5 CFM/FT ² in SPS 364.0403(5)(a).
Purge Ventilation		
2009 IMC S 502.16	A mechanical or approved natural ventilation system is required in NGV garages to be capable of providing 5 ACH within the NGV portion of the garage. The ventilation must operate continuously with two exceptions: It may be interlocked with a gas detection system, or for CNG vehicles it may be interlocked with the lighting circuit.	<ul style="list-style-type: none"> • Natural ventilation is a method of compliance if approved by the AHJ but difficult to achieve in a building. • Airflow from floor to ceiling. • Applies to both Major and Minor Repair Garages
2009 IFC 2211.7.1	Similar to IMC ventilation provisions but excluded by SPS 361.03(14)	The IFC ventilation provisions have an exception for garages that do not do fuel system work or use open flame or welding

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Gas Detection Code Summary

Code Section	Paraphrase	Notes
2009 IBC 406.6.6 2008 NFPA 30A 7.4.7 IFC 2211.7.2	Gas Detection is required in repair garages used for repair of vehicles fueled by non-odorized gases such as LNG.	<ul style="list-style-type: none"> Gas detection is required at the ceiling and in service pits for garages servicing LNG vehicles. IFC chapter 22 is not adopted by the state of Wisconsin but may be adopted by the local AHJ.
2009 IMC 502.16	Purge ventilation systems may be interlocked to a gas detection system rather than run continuously.	Gas detection allows the purge ventilation system to operate infrequently, which will reduce energy costs.
2009 IBC 406.6.6.1 2008 NFPA 30A 7.4.7.1 2012 IFC 2211.7.2.1	Operation: The gas detection system is required to activate an alarm condition upon detection of natural gas at 25% of its LEL or in the event of failure of the system itself. An alarm condition shall result in initiation of a distinct audible alarm, deactivation of heating systems and activation of the purge ventilation system.	The gas detection system must operate in accordance with these sections.

Heating Code Summary

Code Section	Code Verbiage	Notes
2008 NFPA 30A 7.6.6	Where major repairs are conducted on CNG-fueled vehicles or LNG-fueled vehicles, open flame heaters or heating equipment with exposed surfaces having a temperature in excess of 750 degrees F shall not be permitted in areas subject to ignitable concentrations of gas.	It has been standard practice to assume that the entire garage is subject to "ignitable concentrations of gas". Other assumptions should have AHJ approval and an engineering analysis before allowing heating equipment that does not meet the open flame and maximum temperature requirements.

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Electrical Code Summary

Code Section	Paraphrase	Notes
Classified Area in Major Repair Garages		
2008 NFPA 30A 8.2.1 2008 NFPA 30A Annex TIA Table 8.3.1 2008 NEC 511.3(C)(2)	In major repair garages where CNG vehicles are repaired or stored, the area within 18 inches of the ceiling shall be designated a Class I, Division 2 hazardous (classified) location.	
SPS 316.511	Continuous ventilation cannot be used to eliminate the electrically classified area within 18" of the ceiling.	The WI DSPS has eliminated the continuous ventilation option from the NEC.
Proposed SPS section 316.511(2)	Substitute the following wording for 2011 NEC 511.3 (C) (2) (a): The ceiling area shall be unclassified where ventilation is provided from a point not more than 18 inches from the highest point in the ceiling. The ventilation shall conform to chapters SPS 361 to 366.	This proposed NEC amendment is pending adoption by the state. It is recommended to use purge exhaust fans rated for Class 1 Div 2 areas even if the ceiling area is unclassified. Note: The Commercial Building Code, chapters SPS 361 to 366, adopts and references the IMC for the design of ventilation systems. The adopted provisions of the IMC under section 502.16 prescribe provisions for repair garages for natural gas and hydrogen-fueled vehicles.

