Natural Gas Systems: Suggested Changes to Truck and Motorcoach Regulations and Inspection Procedures

U.S. Department of Transportation
Federal Motor Carrier Safety Administration

March 2013

FOREWORD

This report provides recommendations for suggested changes needed to Federal Motor Carrier Safety Regulations (FMCSRs), North American Standard inspection procedures, and out-of-service (OOS) criteria to accommodate and facilitate the use of natural gas (compressed or liquefied) as an alternative to traditional fuels such as diesel and gasoline in commercial vehicles. In addition to providing specific recommendations for changes, this report summarizes the process used to arrive at these recommendations, which included a literature review and gap analysis, industry site visits/consultations, and a formal peer review process.

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16. Abstract

This report provides recommendations for suggested changes to Federal Motor Carrier Safety Regulations (FMCSRs), North American Standard (NAS) inspection procedures, and out-of-service (OOS) criteria to accommodate and facilitate the use of natural gas (compressed or liquefied) as an alternative to traditional fuels such as diesel and gasoline in commercial vehicles. In addition to providing specific recommendations for changes, this report summarizes the process used to arrive at these recommendations, which included a literature review and gap analysis, industry site visits/consultations, and a formal peer review process.

Current FMCSRs, NAS inspection procedures, and OOS criteria are targeted primarily toward liquid-fueled vehicles. They address the unique characteristics of gaseous-fueled vehicles in a very limited way and fail to address cryogenic fuels. The purpose of this project was to identify changes to the current FMCSRs and inspection procedures, if any, that would specifically and fully address the unique characteristics of natural gas used as a fuel and serve to improve the overall safety of commercial vehicle operations by ensuring that commercial vehicles powered by natural gas meet appropriate safety criteria at all times while operating on public roads.

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Commercial motor vehicle, compressed natural gas, CNG, fuel, liquefied natural gas, LNG, safety	**No restrictions**

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Unclassified	**Unclassified**	**86**	**N/A**

SI* (MODERN METRIC) CONVERSION FACTORS

TABLE OF APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME	1,000 L shall be shown in m^3	
fl oz	fluid ounces	29.57	milliliters	ml
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2,000 lb)	0.907	megagrams (or “metric ton”)	mg (or “t”)
		TEMPERATURE	Temperature is in exact degrees	
°F	Fahrenheit	5 × (F-32) ÷ 9 or (F-32) ÷ 1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-lamberts	3.426	candela/m^2	cd/m^2
		Force and Pressure or Stress		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

TABLE OF APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
ml	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
mg (or “t”)	megagrams (or “metric ton”)	1.103	short tons (2,000 lb)	T
		TEMPERATURE	Temperature is in exact degrees	
°C	Celsius	1.8C + 32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	footlamberts	fl
		Force & Pressure Or Stress		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003, Section 508-accessible version September 2009.)

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LIST OF ABBREVIATIONS AND ACRONYMS

Acronym	Definition
APTA	American Public Transportation Association
ASE	National Institute for Automotive Service Excellence
CFR	Code of Federal Regulations
CGA	Compressed Gas Association
CNG	compressed natural gas
CNGV	compressed natural gas vehicle
CSA	Canadian Standards Association
CVEF	Clean Vehicle Education Foundation
CVSA	Commercial Vehicle Safety Alliance
FMCSA	Federal Motor Carrier Safety Administration
FMCSR	Federal Motor Carrier Safety Regulations
FMVSS	Federal Motor Vehicle Safety Standards
FTA	Federal Transit Administration
HM	hazardous materials
IANGV	International Association of Natural Gas Vehicles
ISO	International Standards Organization
LNG	liquefied natural gas
LNGV	liquefied natural gas vehicle
LPG	liquefied petroleum gas
NAS	North American Standard
NFIRS	National Fire Incident Reporting System
NFPA	National Fire Protection Association
NGV	natural gas vehicle
NGVIR	Natural Gas Vehicle Incident Reporting Program

Acronym	Definition
NHTSA	National Highway Traffic Safety Administration
NREL	National Renewable Energy Laboratory
OOS	out of service
PHMSA	Pipeline and Hazardous Materials Safety Administration
PRD	pressure relief device
PRV	pressure relief valve
SAE	Society for Automotive Engineers
TCRP	Transit Cooperative Research Program
TMC	Technology & Maintenance Council of the American Trucking Associations
UNECE	United Nations Economic Commission for Europe
USDOT	U.S. Department of Transportation

EXECUTIVE SUMMARY

PURPOSE

This report provides recommendations for changes to Federal Motor Carrier Safety Regulations (FMCSRs), North American Standard (NAS) inspection procedures, and out-of-service (OOS) criteria to accommodate and facilitate the use of natural gas (compressed or liquefied) as an alternative to traditional fuels such as gasoline and diesel fuel in commercial vehicles.[1]

Current FMCSRs and inspection procedures are targeted primarily toward liquid-fueled vehicles. They address the unique characteristics of gaseous-fueled vehicles in a limited way and fail to address cryogenic fuels. The purpose of this project was to identify changes to the current FMCSRs and inspection procedures, if any, that are required to specifically and fully address the unique characteristics of natural gas used as a fuel and to improve the overall safety of commercial vehicle operations by ensuring that commercial vehicles powered by natural gas meet appropriate safety criteria at all times while operating on public roads.

PROCESS

This project began with a review of current FMCSRs that are applicable to natural gas-fueled commercial vehicles. This review focused on the FMCSRs that address aspects of natural gas vehicles that are potentially different from liquid-fueled vehicles, in particular those related to the vehicle fuel system.

Following this review, the performing research organization conducted a literature review of codes, standards, best practices, and lessons learned that are related to natural gas-fueled medium- and heavy-duty vehicles. The reviewed documents include codes, standards, and best practices developed by U.S. and international standards organizations; lessons learned and best practice recommendations for alternative-fueled vehicles published by Federal agencies and their contractors; lessons learned, and best practice recommendations for alternative-fueled vehicles published by industry organizations; and safety regulations related to natural gas vehicles adopted by California, Canada, and the European Union. The literature review also included a review of natural gas vehicle (NGV) fire and safety incidents included in the National Fire Incident Reporting System (NFIRS) maintained by the U.S. Fire Administration and the voluntary Natural Gas Vehicle Incident Reporting (NGVIR) program administered by the Clean Vehicle Education Foundation (CVEF).

Based on the review of current regulations and the literature review, the performing organization identified gaps in the current regulations, NAS inspection procedures, and vehicle OOS criteria, which leave the unique safety concerns of natural gas-fueled vehicles unaddressed. Based on this

[1] Liquid petroleum gas (LPG) can also be used as a fuel in heavy-duty vehicles, but consideration of changes required to FMCSRs to accommodate LPG as a fuel are beyond the scope of this project.

gap analysis, the performing organization developed a preliminary list of recommended changes to FMCSRs, NAS inspection procedures, and OOS criteria to address the identified gaps.

The performing organization then conducted a series of industry site visits/consultations to gather feedback on the preliminary recommendations from a sample of organizations that would be most affected by any proposed changes to Federal Motor Carrier Safety Administration (FMCSA) regulations. These organizations included companies involved in the design, manufacture, and use of medium- and heavy-duty natural gas engines and commercial vehicles, as well as other State and Federal Government agencies. The feedback from these organizations was positive, and there was general agreement that gaps do exist in the FMCSRs that need to be addressed.

The comments and feedback received during the industry consultations were considered by the performing organization when developing draft final recommendations and a draft final report for the project. This report was submitted to FMCSA for review and was then submitted for a formal peer review process.

Peer review comments were considered when developing the final recommendations included in this document.

STUDY FINDINGS

The gap analysis conducted for this project identified a number of areas where current FMCSRs and NAS inspection procedures do not fully address the unique safety issues of commercial vehicles powered by compressed natural gas (CNG) and liquefied natural gas (LNG). In order to strengthen these regulations, and to better ensure that commercial NGVs will be maintained and operated in a manner that will provide the highest level of public safety according to the best practices that now prevail, this report makes a number of recommendations for changes, including the following:

- FMCSA should specify minimum fuel system safety requirements for in-use NGVs.
- FMCSA should specify minimum labeling requirements for in-use NGVs.
- FMCSA should require NGV fuel system maintenance by only trained mechanics.
- FMCSA should require NGV accident reporting.
- FMCSA should require labeling for NGV conversions.
- FMCSA should specifically include the vehicle fuel system in the list of vehicle components/systems to be checked during daily driver inspections.
- FMCSA should work with the Commercial Vehicle Safety Alliance (CVSA) to modify the NAS inspection procedures, to clarify what items an inspector should look for when inspecting a commercial vehicle powered by natural gas.
- FMCSA should recommend to the CVSA additional OOS criteria for NGVs.

As with current FMCSRs, the proposed changes would apply to all in-use commercial vehicles subject to FMCSRs—those used in interstate commerce—whether manufactured as natural gas vehicles by original equipment manufacturers or converted to natural gas operation by the vehicle owner or a third party. Note that a commercial vehicle does not necessarily have to cross State lines to be in interstate commerce; if the passengers or cargo carried on board cross a State line, the commercial vehicle is involved in interstate commerce. Individual States also have the option of adopting the FMCSRs, in which case that State would apply them to all commercial vehicles in the State, including vehicles used exclusively in intrastate commerce.

All of the recommendations are consistent with industry standards and best practices for NGVs. In particular, they generally follow the recommendation of National Fire Protection Association's (NFPA), "Vehicular Gaseous Fuel Systems Code, 2010" (NFPA 52). The final recommendations also took into account feedback received during industry site visits and comments received from peer reviewers.

Note that the NFPA is in the process of updating NFPA 52, with a target publication date of 2013 for a revised standard. When published, FMCSA should review the updated edition of NFPA 52 to determine whether any changes relative to the 2010 edition reviewed for this project should be incorporated into updated agency policies, plans, or procedures.

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1. INTRODUCTION

This report provides recommendations for suggested changes to Federal Motor Carrier Safety Regulations (FMCSRs), North American Standard (NAS) inspection procedures, and out-of-service (OOS) criteria to accommodate and facilitate the use of natural gas (compressed or liquefied) as an alternative fuel to diesel fuel in commercial vehicles. In addition to providing specific recommendations for changes, this report summarizes the process used to arrive at these recommendations, which included a literature review and gap analysis, industry site visits/consultations, and a formal peer review process.

1.1 PURPOSE

This report is the final deliverable of a project designed to implement a comprehensive assessment of suggested changes to FMCSRs and NAS inspection procedures and vehicle OOS criteria to accommodate and facilitate the use of natural gas (compressed or liquefied) as an alternative fuel to traditional fuels such as diesel fuel and gasoline in commercial vehicles. This project supports the mission of the Federal Motor Carrier Safety Administration (FMCSA) to promote safe commercial vehicle operations through education, regulation, enforcement, and innovative research and technology, and to reduce truck and bus crashes and the resulting injuries and fatalities.

Current FMCSRs and NAS inspection procedures are targeted primarily toward liquid-fueled vehicles. They address the unique characteristics of gaseous-fueled vehicles in a limited way and fail to address cryogenic fuels (such as liquefied natural gas [LNG]). The purpose of this project was do not specifically identify changes to the current FMCSRs and NAS inspection procedures and OOS criteria, if any, that are required to specifically and fully address the unique characteristics of natural gas used as a fuel, and to improve the overall safety of commercial vehicle operations by ensuring that commercial vehicles powered by natural gas meet appropriate safety criteria at all times while operating on public roads.

In 2009, there were approximately 11 million medium- and heavy-duty trucks registered in the United States.[(1)] Of those vehicles, approximately 45,000 were compressed natural gas (CNG) vehicles and 3,000 were LNG vehicles.[(2)] In 2009, natural gas trucks comprised less than 0.4 percent of the in-use medium- and heavy-duty vehicle fleet, and less than 1 percent of new vehicle sales.

Of the medium- and heavy-duty natural gas vehicles (NGVs) in use in 2009, 43 percent were buses, 24 percent were medium- and heavy-duty trucks, and 33 percent were medium-duty pickups and vans. Approximately 12 percent of NGVs in use are owned by State or Federal Government agencies, 6 percent are owned by electric and natural gas utilities, 9 percent are owned by transit agencies, and 73 percent are owned by private companies and municipal governments. Approximately 34 percent of NGVs are registered in California, 11 percent are

registered in Arizona, 9 percent are registered in Texas, and 7 percent are registered in New York, with the remaining registered in 43 other States.[2]

Between 2003 and 2007, approximately 1,400 medium- and heavy-duty natural gas trucks were sold every year in the United States, but annual sales have since increased to approximately 3,400 units in 2010.(3) Some industry analysts predict continued strong growth in natural gas truck use worldwide. The U.S. market research firm Frost and Sullivan projects that annual North American sales of Class 6–8 natural gas trucks will reach 30,000 units by 2017, or almost 8 percent of new truck sales.(4, 5) Pike Research predicts that U.S. sales of NGVs will grow by an average of more than 25 percent annually between 2010 and 2016, resulting in almost 33,000 vehicles sold by 2016. While this figure includes light-duty vehicles, they predict that most of the growth will be in fleet sales.(6)

The recent and projected growth in natural gas truck use is based on Federal and local policies to encourage the use of alternative fuels, as well as favorable pricing for natural gas compared to gasoline and diesel fuel. In January 2012, the average price of CNG at U.S. public fuel stations was $2.38 per diesel-equivalent gallon, compared to $3.86 per gallon for diesel fuel.(7)

1.2 PROCESS

This project began with a review of current FMCSRs that are applicable to natural gas-fueled commercial vehicles. This review focused on the FMCSRs that address aspects of NGVs that are potentially different from liquid-fueled vehicles, in particular those related to the vehicle fuel system. The text of the relevant FMCSRs and a summary of current NAS inspection procedures and OOS criteria are included in Appendix A.

Following this review, the performing organization conducted a literature review of codes, standards, best practices, and lessons learned that are related to natural gas-fueled medium- and heavy-duty vehicles. The list of reference documents included in the literature review was developed by FMCSA and the performing organization based on prior industry experience, consultation with other Federal agencies, and a Web search. These documents include:

- Codes, standards, and best practices developed by U.S. and international standards organizations (National Fire Protection Association [NFPA], Canadian Standards Association [CSA], International Standards Organization [ISO], Society of Automotive Engineers [SAE]).
- Lessons learned and best practice recommendations for alternative-fueled vehicles published by U.S. Federal agencies and their contractors (Federal Transit Administration [FTA], Transit Cooperative Research Program [TCRP], and National Renewable Energy Laboratory [NREL]).

[2] The only States without any natural gas vehicles in 2009 were Hawaii, Iowa, and South Dakota.

- Lessons learned and best practice recommendations for alternative-fueled vehicles published by industry organizations (Clean Vehicle Education Foundation [CVEF], International Association for Natural Gas Vehicles [IANGV], Technology and Maintenance Council [TMC], and National Institute for Automotive Service Excellence [ASE]).
- Safety regulations related to natural gas vehicles adopted by California (California Highway Patrol), Canada (Transport Canada), and the European Union (United Nations Economic Commission for Europe [UNECE]).

Citations for all documents included in the literature review are included at Appendix B. Section 3 of this document briefly summarizes the most important points gleaned from the literature review. A more comprehensive summary of the literature review was provided to FMCSA in a separate document as the first deliverable under this project. Please note that many of the documents reviewed for this project provide design standards primarily targeted to original equipment manufacturers and/or vehicle converters. FMCSA does not regulate vehicle manufacturers—the Federal Motor Vehicle Safety Standards (FMVSSs), which provide minimum standards for new vehicles produced by vehicle manufacturers, are promulgated by the National Highway Traffic Safety Administration (NHTSA). FMCSA regulates the commercial vehicle operators (motor carriers), and the FMCSRs, which FMCSA promulgates, provide minimum standards for in-use operation and maintenance of commercial vehicles.

FMCSA's presumption is that new vehicles will be originally manufactured in accordance with applicable industry standards and FMVSSs.[3] However, during in-use operation and maintenance, original vehicle systems could be compromised or modified to fall out of compliance. FMCSRs and associated standard inspection procedures are intended to ensure that commercial vehicle owners and operators maintain their vehicles in appropriate condition throughout their life such that they will continue to be safe to operate. As such, the codes, standards, and best practices applicable to original equipment manufacturers are relevant to the development of appropriate FMCSRs and commercial vehicle inspection procedures.

The literature review also included a review of NGV fire and safety incidents included in the National Fire Incident Reporting System (NFIRS) maintained by the U.S. Fire Administration and the voluntary Natural Gas Vehicle Incident Reporting (NGVIR) program administered by CVEF. Review of this information provided insight into the most prevalent types of in-use failures, as well as the safety practices that might mitigate similar failures in the future.

Based on the review of current regulations and the literature review, the performing organization identified gaps in the current FMCSRs, NAS inspection procedures, and vehicle OOS criteria, which leave the unique safety concerns of natural gas-fueled vehicles unaddressed. Based on this gap analysis, the performing research organization developed a preliminary list of recommended changes to FMCSRs, NAS inspection procedures, and OOS criteria to address the gaps.

[3] An exception is in the area of diesel fuel tanks. Even though NHTSA did not promulgate an FMVSS for diesel fuel tanks, FMCSA has promulgated a FMCSR that applies to diesel fuel tanks. Manufacturers follow the FMCSR that applies to diesel fuel tanks.

The performing organization then conducted a series of industry site visits/consultations to gather feedback on the preliminary recommendations from a sample of organizations that would be most affected by any proposed changes to FMCSRs. These organizations included companies involved in the design and manufacture of medium- and heavy-duty natural gas engines and natural gas fuel systems, original equipment manufacturers of natural gas commercial vehicles, as well as fleet owner/operators, commercial vehicle enforcement agencies, port authorities, urban transit agencies, renters and lessors of natural gas trucks, and natural gas conversion contractors. A total of 14 meetings were conducted with 60 representatives of 21 different companies/organizations. A complete list of the individuals who participated in these meetings is included in Appendix C.

At each meeting, the performing organization presented background information on the project and a summary of the preliminary recommended changes to FMCSRs, NAS inspection procedures, and OOS criteria to address natural gas-powered commercial vehicles.

Meeting participants were encouraged to ask questions and provide feedback on the preliminary recommendations, both verbally and in writing as a followup to the meeting. Written comments were received from two organizations. A summary of the feedback received during the consultations is provided in Section 5.

The comments and feedback received during the industry consultations were considered by the performing organization when developing draft final recommendations and a draft final report for the project. This report was submitted to FMCSA for review and was then submitted to a formal peer review process.

For the peer review, the performing organization identified seven individuals to act as reviewers. They have the requisite knowledge and experience based on prior industry experience and recommendations from participants in the industry site visits. The names and qualifications of these individuals were submitted to FMCSA, which chose three to act as peer reviewers. These reviewers collectively have significant experience with safety inspections of commercial motor vehicles, including those powered by natural gas; with operations, maintenance, and safety of natural gas-powered urban transit buses; and with commercial development and safety evaluation of natural gas vehicles.

Each reviewer evaluated the literature review summary and draft final report, and provided written comments and suggested changes. Every recommendation by the peer reviewers was evaluated by the performing organization and FMCSA. The majority of peer review comments were accepted, and the selected comments are reflected in this document.

In parallel with the peer review, the draft report was also submitted to all companies included in the site visits, as well as other Department of Transportation agencies, for review. Comments received from these companies and agencies were also evaluated by the performing organization and FMCSA and were incorporated into this final report as appropriate. Section 6 includes a summary of any comments not accepted, including areas of disagreement among the different reviewers.

2. SUMMARY OF FMCSA REQUIREMENTS FOR NGVs

This section summarizes the current safety regulations promulgated by FMCSA that are applicable to natural gas-powered vehicles, as well as the NAS vehicle inspection procedures and OOS criteria that are published by the Commercial Vehicle Safety Alliance (CVSA).

2.1 FMCSRs

The FMCSRs are contained in the Code of Federal Regulations (CFR), Title 49 (49 CFR). These regulations cover all aspects of commercial vehicle operations and maintenance; this section will only highlight those regulations that are relevant to attributes of natural gas-powered vehicles, which are different from attributes of vehicles powered by diesel fuel. In particular, this includes requirements related to fuel systems, which are contained in 49 CFR Part 393, Subpart E, as well as Inspection, Repair, and Maintenance requirements contained in 49 CFR Part 396, and minimum inspection standards and out-of-service criteria contained in 49 CFR Chapter III, Subchapter B, Appendix G. The full text of these regulations is included in Appendix A.

2.1.1 Fuel System Requirements

49 CFR 393.65 contains requirements applicable to all fuel systems, which include general statements about where and how fuel systems shall be installed on vehicles. Examples include:

- No part of the fuel system shall extend beyond the widest part of the vehicle or be installed forward of the front axle of a power unit.
- Fill pipe openings must be outside of the passenger or cargo compartment.
- Fuel tanks must be installed in a "workmanlike manner."
- Fuel spilled vertically from a fuel tank must not contact exhaust or electrical systems.
- No part of the fuel system can be installed within or above the passenger compartment.[4]

49 CFR 393.67 contains additional requirements applicable to liquid fuel tanks, including side-mounted tanks, for fuels that are liquid at normal atmospheric pressures and temperatures. These requirements are quite detailed and include requirements related to

- Construction and mounting details.
- Required drains and fittings.
- Fill pipe requirements, including minimum fill rate.
- Details of a required venting system.

[4] FMCSA is currently addressing a petition to waive this ban on roof-mounted fuel tanks for CNG vehicles and allow CNG storage cylinders to be mounted over the passenger compartment.

- Required markings.
- Details of required leakage and drop (structural integrity) tests.

49 CFR 393.68 contains additional requirements applicable to "compressed natural gas fuel containers." This section specifies that CNG fuel containers must meet the requirements of FMVSS 304, which specifies minimum design standards for structural integrity as demonstrated by a pressure cycling test and hydrostatic burst test, as well as minimum standards for structural integrity and pressure relief in a fire, as demonstrated by a Bonfire test. FMVSS 304 also specifies minimum labeling requirements for CNG fuel containers. The label information required by FMVSS 304 includes:

- Manufacturer name, address, and phone number.
- "CNG Only."
- Container type (Type, 1, 2, 3, or 4).
- U.S. Department of Transportation (USDOT) symbol denoting compliance with FMVSS 304.
- A statement that the container must be visually inspected every 36 months or 36,000 miles (whichever comes first) or after an accident or fire.
- "Do-not-use-after date" denoting end of certified life.

49 CFR 393 does not include any requirements specific to LNG fuel containers. While these containers might be considered "liquid fuel tanks," they are not subject to the requirements of 49 CFR 393.67, because this regulation applies to "fuels that are liquid at normal atmospheric pressures and temperatures." In order to liquefy at atmospheric pressure, natural gas must be cooled to a temperature of -162° C (-260° F) or lower. At normal atmospheric pressure and temperature, LNG, which is a cryogenic liquid, will gasify and no longer be liquid.

2.1.2 Inspection, Repair, and Maintenance Requirements

49 CFR 396 requires that every motor carrier must "systematically inspect, repair, and maintain" all motor vehicles subject to its control and that all parts and accessories shall be in "safe and proper operating condition at all times." This section also specifies that "authorized personnel" may declare and mark OOS any motor vehicles which "by reason of its mechanical condition or loading would likely cause an accident or breakdown." 49 CFR 396 specifies that, at a minimum, every vehicle will be inspected once every 12 months.

2.1.3 Inspection Standards and OOS Criteria

49 CFR Chapter III, Subchapter B, Appendix G specifies that the following defects or deficiencies in a vehicle fuel system would cause it to "not pass an inspection":

- A fuel system with a visible leak at any point.
- A fuel tank filler cap missing.

- A fuel tank not securely attached to a motor vehicle by reason of loose, broken, or missing mounting bolts or brackets.

Appendix G distinguishes between the OOS criteria listed there for annual inspections and the OOS criteria maintained by the CVSA—discussed in Section 2.2—which "are intended to be used in random roadside inspections." While very similar, Appendix G indicates that an annual inspection requires that "all items required to be inspected are in proper adjustment, are not defective, and function properly prior to the vehicle being placed in service." By contrast, an inspector would only put a vehicle OOS during a roadside inspection if the vehicle condition were "imminently hazardous" as defined by CVSA OOS criteria. It also indicates that at the roadside, inspecting officials are given flexibility to decide whether to put the vehicle OOS at the inspection site, or whether it would be less hazardous to allow the vehicle to proceed to a repair facility not more than 25 miles away.