Existing Conditions Code Summary

Code Section	Paraphrase	Notes
SPS 366.0101 and 366.0300	The requirements of IEBC chapter 3 (Prescriptive Compliance Method) are not included as part of this code.	The prescriptive method of compliance is not allowed, must use the work area compliance method or performance compliance method.
Alterations		
2009 IEBC Chapter 4	Level 1, 2 and 3 alterations must comply with all requirements for their specific level of alteration as well as all requirements for lower levels of alteration.	See the definitions section for criteria for levels 1, 2 and 3 alterations.
Level 1 Alterations		
2009 IEBC 602.4	Materials and Methods - All new work must comply with the materials and methods requirements of the IBC, IECC, IMC and IPC as applicable.	

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Code Section	Paraphrase	Notes
2009 IEBC 606.2	Structural - If the dead load is increased on a structural element of the building by more than 5%, the structural element shall comply with the gravity requirements of the IBC.	Rooftop exhaust fans are often installed in NGV repair garages. The weight of these fans may trigger this structural requirement. Consult a qualified professional to determine if a retrofit of existing structural member(s) may be needed.
2009 IEBC 606.7 SPS 366.0607	Energy Conservation - Unaltered portions of the building are not required to be brought into compliance with the IECC and are permitted to be maintained in their existing conditions.	
Level 2 Alterations		
Fire Sprinkler Requirement		
2009 IEBC 704.2.2	<p>An automatic sprinkler system is required as part of an NGV repair garage when <u>all</u> of the following conditions occur:</p> <ul style="list-style-type: none"> • The work area has exits or corridors shared by more than one tenant or serving an occupant load greater than 30. • The work area is required to be provided with automatic sprinkler protection in accordance with the International Building Code as applicable to new construction • The work area exceeds 50 percent of the floor area; and • The building has sufficient municipal water supply for design of a fire sprinkler system available to the floor without installation of a new fire pump. 	All of these conditions must be valid to warrant the installation of a new fire sprinkler system. See below for the IBC requirements for new construction.
2009 IBC 903.2.9.1	<p>Repair Garages. An <i>automatic sprinkler system</i> shall be provided throughout all buildings used as repair garages in accordance with section 406, as shown:</p> <ol style="list-style-type: none"> 1. Buildings having two or more <i>stories above grade plane</i>, including basements, with a <i>fire area</i> containing a repair garage exceeding 10,000 square feet (929 m²) 2. Buildings no more than one <i>story above grade plane</i>, with a <i>fire area</i> containing a repair garage exceeding 12,000 square feet (115 m²) 3. Buildings with repair garages servicing vehicles parked in basements 4. A group S-1 <i>fire area</i> used for the repair of commercial trucks or buses where the fire area exceeds 5,000 square feet (464 m²) 	This is one of the criteria listed in the IEBC section 704.2.2. All conditions from the IEBC section 704.2.2 must be met to trigger the installation of an automatic sprinkler system.