2.2 NAS INSPECTION PROCEDURES AND OOS CRITERIA

The NAS inspection procedures and OOS criteria are used by local and State officials to conduct roadside safety inspections of commercial vehicles. These procedures have been developed by the CVSA. The following text is from the CVSA Web site, and it describes the organization:[8]

> *CVSA is an international not-for-profit organization comprised of local, State, provincial, territorial and Federal motor carrier safety officials and industry representatives from the United States, Canada, and Mexico. Our mission is to promote commercial motor vehicle safety and security by providing leadership to enforcement, industry and policy makers. CVSA member jurisdictions are represented by various Departments of Transportation, Public Utility and Service Commissions, State Police, Highway Patrols and Ministries of Transport. In addition, CVSA has several hundred associate members who are committed to helping the Alliance achieve its goals: uniformity, compatibility and reciprocity of commercial vehicle inspections, and enforcement activities throughout North America by individuals dedicated to highway safety and security.*

There are six levels of inspection, which focus on different aspects of commercial vehicle operations:[9]

> *LEVEL I—North American Standard Inspection*
>
> > An inspection that includes examination of driver's license, medical examiner's certificate and waiver, if applicable, alcohol and drugs, driver's record of duty status as required, hours of service, seat belt, vehicle inspection report, brake system, coupling devices, exhaust system, frame, **fuel system** [*emphasis added*], turn signals, brake lamps, tail lamps, head lamps, lamps on projecting loads, safe loading, steering mechanism, suspension, tires, van and open-top trailer bodies, wheels and rims, windshield wipers, emergency exits on buses, and hazardous materials (HM) requirements, as applicable.

NOTE: the North American Standard Level I Inspection Procedure requires the inspector to go under the vehicle. The North American Standard Level I Passenger Vehicle Inspection Procedure includes the use of ramps to allow the inspector to go under the vehicle.[(10)]

LEVEL II—Walk-Around Driver/Vehicle Inspection

An examination that includes each of the items specified under the North American Standard Inspection. As a minimum, Level II inspections must include examination of driver's license, medical certificate and waiver (if applicable), alcohol and drugs, driver's record of duty status as required, hours of service, seat belt, vehicle inspection report, brake system, coupling devices, exhaust system, frame, **fuel system** [*emphasis added*], turn signals, brake lamps, tail lamps, head lamps, lamps on projecting loads, safe loading, steering mechanism, suspension, tires, van and open-top trailer bodies, wheels and rims, windshield wipers, emergency exits on buses, and HM requirements, as applicable. It is contemplated that the walkaround driver/vehicle inspection will include only those items that can be inspected without physically getting under the vehicle.

LEVEL III—Driver-Only Inspection

A roadside examination of the driver's license, medical certification and waiver (if applicable), driver's record of duty status as required, hours of service, seat belt, vehicle inspection report, and HM requirements, as applicable.

LEVEL IV—Special Inspections

Inspections under this heading typically include a one-time examination of a particular item. These examinations are normally made in support of a study or to verify or refute a suspected trend.

LEVEL V—Vehicle-Only Inspection

An inspection that includes each of the vehicle inspection items specified under the North American Standard Inspection (Level I) but without a driver present, and is conducted at any location.

LEVEL VI—Enhanced NAS Inspection for Radioactive Shipments

An inspection for select radiological shipments, which include inspection procedures, enhancements to the Level I inspection, radiological requirements, and the enhanced OOS criteria.

This project is only concerned with the vehicle inspection portions of Level I, II, and V inspections. Procedures related to driver records, special inspections, and radiological shipments are not addressed.

The defined procedure for vehicle inspections includes 37 steps, with the inspector proceeding around the vehicle in a prescribed manner and inspecting specific items at each step. The inspector is evaluating both condition and operability of specific vehicle systems, including headlamps, turn signals, windshield wipers, tires, fuel tanks, frame and body, brakes, and cargo securement. For non-passenger vehicles, the vehicle fuel system is checked in steps 16 (left side) and 26 (right side). The North American Standard Level I Passenger Vehicle Inspection Procedure includes inspection of the fuel tank in step 17 (undercarriage).

There are 14 critical vehicle inspection items; a vehicle passes inspection if no defects are found in any of these items. The inspector can put a vehicle "OOS" if the condition of one or more critical items "would be likely to cause an accident or breakdown." OOS vehicles must be repaired to correct the defective condition before being placed back into service.

The fuel system is 1 of the 14 safety-critical vehicle inspection items. Under the currently defined OOS criteria, each fuel system defect listed below would require a vehicle operated on a liquid fuel to be put OOS:

- Fuel system with a dripping leak.
- Fuel tank not securely attached to the vehicle.
- Missing fuel cap (passenger carrying vehicle).

Under the currently defined OOS criteria, only the defect listed below would require a vehicle operated on CNG to be put OOS:

- Any leak detected by smell or audibly and verified by a bubble test[5] or by a flammable gas detection meter.

Under the currently defined OOS criteria, each defect listed below would require a vehicle operated on LNG to be put OOS:

- A cloud of vapor coming from any component of the fuel system.
- Any leak detected by a flammable gas detection meter.
- Dripping liquid that boils or vaporizes in the air.

The OOS criteria for CNG and LNG vehicles highlight the unique physical attributes of natural gas fuel compared to more familiar liquid fuels such as diesel fuel and gasoline. Unlike liquid fuels, natural gas is a gas at ambient temperature and pressure, and therefore, leaks do not "drip." Natural gas is also colorless, so leaks of compressed gas cannot be detected visually. While

[5] In a bubble test, a non-corrosive commercial leak test solution is applied to fuel system joints and fittings. The presence of persistent bubbling or bubble growth indicates a leak. Only commercial leak-test fluids that do not contain ammonia or harsh corrosives should be used for leak testing of natural gas fuel systems. Soaps and detergents should not be used.

natural gas is naturally odorless, natural gas utilities typically add sulfur-based odorants to pipeline gas specifically to aid in leak detection. Most CNG vehicles carry odorized gas on board, so that leaks can be preliminarily detected by smell. Depending on the size of the leak, escaping gas may also create a detectable noise.

However, best practice indicates that suspected leaks of CNG detected by smell or audibly must be verified with a bubble test or a properly calibrated combustible gas detector to ensure that, for example, the smell is not lingering after vehicle fueling or that the sound heard is not from internal gas flow and/or a leaking air brake system.

The odorants used in pipeline natural gas solidify at LNG temperatures, so LNG is not odorized, and leaks cannot be detected by smell.

Large LNG leaks form boiling liquid pools on the ground, which are easy to identify. Smaller leaks of LNG vapors are colorless, but typically they condense water vapor in the surrounding air, creating a visible vapor cloud in the vicinity of the leak, particularly in humid conditions. However, small leaks are occasionally confused with water vapors condensing in the air around components of an LNG fuel system that are below 32° F under normal operating conditions. Care must therefore be taken in declaring an LNG leak solely on the basis of a small vapor cloud.

3. SUMMARY OF LITERATURE REVIEW

This section briefly summarizes the requirements of the reviewed codes, standards, best practices, lessons learned documents, and regulations related to commercial compressed natural gas vehicles (CNGV) and liquefied natural gas vehicles (LNGV).

The reviewed codes and standards were produced by U.S. and international standards organizations, including the National Fire Protection Association [NFPA 52, NFPA 57], the Canadian Standards Association [CSA B109-01], the International Standards Organization [ISO 15500-1, ISO 15500-2, 15501-1, ISO 19078], the Compressed Gas Association (CGA C-6.4), and the Society of Automotive Engineers [SAE J2406, SAE J2343].

Also included were lessons learned and best practice recommendations for alternative-fueled vehicles published by U.S. Federal agencies and their contractors, including the FTA, TCRP, and the NREL, and by the following industry organizations: the CVEF, IANGV, TMC, and ASE.

The literature review also included a review of safety regulations related to natural gas vehicles that have been adopted by California (California Highway Patrol), Canada (Transport Canada), and the European Union (UNECE). Full citations for all documents included in the literature review are included in Appendix B.

U.S. and international standards provide very detailed requirements for the design and testing of natural gas fuel systems. The summary below is a high-level overview of the major issues identified in the literature review.

3.1 CODES, STANDARDS, AND BEST PRACTICES, CNGVS

NFPA 52, Vehicular Gaseous Fuel Systems Code (2010 Edition), Chapter 4 (General CNG Requirements and Qualifications) and Chapter 6 (CNG Engine Fuel Systems) provide a comprehensive set of design standards for CNG vehicles. The SAE-recommended practice, *SAE J2406, Recommended Practices for CNG Powered Medium and Heavy-Duty Trucks* (March 2002) complements NFPA 52 by providing additional detail in some specific areas. These two documents provide an appropriate starting point to determine minimum safety standards for in-use operation of commercial vehicles fueled by CNG.

All the other documents reviewed for this project, including codes and standards produced by other international organizations (CSA, ISO), industry and government recommended practices, and regulations already adopted by California, Canada, and the European Union, are broadly consistent with NFPA 52 and SAE J2406. While there are minor differences in specific requirements in some areas, overall these differences are not significant.

The most significant difference between the requirements of NFPA 52 and those of Canadian (CSA) and European (ISO) standards relate to mounting requirements for CNG and LNG fuel containers. NFPA 52 specifies that the mounting system must be able to withstand a static force in each of the 6 principal directions equal to 8 times the weight of a full fuel container. CSA B109-01 specifies that the force required to separate the fuel container from the vehicle must be

at least 20 times the weight of a full fuel container in the longitudinal direction and 8 times in the transverse direction, and the force must be applied for a duration of not less than 5 seconds. ISO 15501-1 specifies that for vehicles less than 3.5 tonne (7,700 lb) gross vehicle weight the fuel container must remain attached to the vehicle under the following acceleration conditions: 20g longitudinal acceleration or deceleration, 8g lateral acceleration, and 4.5g upward vertical acceleration. For vehicles greater than 3.5 tonne (7,700 lb) gross vehicle weight, the fuel container must remain attached to the vehicle under the following acceleration conditions: 10g longitudinal acceleration, 5g lateral acceleration, and 4.5 g upward vertical acceleration.

The requirements of NFPA 52 and SAE J2406 are numerous and detailed, and address issues such as allowable location of CNG fuel containers on vehicles, minimum requirements for securement and protection of CNG fuel containers, the need to include pressure relief devices (PRD) and shutoff valves on all CNG fuel containers, and required CNG fuel container and vehicle labeling. Many of these requirements are similar, if not identical, to requirements that would be applicable to liquid fuel systems—examples include a prohibition on locating fuel tanks ahead of the front axle or behind the rear bumper of the vehicle and a specification of minimum clearance distance between the bottoms of installed fuel containers and the roadway surface.

Other requirements are specific to CNG fuel systems and are based on the unique physical and chemical attributes of CNG. Examples would include:

- Requirements for minimum structural integrity and labeling of high-pressure CNG fuel containers.
- A requirement to include a PRD on each fuel container to relieve potential overpressure in the cylinder in the event of a vehicle fire.
- Requirements related to sizing, securement, routing, and protection of PRD vent lines to protect vehicle occupants from—and to minimize—the possibility of venting gas being ignited.
- A requirement to include a manual or remotely activated shutoff valve on each CNG fuel container to isolate it from the rest of the fuel system.
- A requirement to include an additional shutoff valve to isolate all CNG fuel containers from the rest of the fuel system and engine.
- A requirement to include standardized vehicle labels to alert first-responders that natural gas is present, in the event of an accident.
- A requirement to include an “excess flow valve” to stop gas flow in the event of a leak downstream from the CNG fuel containers. (*NOTE: This is a recommendation in SAE J2406, but is not required by NFPA 52.*)
- A requirement to include a pressure relief valve downstream from the first-stage pressure regulator to protect engine components from overpressure in the event of a regulator failure. (*NOTE: This is a recommendation in SAE J2406, but is not required by NFPA 52.*)

With respect to inspections of CNG vehicle fuel systems, both the Compressed Gas Association (CGA) and the International Standards Organization (ISO) have developed standards for periodic inspection of CNG fuel storage cylinders and other fuel system components on vehicles (CGA C-6.4 and ISO 19078); these two standards are virtually identical. While perhaps more detailed than practical for annual and roadside inspections by commercial vehicle inspectors, either standard would provide an appropriate starting point for development of North American Standard inspection procedures and OOS criteria specifically for commercial vehicles powered by natural gas.

Both CGA C-6.4 and ISO 19078 recommend a thorough inspection of the fuel systems on CNG vehicles (by a qualified inspector trained to conduct them) at least every 36 months throughout the vehicle's life, as well as every time a vehicle is involved in a fire, collision, or incident. Both standards require, at a minimum, inspection of the following fuel system components: CNG fuel cylinders, fuel cylinder mounting, PRDs, PRD vent lines, and valves.

Both of these documents also define three levels of condition for fuel cylinders and fuel system components that can be evaluated by visual inspection. Level 1 damage is minor damage that will not impair a cylinder's structural integrity or a component's functionality; cylinders and components with Level 1 damage can remain in service. Level 2 damage is damage that may affect a cylinder's structural integrity or a component's functionality, but which may be repairable. Cylinders and components with level 2 damage must be removed from service until the damage can be repaired. Level 3 damage is damage that is so severe it cannot be repaired; cylinders and components with Level 3 damage must be removed from service and destroyed so that they cannot be re-used.

The types of damage that might require a CNG fuel cylinder to be removed from service include: missing or illegible labels; cuts, scratches or gauges; charring/sooting; gas leakage; weathering; impact damage or dents; evidence of over-pressurization; corrosion or stress corrosion cracking; abrasion, including from improper or loose cylinder mounts; and bulging/bowing. Removed cylinders must be repaired to the cylinder manufacturer's specification or be destroyed. The kinds of damage that might require a fuel system component to be replaced include, for example: dents, deformation, or seal damage on PRDs; damaged, plugged, or deformed PRD vent lines; missing mounting hardware or abrasion from loose hardware; and deformed, failed, or leaking valves.

3.2 CODES, STANDARDS, AND BEST PRACTICES, LNGVS

In 2002, NFPA issued *NFPA 57, Liquefied Natural Gas (LNG) Vehicular Fuel Systems Code*. However, the most recent edition of *NFPA 52, Vehicular Gaseous Fuel Systems Code*, issued in 2010, incorporates updated content of NFPA 57 in Chapter 11. The summary below is based on the most recent requirements of NFPA 52. SAE has also produced a surface vehicle recommended practice, *SAE J2343, Recommended Practice for LNG Medium and Heavy-Duty*

Powered Vehicles (July 2008). With respect to LNG vehicles, the most recent edition of NFPA 52 specifically references SAE J2343 and requires that all commercial vehicles comply with it.[6]

The most recent version of NFPA 52, along with SAE J2343, provides an appropriate starting point to determine minimum safety standards for in-use operation of commercial vehicles fueled by LNG, and in fact are virtually the only documents available to do so. Neither CSA nor ISO has produced standards specifically applicable to LNG vehicles, and neither the Canadian government nor the European Union has adopted regulations specific to vehicles powered by LNG. All of the industry best practice and lessons learned documents reviewed for this project deal exclusively with CNG vehicles and do not provide information applicable to LNG vehicles.

California has adopted regulations specific to LNG vehicles (Code of California Regulations, Title 13, Sections 935 and 936); these regulations are broadly consistent with the requirements of NFPA 52 and SAE J2343, though they are more prescriptive in some areas. These regulations specifically reference SAE J2343 and earlier editions of NFPA 52 (but not the 2010 edition).

The requirements of NFPA 52 and SAE J2343, with respect to LNG vehicles, are numerous and detailed, and address issues such as allowable location of LNG fuel containers on vehicles, minimum requirements for securement and protection of LNG fuel containers, the need to include pressure relief valves (PRV) and shutoff valves on LNG fuel containers and fuel system components, minimum design criteria for LNG fuel containers with respect to structural integrity and heat leak, and required LNG fuel container and vehicle labeling.

Many of these requirements are similar, if not identical, to requirements that would be applicable to diesel and gasoline fuel systems—examples include a prohibition on locating fuel tanks ahead of the front axle or behind the rear bumper of the vehicle and a specification of minimum clearance distance between the bottoms of installed fuel containers and the roadway surface.

Other requirements are specific to LNG fuel systems and are based on the unique physical and chemical attributes of LNG as a cryogenic fuel (temperature less than -162° C [-260° F]). Examples include:

- Requirements for minimum structural integrity (drop tests), maximum heat leak (flame test), minimum vapor space volume, and labeling of low-temperature LNG fuel containers.
- A requirement that LNG fuel containers located above a passenger compartment be protected from impact by a guard rail or shield, and include a spill pan between the container and passenger compartment that can withstand cryogenic temperatures and shield passengers in the event of a leak.

[6] As reported by one peer reviewer, future editions of NFPA 52 will reportedly move all references to SAE J2343 to an annex because it is a recommended practice and not an enforceable standard. Industry may also seek to adopt the substance of SAE J2343 as an enforceable standard via a standard-setting body such as the American National Standards Institute (ANSI).

- A requirement to include PRVs on each LNG fuel container, on LNG pump cases, and on any section of LNG piping that can be isolated between two shutoff valves. (PRVs shall communicate directly with the vapor space of the fuel tank and shall not come into contact with liquid LNG under normal operating conditions. This is required to relieve potential overpressure from LNG that evaporates as heat is absorbed.[7])
- A requirement that each LNG fuel container be equipped with a manual vent valve to allow controlled release of pressure from the container's vapor space.
- Requirements related to sizing, securement, routing, and protection of PRV vent lines to protect vehicle occupants from—and to minimize—the possibility of venting gas being ignited.
- A requirement to include a manual or remotely activated shutoff valve on each LNG fuel container and in the LNG fuel supply line to the engine.
- A requirement to include a "backflow preventer" to stop flow of LNG from the fuel container to the filling connection.
- A requirement to include on the vehicle a "fully-engineered onboard methane detection system" to help detect fuel leaks because LNG is not odorized. (Methane sensor locations will include, at a minimum, the "engine and driver's compartment and any enclosed fuel container or installation within a compartment." The detection system shall provide "visual and audible warnings when gas is detected," and the visual warning shall be "plainly visible to the driver before entering the driver's compartment and when seated in the normal driving position" [SE J2343].)
- A requirement to include standardized vehicle labels to alert first-responders that LNG is present, in the event of an accident.

With respect to inspections of, and OOS criteria for, LNG vehicle fuel systems, no standard procedure is currently available that would be the equivalent of CGA C-6.4 and ISO 19078 for CNG fuel systems. There is also no industry agreed-upon recommended minimum interval for inspection of LNG fuel containers to evaluate their condition and structural integrity (i.e., equivalent to the requirement to inspect CNG fuel cylinders at least every 36 months).

Regulations promulgated by the Pipeline and Hazardous Materials Safety Administration (49 CFR 180, Continuing Qualifications and Maintenance of Packaging) require that all USDOT cylinders must be periodically inspected and "requalified" in accordance with the requirements listed in the "Requalification Table" shown in 49 CFR 180.209. For each type of cylinder this table lists a test pressure and a requalification period. Under the current version of NFPA 52, vehicular LNG fuel containers must be manufactured in accordance with "USDOT Specification 4L" and are therefore subject to the inspection and requalification requirements of 49 CFR 180.

[7] PRVs that protect an LNG container must be designed and sized to accommodate the additional relieving capacity from every anticipated source of heat and overpressure from the vehicle, including piping and pump PRVs.

However, specifically for USDOT 4L cylinders, the requalification table in 49 CFR 180.209 indicates that "No test is required," and there is no requalification period listed.

3.3 ANALYSIS OF PRIOR NGV INCIDENTS

To evaluate causes of prior accidents and incidents with commercial CNG and LNG vehicles, the project team contacted the U.S. Fire Administration to obtain records from NFIRS and contacted CVEF to obtain records that they have collected in the voluntary NGVIR program.

NFIRS is a voluntary system that collects information in a standard format on fire incidents in the United States; the database includes only those fire incidents reported to the system by the fire departments that report to NFIRS. Not all States participate in NFIRS, and those fire departments that report to NFIRS within a State do not necessarily report all their fire incidents. Additionally, some fire departments that report fire incidents do not report associated casualties. States and/or fire departments that report in one particular year may not report to NFIRS the following year. Therefore, NFIRS is not representative of all fire incidents in the United States and is not a census of fire incidents or casualties.

The project team received 11 compact disks containing NFIRS data, one for each year between 1999 and 2009 (2009 is the most recent year available). These disks contained only 163 individual records in which 1 or more vehicles were listed as involved in the incident, but due to the inclusion of mutual aid incidents, some records may be duplicative of the same incident. The disks contained hundreds of thousands of records of structure fires in which no vehicles were involved.

Of the 163 incidents involving vehicles, only 7 incidents had natural gas listed as a material that had ignited; of these 7 incidents, 3 involved commercial vehicles and 4 involved passenger vehicles. Only two of these seven incidents likely involved vehicles powered by natural gas (namely, one commercial vehicle and one passenger car). In the first instance (involving a commercial vehicle), the actual cause of the natural gas vehicle fire is not listed. In the second instance (involving a passenger car), it appears that a collision with one or more other vehicles caused natural gas to leak from the vehicle and ignite. Of the remaining five incidents, two appear to be cases in which construction equipment disturbed an underground gas line, causing gas to leak and ignite. The other three appear to be cases in which a vehicle crashed into a building, causing natural gas lines within the building to leak and ignite.

The database of NGV incidents collected by CVEF includes 138 separate incidents involving accidents, equipment failures, and fires in which NGVs were involved.[8] Incidents are reported from the United States and Canada, as well as various countries in Europe, South America, and Asia; 56 percent of reported incidents are from the U.S., and 44 percent are from other countries. The earliest reported incident is from 1976 (Italy), and the most recent is from December 2010 (U.S.). The database includes incidents involving both light-duty and heavy-duty vehicles: 51

[8] The database also includes 21 incidents involving natural gas fueling stations or reports of performance issues with natural gas engines. The database does not include any incidents involving LNG vehicles.

percent of incidents involved passenger cars and trucks, 38 percent involved transit, school or shuttle buses, and 11 percent involved other commercial vehicles (i.e., 14 commercial motor vehicles [as compared to a total of about 7 million commercial vehicles in the U.S.]). Most of the reported incidents involved only one NGV, but several summarized recalls or systemic problems with specific NGV fuel system components (for example, pressure relief devices—PRDs) that affected a large number of vehicles. Types, causes, and numbers of NGV incidents in the NGVIR database are listed below:

- Cylinder rupture:
  - Manufacturing defect, 8.
  - PRD altered or missing, 3.
  - PRD did not release in a fire, 14.
  - Impact damage to cylinder, 4.
  - Cylinder corrosion or stress cracks, 11.
  - Other cylinder damage, 3.
  - Over pressure at fuel station, 3.
  - Other, 4.
- PRD release (no fire):
  - Manufacturing defect, 8.
  - Poor design, 2.
  - Ice in PRD vent line, 2.
  - Over pressure during fueling, 1.
  - Unknown, 1.
- Vehicle fire (no cylinder rupture):
  - No release of natural gas, 8.
  - PRD released, venting natural gas did not ignite, 7.
  - PRD released, venting natural gas ignited, 1.
  - Natural gas system failure caused fire, 1.
- Accident with other vehicle:
  - No release of natural gas, 8.
  - PRD released, venting natural gas did not ignite, 1.
  - PRD released, venting natural gas ignited, 1.
  - Cylinder rupture, natural gas ignited, 1.
  - Fuel line leak, natural gas did not ignite, 1.
- Single-vehicle accident:
  - Hit overpass, damaged roof-mounted CNG system, 5.

  - Drive-away from fuel station with fuel line connected, 1.
- Cylinder or fuel line leak:
  - Manufacturing defect, 4.
  - Weld failure, 1.
  - Stress corrosion crack, 1.
  - Fill receptacle or valves, 4.
  - Poor installation, 4.
- Other:
  - Poor maintenance practice, 3.
  - Operational problems, 2.
  - Improper conversion, 1.
  - Cylinder securement failed, 1.

This does not include 15 reported incidents of in-service CNG cylinder ruptures for which no cause could be determined. Twelve of these incidents were in Asia (China, India, Pakistan, Bangladesh, Myanmar, and Thailand), one was in Australia, and two were in South America (Brazil and Argentina). As suspected, though unconfirmed, a contributing factor to many of these incidents was the use of improperly designed tanks that do not meet U.S. standards for structural integrity.

In 41 percent of the incidents for which the cause is known, a failure or rupture of a CNG cylinder installed on a vehicle was involved. The vast majority of these failures occurred during vehicle fueling or during a vehicle fire.

Of the cylinder failures for which the root cause is known, the majority were caused by cylinder damage, which weakened the cylinder, or by a failure of the installed PRD to release during a vehicle fire. The most common types of cylinder damage were physical damage due to impact with road debris, and corrosion and/or stress cracking in the metal cylinder or composite overwrap. In a number of instances, stress cracks were caused by leaking battery acid dripping on the tanks.

In about 35 percent of the reported NGV fire incidents, the installed thermally activated PRD on one or more cylinders failed to release in the fire despite high pressure in the cylinder. This happened because the vehicle fire impinging on the cylinder was localized in an area away from the PRD—the fire raised the temperature and pressure in the cylinder without increasing the temperature in the vicinity of the PRD enough to melt the eutectic plug and release the gas. In most cases only one of several cylinders ruptured—PRDs on the other cylinders worked as intended, releasing gas.

In 20 percent of reported fire incidents, the fire was extinguished before the CNG fuel system was impacted, and no gas was released. In 42 percent of reported fire incidents, PRDs on all of the impacted cylinders worked as intended, releasing gas to relieve overpressure in the cylinders.