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Code Section	Paraphrase	Notes
Excerpt from the Q&A Section on the DSPS Webpage from September 1, 2011	<p>Question. IBC 903.2.9.1 and 903.2.10.1 When applying the fire sprinkler threshold requirements of IBC Sections 903.2.9, 903.2.9.1, and 93.2.10.1, what are the commercial trucks or buses referred to there?</p> <p>Answer. Fire apparatus are not to be considered commercial trucks. The following is a listing of the types of commercial trucks or buses being referred to in IBC 903.2.9, 903.2.9.1, and 903.2.10.1: Semitrailer Tractors, Trucks having a gross vehicle weight over 26,000 pounds, and passenger vans or buses with a seating capacity of 16 or more.</p>	
Change of Occupancy		
2009 IEBC 901.1	Chapter 9 of the IEBC applies in 2 separate cases: 1. Where there is a change in occupancy classification according to the IBC. 2. Where the occupancy classification is not changed, but there is a change in use which triggers new code applications.	Most repair garage NGV conversions would be classified as a S-1 occupancy both before and after the conversion, so the occupancy classification would not normally change, however the change in use will trigger new code provisions.
2009 IEBC 901.2	When there is a change in occupancy without a change in occupancy classification, IEBC sections 902 through 911 will apply (see below).	Not all of these sections are applicable to an NGV repair garage conversion project.
2008 IEBC 902	Special Use and Occupancy	These sections only apply to buildings undergoing a change of occupancy classifications, and would not apply to a repair garage NGV conversion project.
2009 IEBC 903	Building Elements and Materials	
2009 IEBC 904	Fire Protection	
2009 IEBC 905	Means of Egress	
2009 IEBC 906	Accessibility	
2009 IEBC 907	Structural	
2009 IEBC 908 SPS 316.003(3)	Electrical - Unsafe Conditions: If existing electrical installations are deemed unsafe, the AHJ may require them to be brought into compliance with the current version of the NEC.	If existing electrical installations are not deemed unsafe, they do not need to be brought into compliance with current NEC requirements. (Reference SPS 316.003(3)).
2009 IEBC 909.1	Mechanical - If the occupancy is changed so that new ventilation requirements apply, then the ventilation systems must be brought into compliance with the IMC.	In Wisconsin, 0.5 CFM/sq. ft. is required in a repair garage for air quality of occupied spaces. Note: NGV repair garages are subject to the additional provisions for purge ventilation.
2009 IEBC 911.1	Light and Ventilation: Light and ventilation shall comply with the requirements of the International Building Code for new occupancy.	Lighting requirements will not change for an NGV repair garage. Refer to the Ventilation code summary for additional information.

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Other Code Provisions

Code Section	Paraphrase	Notes
Separation Walls		
SPS 364.0403(5)(b)	<p><i>Adjacent spaces with differing ventilation requirements:</i></p> <p>1. Except as provided in subd. 2., spaces with different ventilation requirements shall be provided with a complete solid separation, or the most stringent ventilation requirement shall apply to all unseparated areas.</p> <p>2. The separation as specified in subd. 1. is not required where an engineered ventilation design system will prevent the concentration of contaminants from exceeding that obtainable by providing a physical separation.</p>	This SPS section allows for the use of separation walls to limit areas with specific ventilation requirements.
2008 NFPA 30A A.7.6.6	Heat producing appliances - Enclosed rooms or spaces storing CNG- or LNG fueled vehicles should prohibit the transmission of gases to other areas of the building. Areas outside of the enclosed space can use other heating methods.	Areas adequately separated from areas containing NGVs are not subject to the heater requirements of the 750°F limit or open flames.
2008 NEC 511.3(E)(1) 2008 NFPA 30A Annex TIA Table 8.3.1	Electrical - Areas adjacent to a classified area where flammable vapors are unlikely to be released shall be unclassified where mechanically ventilated at 4 ACH or greater, designed with positive air pressure, or cut off from the classified area by walls or partitions.	Any of these three methods may be used to declassify the area on the non-hazardous side of the wall.
2008 NFPA 30A 8.3.2	Electrical - A designated classified area, as specified in table 8.3.1, shall not extend beyond a floor, wall, roof, or other solid partition that has no openings.	A wall may be used to isolate areas exposed to gas accumulation and declassify the area on the non-hazardous side of the wall.
2008 NFPA 30A 7.3.6	The fuel dispensing area shall be separated from all other portions of the building by fire rated assemblies in accordance with section 7.3.6.	For information only, indoor fueling is beyond the scope of this document.
Energy Recovery Systems		
SPS 364.0514 2009 IMC 514.2	<p>This is a department exception to the prohibitions in IMC section 514.2:</p> <p>An engineered energy recovery ventilation system design may be used in the systems specified in IMC section 514.2 provided that corrosion, cross-contamination and fouling are addressed by the engineered system.</p>	Energy recovery systems can be used in conjunction with the ventilation system in a NGV repair garage.

WISCONSIN STATE ENERGY OFFICE

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REV 10/02/13