In more than half of the incidents in which gas was released through a PRD, the leaking gas ignited and burned. In many of these cases, poor installation contributed to ignition of the released gas—in a potentially unsafe manner—for example, PRD vents routed through the engine compartment where they were melted by the fire, allowing natural gas to ignite and feed the fire in the engine compartment rather than being vented in a safe direction.

Note that the majority of the vehicle fires included in the list of incidents were not caused by a leaking CNG fuel system and were in light-duty vehicles; most fires were started by an electrical short, stuck brakes (which ignited a tire), or leaking gasoline, diesel fuel, or hydraulic fluid impinging on a hot engine or exhaust components.

In two-thirds of the reported incidents involving an NGV and one or more other vehicles, no gas was released from the NGV. In the remaining accidents, natural gas was released, either through a PRD, from a leaking fuel line, or from a ruptured natural gas fuel cylinder.

There were five reported incidents of a CNG bus striking an overhead structure and damaging the roof-mounted natural gas fuel system. In most of these cases, natural gas was vented from one or more cylinders due to a cylinder puncture, damage to a PRD, or damage to a high-pressure fuel line.

In terms of potential changes to FMCSRs, and vehicle inspection procedures, these prior NGV incidents raise the following issues:

- The importance of ensuring that CNG cylinders are certified to comply with U.S. standards (FMVSS 304) for structural integrity.
- The importance of protecting CNG cylinders from impact by road debris.
- The importance of regular CNG cylinder inspection to identify physical damage and/or corrosion and stress cracks that could weaken them.
- The importance of proper installation for PRDs and their vent lines, to ensure that PRDs will activate reliably in a vehicle fire, and to minimize the possibility of venting gas igniting.
- The importance of proper installation for, and regular inspections of, fuel system components (lines, valves) to preclude in-use wear and damage.
- The need to remind vehicle operators of vehicle height if a roof-mounted CNG fuel system increases vehicle height compared to similar gasoline- or diesel-fueled vehicles.

3.4 OPERATIONAL SAFETY FOCUS FOR NGVs

Based on the literature review summarized above, including the analysis of prior NGV incidents, the most important areas of focus for safety of natural gas commercial vehicle operations and maintenance include the following:

- Ensuring compliance with certification standards for structural integrity of natural gas fuel storage containers (i.e., FMVSS 304 for CNG and SAE J2343 for LNG), including

the requirement to remove CNG fuel containers from service at the end of their certified life.[9, 10]

- Ensuring that vehicles are at all times equipped with specific safety features related to natural gas, including PRDs (for CNG) or PRVs (for LNG), fuel container shutoff valves, and methane detection systems if un-odorized natural gas is used.
- Ensuring that PRD/PRV vents are properly mounted, routed, and protected to minimize impact of venting gas on vehicle occupants and bystanders and to minimize the possibility of ignition of venting gas.
- Ensuring that natural gas fuel storage containers and other fuel system components are at all times properly protected from wear and damage due to vehicle vibration and shock loads, impact with road debris, contact with corrosive liquids, and proximity to exhaust heat.
- Ensuring that NGVs are at all times labeled to identify fuel type (CNG, LNG, and whether "un-odorized"), relevant fuel system technical characteristics (i.e., service pressure), and location of PRD/PRV vents and shutoff valves.
- Ensuring regular and thorough inspection of natural gas fuel storage containers and other fuel system components to identify physical wear and damage which could compromise their structural integrity or functionality, and remove vehicles with unsafe components from service.
- Ensuring that drivers are aware of vehicle height if natural gas fuel systems are roof-mounted to minimize possibility of damage from impact by overhead structures.

[9] In the past, CNG fuel containers were typically certified by the manufacturer for a 15-year service life. Recently, manufacturers have begun to certify CNG fuel containers for a 20-year service life.

[10] Containers used to carry natural gas on vehicles as freight are subject to requirements promulgated by the Pipeline and Hazardous Materials Safety Administration (PHMSA) (49 CFR 172, 173, and 180). However, vehicular fuel systems are exempt from these PHMSA regulations as "materials of trade" (see 49 CFR 171.8 and 173.6).

4. GAP ANALYSIS

This section summarizes an analysis of areas where current FMCSRs, NAS inspection procedures, and OOS criteria do not fully address the unique safety issues of CNG- and LNG-powered commercial vehicles. The intent is to highlight areas where current regulations and procedures could be strengthened, in accordance with industry standards and best practices, to better ensure that commercial NGVs will be maintained and operated in a manner that will provide the highest level of public safety.

It is important to note that the analysis starts with a presumption that commercial vehicles will be manufactured in accordance with appropriate Federal regulations and industry standards, with the understanding that they could potentially fall out of compliance through in-use operations and maintenance practices. As such, the analysis focuses on items that could be most affected by lack of, or inappropriate, maintenance actions—for example, a CNG vehicle could be delivered with PRDs on every fuel cylinder, but over time, a vehicle operator could fail to replace one or more defective PRDs or could replace them with an inappropriate PRD.[11] Likewise, a vehicle operator could fail to replace a crimped or broken PRD vent line, or could fail to keep the vent lines clear of debris. On the other hand, it is less likely, but not inconceivable, that a vehicle operator would move a CNG fuel cylinder from the originally installed location to a different, inappropriate location on the vehicle.

4.1 FMCSRs

The current FMCSRs require that CNG fuel containers installed on commercial vehicles must comply with the minimum design standards for structural integrity and container labeling as specified in FMVSS 304, but they do not require LNG fuel containers to comply with equivalent standards for structural integrity and labeling.

The current FMCSRs do not require fuel systems on CNG or LNG commercial vehicles to be equipped with the natural gas-specific safety features/systems recommended by industry standards and best practices. These systems include:

- PRDs (for CNG) or PRVs (for LNG) on all fuel containers.
- A manual or automatic shutoff valve on each fuel container to isolate it from the rest of the system and another valve to isolate the fuel system from the engine when multiple containers are used.

[11] CNG fuel cylinders are tested with a specific valve/PRD design and should only be replaced with the valve/PRD design recommended by the manufacturer. The American National Standards Institute NGV2 design standard specifies that cylinders be labeled “For use only with the container manufacturer’s pressure relief devices and valves.”

- A methane detection system when un-odorized natural gas is used on the vehicle.[12]
- PRVs on LNG pump cases and on any section of LNG piping that can be isolated between two shutoff valves.
- A manual vent valve to allow controlled release of pressure from the vapor space on LNG containers.
- A backflow preventer at the filling connection (for LNG).
- A device (gauge) near the filling connection on LNG vehicles that provides indication when an LNG tank has been filled to its maximum allowable liquid level.

The current FMCSRs do not include mandatory installation details for CNG and LNG fuel systems to address specific issues unique to natural gas fuel. In particular, there are no requirements for sizing, routing, and protection of PRD/PRV vents.

The current FMCSRs do not require CNG and LNG vehicles to be labeled as recommended by industry standards and best practices.

4.2 NAS INSPECTION PROCEDURES

The current NAS inspection procedures do not require inspectors to evaluate CNG or LNG fuel containers on commercial vehicles for compliance with FMVSS 304 (CNG) or NFPA 52/SAE J2343 (LNG) by, for example, reviewing fuel container labels to determine:

- If required data is present and legible.
- If the original certification period has expired.
- The date of the last fuel system inspection by a qualified and certified inspector.

The current NAS inspection procedures do not require inspectors to verify that the natural gas-related safety systems required by industry standards and best practices are in place and operable on commercial CNG and LNG vehicles; items that could be checked include PRD/PRVs, PRD/PRV vents, shutoff valves, and methane detection systems (un-odorized gas).

The current NAS inspection procedures do not require inspectors to verify that vehicle labels recommended by industry standards and best practices are in place on CNG and LNG commercial vehicles.

[12] This is primarily an issue for LNG vehicles. However, at least one transit agency is currently fueling CNG vehicles using a fuel station that stores LNG, which is then vaporized and compressed onto the vehicles without adding any odorant.

4.3 OOS CRITERIA

The NAS inspection OOS criteria for CNG and LNG vehicles currently address only fuel leaks. Other in-use conditions that could present a significant safety hazard for CNG and LNG commercial vehicles include:

- A fuel tank not securely attached to the vehicle.
- Missing liquid level gauge at fill connection on LNG vehicles.
- Missing or inoperable PRDs/PRVs on fuel containers.
- Missing or inoperable shutoff valves in the fuel system and on fuel containers.
- Missing/damaged or improperly located PRD/PRV vents.
- Missing or inoperable methane detection system (un-odorized gas).
- Un-certified, expired, or damaged fuel cylinder.
- Missing vehicle labels identifying fuel type.

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5. SITE VISITS AND INDUSTRY CONSULTATIONS

This section summarizes the industry outreach conducted as part of this project to collect feedback on potential changes to FMCSRs and NAS inspection procedures from the companies and organizations that would be most affected by the changes.

5.1 SUMMARY OF SITE VISITS

As part of this project, the performing organization convened a series of meetings to gather feedback on preliminary recommendations for changes to FMCSRs and NAS inspection procedures from a representative sample of organizations that would be most affected by any changes. These organizations included companies involved in the design and manufacture of medium- and heavy-duty natural gas engines, CNG and LNG fuel systems, and commercial CNG and LNG vehicles; commercial fleet owner/operators and renters/lessors that currently use CNG and LNG trucks; and other State and Federal Government agencies involved with development and/or enforcement of regulations for commercial vehicles.

A total of 14 meetings were conducted with 60 representatives of 21 different companies/organizations. The following organizations participated in these meetings (a complete list of the individuals who participated is included at Appendix C):

- California Highway Patrol.
- National Highway Traffic Safety Administration.
- Federal Transit Administration.
- Westport Innovations Inc. (natural gas engine manufacturer).
- Peterbilt Motors Company (CNG and LNG commercial truck manufacturer).
- Kenworth Motor Company (CNG and LNG commercial truck manufacturer).
- Daimler Trucks of North America (CNG commercial truck manufacturer).
- BAF Technologies (CNG commercial truck secondary manufacturer).
- Chart Incorporated (LNG fuel system manufacturer).
- Agility Fuel Systems (CNG fuel system manufacturer).
- Ryder Systems Inc. (CNG and LNG vehicle renter/lessor).
- Port of Los Angeles (manager of Clean Truck Program that administers concession contracts with NGV fleet drayage companies).
- Golden State Express (NGV drayage fleet owner/operator).
- Green Fleet Systems (NGV drayage fleet owner/operator).
- The Dependable Companies (NGV drayage fleet owner/operator).

- TTSI (NGV drayage fleet owner/operator).
- Southern Counties Express (NGV drayage fleet owner/operator).
- Harbor Express (NGV drayage fleet owner/operator).
- Los Angeles County Metropolitan Transportation Authority (CNG urban transit bus fleet operator).
- Foothill Transit (CNG urban transit bus fleet operator).
- Truck & Engine Manufacturer's Association.

In addition to meetings with representatives of the above organizations, presentations were made to the CVSA Vehicle Committee at the 2012 Commercial Vehicle Safety Alliance (CVSA) Workshop in April 2012 and to the American Public Transportation Association (APTA) Clean Propulsion Committee at the APTA Bus and ParaTransit Conference in May 2012. At the CVSA meeting, approximately 57 individuals from various organizations involved with commercial vehicle inspections attended the presentation.

At the APTA meeting, approximately 40 individuals from various North American transit agencies attended the presentation. While not typically regulated by FMCSA,[13] transit agencies were included in this outreach effort because they have the longest and most extensive history operating natural gas-powered heavy-duty vehicles in the United States.

At each meeting, the performing organization presented background information on the project and a summary of the preliminary recommended changes to FMCSRs, NAS inspection procedures, and OOS criteria to address natural gas-powered commercial vehicles.

Meeting participants were encouraged to ask questions and provide feedback on the preliminary recommendations, both verbally and in writing as a followup to the meeting. Written comments were received from two organizations. A summary of the feedback received during the industry consultations is provided below.

5.2 SUMMARY OF SITE VISIT COMMENTS

The majority of individuals and organizations who participated in the site visits for this project recognized and agreed that there are gaps in current FMCSRs, inspection procedures, and OOS criteria related to safety of in-use natural gas vehicles. Most agreed that some changes are warranted in order to fill these gaps, including specification of minimum requirements for in-use natural gas fuel systems, vehicle labeling requirements, training requirements for natural gas fuel

[13] Transit buses are typically operated by State or local government agencies and are not typically used in interstate commerce. However, these vehicles are subject to the same State inspection requirements as commercial vehicles, and the States are encouraged to adopt and incorporate the FMCSRs as part of their State regulations. For example, transit bus drivers are required to have a valid commercial driver's license because all States have adopted the FMCSRs.

system maintainers (inspectors, maintenance, and repair personnel), and accident reporting requirements. Several manufacturers indicated that they welcomed more regulatory certainty related to NGVs, for example in the area of requirements for onboard methane detection systems.

One natural gas fuel system manufacturer and several natural gas fleet owner/operators indicated that they did not think additional Federal regulation is required, either because natural gas does not pose significantly greater risk than diesel fuel or because the industry is already highly regulated. One fleet operator questioned the need for additional regulation at this time given the small size of the current natural gas commercial vehicle fleet. Several fleet owner/operators also expressed a desire to have a single, standardized set of regulations applicable to all in-use commercial NGVs nationwide, rather than allowing more restrictive regulations in one or more States.[14]

Almost all participants agreed that the voluntary standards codified in NFPA 52, Chapter 4 (General CNG Requirements and Equipment Qualifications), Chapter 6 (CNG Engine Fuel Systems), and Chapter 11 (LNG Engine Fuel Systems) are an appropriate starting point for development of minimum standards for in-use NGVs. All vehicle and fuel system manufacturers indicated that their current products comply with the intent of NFPA 52 when manufactured.

However, almost all manufacturers expressed opposition to FMCSA's adopting the complete language of NFPA 52 as a standard for in-use commercial vehicles, either by reference or by replicating the complete current language of NFPA 52 in revised FMCSRs. These manufacturers made the following points about NFPA 52:

- As a voluntary, consensus-based standard, NFPA 52 was not designed to be a regulatory document.
- Some specific requirements in NFPA 52 are open to interpretation as to how they can/should be implemented.
- Some specific requirements in NFPA 52 are not practical on all commercial vehicles.
- Not all manufacturers agree that certain specific requirements in NFPA 52 are necessary for safe operation of NGVs.

Some of the specific requirements of NFPA 52 manufacturers noted as being open to interpretation, impractical, or unnecessary include:

- Requirement for an onboard methane detection system if LNG fuel tanks are mounted outside of the passenger compartment in open air.
- Requirement for duplicative fuel system labels on the fuel tank, at the fuel fill location, and in the engine compartment.

[14] These owner/operators are located in California, which is one of only two States that currently have minimum standards for in-use commercial NGVs codified into State law.

- Define minimum ground clearances for natural gas fuel tanks.
- Requirement for permanent manufacturer markings on all "hose and metallic hose" used in CNG fuel systems.

Most manufacturers, and several fleet operators, indicated that FMCSA should extract the most critical safety features/items for NGVs from NFPA 52, with a focus on items that would be practical to evaluate during annual and roadside inspections, and then use these items as the basis for creating minimum requirements for in-use vehicles in revised FMCSRs. Almost all participants agreed that the following items from NFPA 52 should be included on the list of minimum safety features for in-use vehicles:

- CNG fuel containers shall be protected with a screen or shield to prevent damage from road hazards. The shield shall not allow solid or liquid materials to collect between the shield and the fuel container.[15]
- PRDs must be installed on each CNG fuel cylinder; PRVs must be installed on each LNG fuel container.
- PRDs and PRVs must be located such that venting gas is directed to the exterior of the vehicle in a "safe direction," or must be equipped with outlet piping that directs exiting gas to the exterior of the vehicle and in a "safe direction."
- A manual or automatic shutoff valve must be installed on each CNG or LNG fuel container to isolate it from rest of the fuel system. If more than one fuel container is used, another automatic valve must be installed to isolate all fuel containers from the engine.
- A PRV must be integrated into, or installed downstream of, the first-stage regulator on CNG vehicles.
- A backflow preventer must be installed at the filling connection on LNG vehicles.

Some, but not all, participants agreed that the following items from NFPA 52 or SAE J2406 should also be included in the list of minimum safety features for in-use NGVs:

- A methane detection system must be installed if un-odorized natural gas will be used in the vehicle.
- An excess flow device must be installed on the fuel line to the engine.

With respect to requirements for PRD vents, not all participants could agree on a minimum standard for vent line location that would constitute venting in a "safe direction." The performing organization suggested a standard that PRD/PRV vents must "extend to the top level of or above the vehicle passenger compartment and direct gas up and away from vehicle." Some

[15] By their nature, LNG fuel containers incorporate double-wall construction, with the inner vessel containing the LNG and the exterior vessel wall providing both insulation and protection form road debris. A separate shield is not required.

manufacturers suggested that this was not practical for all commercial vehicles, in particular for school buses and "strip chassis" applications in which the primary manufacturer sells a chassis with a complete engine and fuel system to a secondary manufacturer, who then adds a vocational body. Other participants indicated that venting location was more critical for LNG vehicles than for CNG vehicles because LNG fuel systems typically vent periodically to relieve pressure inside the tank as heat is absorbed and some LNG is vaporized, while CNG fuel systems are designed to vent only due to tank overpressure caused by a fire.

One manufacturer recommended that FMCSA consider mandating automatic shutoff valves on all natural gas fuel containers. This would go beyond the current requirements of NFPA 52, which allows either a manual or an automatic valve.

Several participants indicated that it is important that any revised regulations make clear distinctions between what is required for CNG vehicles and what is required for LNG vehicles. For example, it was noted that CNG fuel containers are high-pressure vessels subject to pressure cycling that could cause structural damage over time and are susceptible to exterior damage that can impair their structural integrity. LNG fuel containers are low-pressure vessels that are not subject to the same type of pressure cycling. By their nature they also incorporate double-wall construction—damage to the outermost vessel wall will impair tank performance (by increasing heat leak) but will not generally reduce the overall structural integrity of the container. As such, CNG and LNG fuel containers should be subject to different requirements for periodic in-use inspection, and they should have different OOS criteria.

Similarly, one manufacturer expressed the opinion that any certification/training requirement for mechanics who work on natural gas fuel systems should apply to CNG mechanics only, and should not apply to people who work on LNG systems. Their belief is that any special training requirements that apply to LNG fuel systems, but not diesel fuel systems, are unwarranted and create an unnecessary distinction between different "liquid" fuels.

A number of participants raised concerns related to the NFPA 52 requirement to include onboard methane detection if un-odorized natural gas will be used on a vehicle. Pipeline natural gas is odorized by natural gas utilities to aid in leak detection, so that most CNG vehicles carry odorized gas. Un-odorized gas would be present on a vehicle in one of the following situations:

1. LNG Vehicles: The odorants used by utilities cannot be added to cryogenic LNG because they solidify at LNG temperatures. All LNG vehicles therefore use un-odorized gas.
2. L/CNG Fuel Stations: Some fleet owner/operators are known to receive their natural gas delivered as LNG by tank truck; the natural gas is stored as LNG, which is then vaporized, compressed, and then dispensed onto their vehicles (L/CNG) without adding an odorant.
3. Landfill Gas: One participant noted that some refuse hauling companies use landfill gas to power their vehicles. This locally produced gas may not enter a utility pipeline before being filtered, compressed, and dispensed onto vehicles. The gas may be used un-odorized.

One manufacturer indicated that despite the recommendations of NFPA 52 they believe that onboard methane detection should not be required for LNG vehicles with fuel tanks mounted

outside the passenger compartment in open air (i.e., on the frame rail behind vehicle cab), even though the LNG is not odorized. They indicated that in this situation small gas leaks pose minimal safety hazard, and that large leaks are obvious without methane sensors.

The same manufacturer also expressed concern that methane sensors are so sensitive that they could easily provide false-positive indications of a fuel leak.

A second manufacturer indicated support for the onboard methane detection requirement, but indicated that if the tank is mounted outside the passenger compartment in open air it is difficult to locate a sensor in the area of the fuel tank that will reliably detect a leak. They recommended requiring methane sensors only in the engine and passenger compartments.

Another manufacturer indicated that they would welcome regulatory certainty in this area because their policy is to provide methane detection on all natural gas trucks, but that some customers do not want to pay for it. This manufacturer wanted it to be made clear that if methane detectors were required for un-odorized gas it would be the responsibility of the owner/operator to ensure this requirement was met, not the vehicle manufacturer (i.e., if an owner specifies a CNG truck without methane detection but then decides to use un-odorized CNG, the manufacturer would not be held responsible). This same manufacturer recommended that FMCSA consider specifying that un-odorized CNG cannot be used for commercial trucks.

Many participants, both manufacturers and fleet operators, also expressed concern about the practicality of annual and roadside inspections of natural gas commercial vehicles. While agreeing that the actual condition of fuel containers and other fuel system components is relevant to determining whether in-use vehicles are safe, they noted that the location of these components on most commercial vehicles make visual inspection difficult. Natural gas fuel cylinders are typically located on the roof of the vehicle, within a compartment, or behind fixed shields. Given this, defining practical inspection procedures and enforcing OOS criteria will be difficult.

There was general agreement among all participants that determining whether a natural gas commercial vehicle has a fuel leak is significantly more difficult than determining whether a diesel vehicle has a fuel leak. There was also general agreement that properly assessing the structural condition of a CNG or LNG fuel tank requires specialized knowledge and training. Participants therefore expressed concern that FMCSA not define OOS criteria so strictly that natural gas commercial vehicles be put out of service by untrained inspectors for only minor infractions.

In this context, some of the recommendations made by various participants related to commercial NGV inspection procedures and OOS criteria include:

- FMCSA should consider different levels of inspection for annual vehicle inspections and random roadside inspections; roadside inspections will likely need to be less detailed.
- Inspectors will need to be given some level of discretion to tailor their inspections based on fuel tank location and relative risk factors. For example, CNG tanks mounted on the frame rail close to the road surface warrant a more thorough inspection than roof-mounted tanks.

- FMCSA should consider a two-tiered system of penalties. Major problems that would create an imminent hazard would put a vehicle out of service immediately, while vehicles with minor problems would be given a ticket that requires corrective action within a given time period, but would not be put out of service. Examples of potential major infractions requiring a vehicle to be put out of service include a verified fuel leak, suspected severe tank damage, or a missing PRD. Examples of potential minor infractions include a missing vehicle or fuel system label, or a CNG tank not inspected by a certified inspector in the past 36 months.
- In assessing the condition of a CNG fuel tank, inspectors should focus on the condition of the tank shield first. Major dents or tears to the shield warrant further investigation to ensure that the tank behind it has not also been damaged. Accumulation of debris (i.e., rocks) between the shield and the tank also warrants further investigation to ensure that the tank has not been damaged by the debris. However, if the shield is undamaged and there is no debris accumulated, it is unlikely that the inner tank has been damaged.
- Inspectors cannot apply the same OOS criteria to LNG vehicles that they apply to CNG vehicles. For example, damage to the exterior surface of an LNG tank will not impair the structural integrity of the tank, and does not warrant further investigation or putting the vehicle out of service. Unlike CNG tanks, there is not a current industry-recommended minimum inspection interval, nor an agreed procedure for evaluating LNG tank structural integrity based on specific indications of damage.

Virtually all the site-visit participants also expressed strong concern that FMCSA not enforce the requirement of FMVSS 304, which states that every CNG fuel container must be labeled with a statement that: “This container should be visually inspected after a motor vehicle accident or fire and at least every 36 months or 36,000 miles, whichever comes first, for damage and deterioration.” The universally expressed specific concern was that commercial vehicles could travel more than 100,000 miles per year so that, as written, a commercial vehicle might require an inspection as frequently as every 4 months. All participants agreed that a qualified inspector should inspect CNG fuel containers on commercial vehicles every 36 months, with no reference to accumulated mileage.

Members of the CVSA Vehicle Committee were very interested in the issue of commercial NGVs. Several members expressed concerns about the practicality of annual and roadside inspections for natural gas fuel systems, which were consistent with the concerns expressed by manufacturers and fleet operators. Several members also expressed support for a two-tiered penalty system, where vehicles are put OOS immediately for the most serious violations and only issued a ticket for less serious violations.

CVSA staff members indicated that for CVSA to change the OOS criteria for commercial NGVs, to include, for example, putting a vehicle OOS if a CNG tank had not been inspected within the past 36 months, a change to FMCSRs would first be required. CVSA could, however, mandate that a vehicle without a PRD on a CNG fuel tank be put OOS based on “imminent hazard,” even without FMCSA regulation.

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6. PEER REVIEW

6.1 PEER REVIEW PROCESS

Based on industry experience and recommendations gathered during the site visits, the performing organization identified seven individuals who could provide a formal peer review of the draft recommendations for change to FMCSRs, NAS inspection procedures, and OOS criteria to address natural gas commercial vehicles. These individuals collectively have long experience with design, specification, maintenance, and operation of heavy-duty NGVs, as well as commercial vehicle inspection procedures.

Resumes for these individuals were submitted to the FMCSA technical representative for this project, who then chose the following three individuals to act as peer reviewers for this project:

- Paul M. Horgan—transportation consultant, with expertise in hazardous materials and commercial vehicle inspection.
- Douglas B. Horne—President of CVEF.
- Bill Parsley—transit operations and maintenance consultant, with expertise in alternative fuel transit buses.

A draft copy of this document was submitted to each reviewer. Draft copies of the peer review document were also given to representatives of each organization that participated in the industry site visits and to representatives of other Department of Transportation agencies. In addition to comments from the three peer reviewers, the performing organization also received additional written comments on the peer review draft from five other individuals who reviewed the draft document.

The comments that were received are reflected in the final recommendations in Section 7.

6.2 SUMMARY OF PEER REVIEW COMMENTS

The peer reviewers submitted a number of detailed comments on various aspects of the Draft Final report. Several comments or recommendations made by the peer reviewers are considered but are not adopted in the final recommendations in Section 7, for various reasons. The most significant of these are discussed below.

6.2.1 Mandates Beyond Current Industry Best Practice

Several peer reviewers recommended that specific items be included by FMCSA in the list of Minimum Fuel System Safety Requirements (Section 7.1.1), even though they are not included in the current version of NFPA 52. The most significant of these items include:

- Recognition that in practice some CNG vehicles use manifolded PRDs to protect more than one fuel container with a single PRD.

- Additional design and marking requirements for LNG fuel containers including:
  - Vibration testing.
  - Mandating that an internal tank must be supported on both ends if the tank is mounted horizontally.
  - Mandating more stringent requirements related to allowable heat leak.
  - Adding the Marked Rated Hold Time (reference 49 CFR Part 173.318(g)) or its equivalent to an LNG container's nameplate.
- For LNG vehicles, LNG container liquid level and pressure gauges that can be read in the vehicle operator's compartment.
- For LNG vehicles, a temperature sensing device that can detect when the fuel's temperature upstream of the vehicle's engine is colder than design parameters, warn the driver, and isolate the engine from the fuel system before it is damaged.
- A warning system in the driver compartment for LNG tank overpressure that requires manual venting.
- A detection system to detect failed solenoid valves on CNG cylinders.

The last item, a failed solenoid valve detection system, will reportedly be included in the next version of NFPA 52, due to be published in 2013. The industry is also reportedly working on revised standards for LNG fuel container certification, but the status of those efforts could not be determined by the authors of this report.

A major assumption of this project is that when revising FMCSRs, FMCSA will seek to reflect current industry standards and best practices for NGVs and will not create new requirements that have not been fully vetted by, for example, passing through the industry review processes used by standards development organizations, such as NFPA. Therefore, the above items were not included in the final recommendations in Section 7.1.

When developing proposed regulatory language for any FMCSR revisions, FMCSA should review the most recent version of NFPA 52 to identify any relevant changes relative to the 2010 edition used for this project. Significant changes should be reflected in the proposed FMCSR revisions.

6.2.2 Certification of NGV Conversions

One peer reviewer recommended that FMCSA should certify all third-party conversions of commercial vehicles to natural gas operation.

Certification of NGV converters is beyond the current authority of FMCSA.

6.2.3 Certification of Qualified NGV Inspectors

One peer reviewer recommended that FMCSA should certify and maintain a database of NGV inspectors to facilitate verification during annual and roadside inspections that CNG fuel systems had in fact been inspected by a "qualified inspector" within the past 36 months. Another reviewer noted that third-party organizations currently train personnel and administer databases

for qualified pipeline personnel, and that these organizations could also administer qualification of inspectors and maintainers for NGV fuel systems.

Certification of NGV inspectors is beyond the current authority of FMCSA.

6.2.4 Un-odorized CNG and Onboard Methane Detection

As with the participants in industry site visits, there was disagreement among the peer reviewers about the need for onboard methane detection systems for CNG vehicles that use un-odorized gas. One reviewer recommended that, instead of requiring onboard methane detection on any CNG vehicles, FMCSA should instead mandate that un-odorized CNG may not be used on commercial vehicles. The Truck and Engine Manufacturer's Association (EMA) also recommended this course of action, because they were concerned that vehicle manufacturers might be held liable for actions of vehicle owners over which they have no control.

FMCSA does not have the authority to ban the use of un-odorized CNG, nor the means to enforce such a ban.[16] The proposed language in Section 7.1.1 that deals with un-odorized CNG makes it clear that responsibility for ensuring that vehicles will be equipped with onboard methane detection falls to the vehicle owner, not the vehicle manufacturer.

6.2.5 Better Reporting System for NGV Incidents

One reviewer indicated that the current systems in place for reporting and tracking NGV "incidents" nationwide—such as accidents, major fuel leaks, and tank damage due to impact with road debris—are inadequate.[17] He recommended that FMCSA require more detailed reporting by commercial vehicle operators that use NGVs.

As discussed in Section 7.1.4, FMCSA currently requires that commercial vehicle operators maintain accident records only for accidents that involve a fatality or bodily injury requiring medical treatment away from the accident scene, or which result in disabling damage to one or more vehicles involved. This report recommends minor changes to the existing reporting requirements, primarily to help enforce required fuel system re-inspections for CNG vehicles. We do not recommend a different reporting threshold for NGVs compared to diesel or gasoline fueled vehicles.

While better information on NGV incidents is a worthwhile goal, collection of this data goes beyond FMCSA's current mandate.

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[16] Note that NFPA 52 (section 4.2.1.1) requires natural gas to be odorized if dispensed to the public. However, NFPA 52 is voluntary unless adopted by State or local fire marshals. Under 49 U.S.C. 119, FMCSA has no authority to mandate such adoption because the type of fuel has no bearing on the mission of the agency "to reduce the number and severity of large-truck-involved crashes through more commercial motor vehicle and operator inspections and motor carrier compliance reviews, stronger enforcement measures against violators, expedited completion of rulemaking proceedings, scientifically sound research, and effective commercial driver's license testing, recordkeeping, and sanctions.''

[17] In accordance with PHMSA requirements, incidents and accidents involving transport of hazardous materials, including natural gas, must be reported to the National Response Center. However, vehicle fuel systems are exempt from these reporting requirements as "materials of trade."

6.2.6 Training for Commercial Vehicle Inspectors

Several reviewers indicated that there is a need for increased training of commercial vehicle enforcement personnel relative to inspection of NGV fuel systems. This sentiment was also expressed by a number of site-visit participants, including members of the CVSA Vehicle Committee.

Specification of training requirements for commercial vehicle inspectors is beyond the scope of this current project. It is anticipated that FMCSA will address this issue through one or more separate projects in the future.

6.2.7 NGV Hazard Assessment

Due to the potential for regular venting of natural gas through PRVs, one reviewer indicated that LNG vehicles transiting tunnels might present additional risk compared to CNG vehicles.

Based on the literature review, the authors of this report believe that any risk would be minimal, due to the fact that natural gas is continually being drawn from the LNG fuel system while a vehicle's engine is running, thus minimizing the possibility of an increase in vapor pressure that would lead to venting. LNG fuel system venting is typically caused by a vehicle sitting for extended periods without being operated.

That being said, a full evaluation of this issue would require a formal hazard assessment, which is beyond the scope of this project.

The FTA, through the Transit Cooperative Research Program, has previously sponsored a formal hazard assessment of alternative fuel buses (see literature review sources), but this focused on CNG fuel systems and did not consider LNG fuel systems.

7. FINAL RECOMMENDATIONS

This section presents the final recommendations that were developed during this project for suggested changes to FMCSRs and NAS inspection procedures and OOS criteria to accommodate CNG and LNG commercial vehicles. These recommendations are based on the literature review and gap analysis summarized in Sections 3 and 4, and reflect feedback gathered during the site visits/industry consultations (Section 5) and comments received from peer reviewers (Section 6). The starting point for most recommendations are the voluntary standards and best practices for NGVs codified in *NFPA 52, Vehicular Gaseous Fuel Systems Code, 2010 Edition.* References are provided for the applicable sections of NFPA 52.

To the extent that there was a diversity of opinion expressed during site visits, or significant disagreement between site-visit participants and peer reviewers with respect to a recommendation, or if a recommendation deviates significantly from the requirements of NFPA 52, this is highlighted.

7.1 FMCSRs

7.1.1 Specify Minimum Fuel System Safety Requirements for NGVs

FMCSA should set minimum standards for safe conditions of natural gas fuel systems on in-use commercial vehicles. These standards could apply to all natural gas fuel systems installed on such vehicles, including systems that supply fuel to the main propulsion engine(s), as well as systems that supply fuel to any auxiliary engines that power vehicle-mounted equipment. For the most part, these standards should be based on the requirements of NFPA 52, but be consistent with feedback received during site visits. FMCSA should not adopt the full language of NFPA 52 by reference in any revised FMCSRs. Rather, FMCSA should extract the most critical items from the most recent version of NFPA 52, with a focus on components/systems most likely to be damaged in-use or subject to modification by the vehicle owner during maintenance.

The following items are recommended to be included in the list of minimum standards for in-use vehicles with **CNG** fuel systems:

- All CNG fuel containers installed on commercial vehicles shall be manufactured, inspected, tested, and marked in accordance with FMVSS 304 (49 CFR 571.304) [NFPA 52 4.4.4].
- CNG fuel cylinders shall be removed from service when they have reached the manufacturer's labeled expiration date. No commercial vehicle will be allowed to remain in service with an expired CNG fuel cylinder [NFPA 52 4.4.4.1, 6.13.3.1].
- CNG fuel cylinders and fuel system components installed on commercial vehicles shall be inspected for damage and deterioration by a trained, qualified inspector at least once in every 36-month period (modifying the requirement for inspection once every 36 months *or once every 36,000 miles, whichever comes first* by deleting the italicized words), and after the vehicle has been involved in a fire or in an accident that is reportable in accordance with 49 CFR 390.15 (see Section 7.1.4) [NFPA 52 6.13.3].

- After completing each inspection, the qualified inspector shall change the date of the next required inspection on the vehicle label at the fuel fill connection (see Section 7.1.2) [NFPA 52 6.11.1.1]. A record of the most recent inspection shall be carried on the vehicle at all times.[18]

  It is recommended that NHTSA modify its FMVSS 304 requirement for inspection of the CNG fuel cylinders and fuel system once every 36 months or once every 36,000 miles, whichever comes first by deleting the reference to mileage. Commercial vehicles typically travel more than 100,000 miles per year; requiring inspections 3 times per year would be too burdensome and unnecessary as disclosed by participants in the site visits. It appears that this requirement was originally intended for passenger cars and that commercial vehicles were not taken into account. This triennial inspection is a detailed inspection of the fuel cylinders and fuel system to be performed by a CNG-trained mechanic. It is not to be confused with the annual vehicle safety inspection required by 40 CFR 396.17.

- CNG fuel containers on commercial vehicles shall be protected with a means to prevent damage from road hazards, loading, unloading, direct sunlight, exhaust heat, and vehicle use including accidental physical damage from cargo and/or from cargo leakage [NFPA 52 6.3.2.1]. Screens or shields, if used, shall be installed in a manner that prevents direct contact between the shield and the fuel container and does not allow solid or liquid materials to collect between the shield and the fuel container [NFPA 52 6.3.2.2].
- Each CNG fuel container installed on a commercial vehicle shall be equipped with one or more PRDs with the number, location and part number as specified by the container manufacturer.[19] Each PRD shall be in direct communication with the fuel inside the cylinder and shall be vented to the atmosphere [NFPA 52 4.5.1]. Each PRD shall be located such that the temperature to which it is subjected will be representative of the temperature to which the fuel container it is protecting is subjected. [NFPA 52 4.5.1].
- Each PRD installed on a commercial vehicle shall be vented to the outside of any compartment capable of accumulating a combustible mixture of gas. PRD vents shall be secured to the vehicle and shall be located such that venting gas will not enter a wheel well, the engine compartment, the passenger compartment, or the cargo compartment of the vehicle, and shall not be directed toward the engine exhaust or components that are normally hot during vehicle use, or toward any other ignition source. PRD vents shall be constructed in a manner to prevent entry of water or dirt into the vent or PRD, and to drain any water that enters so it cannot accumulate. Vent lines shall not be loose, crimped, or broken [NFPA 52 6.4].

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[18] In accordance with current industry practice, CGA C-6.4, *Methods for External Visual Inspection of Natural Gas Vehicle (NGV) and Hydrogen Vehicle (HV) Fuel Containers and Their Installations,* Third Edition, 2007, should be used when conducting these inspections.

[19] The current language of NFPA 52 is clear that each CNG fuel container must be protected by one or more PRDs. One peer reviewer pointed out that in practice some large vehicles use a single manifolded PRD to protect two cylinders. This issue may require further evaluation by FMCSA before finalizing any revised FMCSRs.

- Each CNG fuel container installed on a commercial vehicle shall be equipped with either a manual valve or a normally closed, remotely actuated shutoff valve connected directly to the cylinder and equipped to bleed the cylinder manually [NFPA 52 6.6.1].
- If more than one CNG fuel container is used on a commercial vehicle, the vehicle shall be equipped with either a manual one-quarter-turn valve or a normally closed, remotely actuated shutoff valve installed in a location such that closing the valve will isolate the fuel storage system from the engine [NFPA 52 6.6.2]. If manual valves are used they must be located where they can be accessed without a key or tool, and their location must be labeled (NFPA 52 6.6.2.2).
- Commercial vehicles equipped with CNG fuel systems shall be equipped with a valve that automatically prevents fuel flow to the engine if the engine is not running, even if the ignition is switched on [NFPA 52 6.6.3].

The following items are recommended for further evaluation as to whether they should also be included in the list of minimum standards for in-use vehicles with compressed natural gas fuel systems. These items are recommended for further evaluation either because they go beyond the current requirements of NFPA 52, or because there was substantial disagreement as to their necessity among site-visit participants and/or peer reviewers:

- Commercial vehicles with CNG fuel systems must include a pressure relief valve installed downstream of the first-stage regulator.

  This is not a requirement of NFPA 52 but is included in SAE J2406, Recommended Practice for CNG Powered Medium and Heavy-Duty Trucks. *Virtually all site-visit participants agreed that this should be included in the list of minimum requirements for in-use commercial vehicles.*

- Commercial vehicles with CNG fuel systems shall be equipped with a device or method to prevent excess fuel flow on each line that supplies fuel to the engine.

  This is not a requirement of NFPA 52, but is included in SAE J2406, Recommended Practice for CNG Powered Medium and Heavy-Duty Trucks. *There was disagreement among site-visit participants as to whether this is necessary for CNG vehicle safety and how to interpret or implement this requirement. Experience has shown that fuel flow limiting devices can shut off during transient conditions, causing a vehicle to lose power at a critical time and thereby causing an unsafe condition.*

- If an owner/operator of a commercial vehicle with a CNG fuel system chooses to use un-odorized natural gas in the vehicle, the owner shall ensure that the vehicle is equipped with an onboard methane detection system [NFPA 52 4.2.1.1], and that the vehicle is equipped with exterior blue diamond labels with the text “un-odorized CNG.”

  There was disagreement among site visit participants as to whether a methane detection system is required if CNG fuel tanks are located outside the passenger or cargo compartment in open air (i.e., mounted on frame rail behind the vehicle

cab). Other site-visit participants questioned how such a requirement should be implemented and, in particular, the minimum number and placement of methane sensors. The intent of the NFPA 52 requirement for a methane detection system is to detect gas that has leaked into the passenger compartment or some other enclosed compartment where it could collect and achieve flammable levels. As such, it would seem reasonable to require, at a minimum, detection sensors in the passenger compartment of the vehicle, but not in the vicinity of the fuel containers if they are mounted in open air.

An alternative would be for FMCSA to specify that un-odorized CNG shall not be used by commercial vehicles; however, it is not clear whether FMCSA would have the authority to enforce such a ban.

The following items are recommended to be included in the list of minimum standards for in-use vehicles with **LNG** fuel systems:

- All LNG fuel containers installed on commercial vehicles shall be designed, manufactured, inspected, tested, and marked in accordance with the Regulations of USDOT Specification 4L or the "Rules for the construction of Un-fired Pressure Vessels," American Society of Mechanical Engineers Boiler and Pressure Vessel Code [NFPA 52 11.3.1], and shall be certified for structural integrity via drop and flame tests as specified in SAE J2343, Section 4.2.12 and 4.2.13. [NFPA 52 11.3.5.3].
- Each LNG fuel container installed on a commercial vehicle shall be equipped with one or more PRV with the number, location, and part number as specified by the container manufacturer. Each PRV shall be in direct communication with the vapor space inside the container and shall not contact the liquid inside the container under normal operation [NFPA 52 11.4].
- Each PRV installed on a commercial vehicle shall be vented to the outside of any compartment capable of accumulating a combustible mixture of gas. PRV vents shall be secured to the vehicle and shall be located such that venting gas will not enter a wheel well, the engine compartment, the passenger compartment, or the cargo compartment of the vehicle. PRV vents shall exit at or above the top surface of the passenger compartment and shall direct venting gas up and away from the vehicle. Venting gas shall not be directed toward the engine exhaust or components that are normally hot during vehicle use, or toward any other ignition source. Vent lines shall not be loose, crimped, or broken. PRV vents shall be constructed in a manner to prevent entry of water or dirt into the vent or PRV and to drain any water that enters so it cannot accumulate [NFPA 52 11.4].
- Each LNG fuel container installed on a commercial vehicle shall be equipped with either manual valves or normally closed, remotely actuated shutoff valves capable of isolating it from the rest of the fuel system. Both liquid and vapor lines exiting the container shall have shutoff valves [NFPA 52 11.3.4]. All valves shall be labeled as to function. If manual valves are used, they must be located where they can be accessed without a key or tool [NFPA 52 11.12.1.14].

- If more than one LNG fuel container is used on a commercial vehicle, and the fuel is not supplied simultaneously from all of them, the vehicle shall be equipped with automatic valve(s) that shutoff fuel flow from the container(s) not being used [NFPA 11.12.4.5].
- Commercial vehicles equipped with LNG fuel systems shall be equipped with a valve that automatically prevents fuel flow to the engine if the engine is not running, even if the ignition is switched on [NFPA 52 11.12.4.4].
- Commercial vehicles equipped with an LNG fuel system shall be equipped with a backflow check valve to prevent return flow of LNG from the fuel container(s) to the filling connection [NFPA 52 11.12.4.6].
- Commercial vehicles equipped with an LNG fuel system shall be equipped with a gauge or other device that provides indication when the LNG fuel container(s) are filled to the maximum allowable liquid level. This indication shall be visible and/or audible to an individual when fueling the vehicle [NFPA 11.3.2.1].

The following items are recommended for further evaluation as to whether they should also be included in the list of minimum standards for in-use vehicles with LNG fuel systems. These items are recommended for further evaluation either because they go beyond the current requirements of NFPA 52, or because there was substantial disagreement as to their necessity among site-visit participants and/or peer reviewers:

- Commercial vehicles with LNG fuel systems shall be equipped with an onboard methane detection system [NFPA 52 11.12.1.2].

  There was disagreement among site-visit participants as to whether a methane detection system is required if LNG fuel tanks are located outside the passenger or cargo compartment in open air (i.e., mounted on frame rail behind the vehicle cab). Other site-visit participants questioned how such a requirement should be implemented and, in particular, the minimum number and placement of methane sensors. The intent of the NFPA 52 requirement for a methane detection system is to detect gas that has leaked into the passenger compartment or some other enclosed compartment where it could collect and achieve flammable levels. As such it would seem reasonable to require, at a minimum, detection sensors in the passenger compartment of the vehicle, but not in the vicinity of the fuel containers if they are mounted in open air.

- Commercial vehicles with LNG fuel systems shall be equipped with a device or method to prevent excess fuel flow on each line which supplies fuel to the engine.

  This is not a requirement of NFPA 52, but it is included in SAE J2343, Recommended Practice for LNG Medium and Heavy-Duty Powered Vehicles. There was disagreement among site-visit participants as to whether this is necessary for LNG vehicle safety and how to interpret or implement this requirement. Experience has shown that fuel flow limiting devices can shut off during transient conditions, causing a vehicle to lose power at a critical time and therefore causing an unsafe condition.

Note that, unlike CNG fuel cylinders, LNG fuel containers are not required to be labeled with an expiration date by the manufacturer. In addition, there is no industry-agreed minimum inspection interval for evaluation of deterioration and structural integrity of LNG fuel containers as there is for CNG cylinders (e.g., inspection by a qualified inspector every 36 months). Therefore, we are not recommending that regular inspection by a qualified inspector, or removal of expired cylinders, be included in the minimum in-use standards for LNG fuel systems.

7.1.2 Specify Minimum Labeling Requirements for NGVs

FMCSA should specify minimum labeling requirements for commercial vehicles powered by natural gas. Labeling is required to alert emergency responders to the presence of natural gas fuel on the vehicle, to alert vehicle operators to maximum fuel fill pressure, and to help commercial vehicle inspectors evaluate vehicle condition and compliance with in-use vehicle standards.

The following are the recommended minimum labels required for commercial vehicles powered by natural gas:

- All CNG fuel containers installed on commercial vehicles shall have permanent labels as specified in FMVSS 304 (49 CFR 571.304). All LNG fuel containers installed on commercial vehicles shall have permanent labels as specified in SAE J2343 Section 4.2.11.
- All commercial vehicles powered by natural gas fuel shall have a permanent, weather-resistant label located in the vicinity of the fuel fill connection, with the following minimum information:
  - Fuel type (CNG or LNG).
  - Service pressure.
  - Total water volume of all fuel containers.
  - Company name, address, phone number, and email address of fuel system installer.
  - Fuel container expiration date (CNG only).
  - Date of next required fuel system inspection by a qualified inspector (CNG only).

The above information may be combined with the information on required fuel container labels (first bullet above) into a single label or data plate, if the label or data plate is affixed to the fuel container and is clearly visible to an individual making a fueling connection to the vehicle.

- All commercial vehicles powered by natural gas shall be identified with permanent, weather-resistant “blue diamond” labels affixed to the front and the lower right rear of the vehicle. In addition, all commercial vehicles shall include the label on each side of the power unit cab, below the USDOT numbers that are mandated by 49 CFR 390.21. As with the USDOT numbers, the labels should be legible from 50 feet in daylight. Labels shall meet the requirements of NFPA 52, Sections 6.11.3.1 and 6.11.3.2. Wording on the label shall be as follows:
  - “CNG” for vehicles carrying natural gas to which an odorant has been added.

  - "UN-ODORIZED CNG" for vehicles carrying compressed natural gas to which no odorant has been added.
  - "LNG" for vehicles carrying liquefied natural gas.

- If manual, rather than remotely operated automatic fuel shutoff valves are used on commercial vehicles powered by natural gas, these vehicles shall be labeled with permanent, weather-resistant labels affixed to the exterior of the vehicle noting the location of each manual fuel shutoff valve at each location where such a valve is located. To the extent feasible, labels shall be affixed to the exterior of the vehicle so as to be visible to emergency responders. If the shutoff valve is located in a compartment or behind a door, the compartment or door shall be labeled on the exterior.
- If PRD or PRV vent outlets on a commercial vehicle are located behind a shield or screen, or are in any way obscured from the view of a person approaching the vehicle from the side, their location will be marked on the exterior of the vehicle with a permanent, weather-resistant label.
- Commercial vehicles with roof-mounted natural gas fuel containers shall include a permanent label in the driver's compartment, clearly visible to a seated operator, which includes the maximum total height of the un-laden vehicle.

7.1.3 Require NGV Fuel System Maintenance by Trained Mechanics

FMCSA should specify that natural gas fuel systems, including both CNG and LNG systems, be maintained only by mechanics with specific training related to natural gas fuel systems, including familiarity with the properties and hazards associated with natural gas fuel.

The following language is proposed to be added to the Code of Federal Regulations, Title 49, Part 396 - Inspection, Repair, and Maintenance. This proposed language directly parallels existing language related to qualifications of brake inspectors in 49 CFR 396.25, with the following minor modifications for clarity:

> (a) The motor carrier shall ensure that all inspections, maintenance, repairs, or service to the fuel systems of its commercial motor vehicles that are powered by natural gas are performed in compliance with the requirements of this section.
>
> (b) For purposes of this section, *natural gas fuel system maintainer* means any employee of a motor carrier who is responsible for ensuring that all natural gas fuel system inspections, maintenance, service, or repairs to any commercial motor vehicle subject to the motor carrier's control, meet the applicable Federal standards.
>
> (c) No motor carrier shall require or permit any employee who does not meet the following minimum natural gas fuel system maintainer qualifications to be responsible for the inspection, maintenance, service, or repairs of any natural gas fuel system on its commercial motor vehicles.
>
> (d) The motor carrier shall ensure that each natural gas fuel system maintainer is qualified and capable of performing the assigned natural gas fuel system service or inspection tasks by reason of experience, training, or both as follows:

(i) Has successfully completed an apprenticeship program sponsored by a State, a Canadian Province, a Federal agency or a labor union, or a training program approved by a State, Provincial, or Federal agency, or has a certificate from such an apprenticeship program or training program which qualifies the person to perform the assigned natural gas fuel system service or inspection task, or

(ii) Has natural gas fuel system-related training or experience or a combination thereof totaling at least 1 year. Such training or experience may consist of:

(A) Participation in a training program sponsored by a natural gas fuel system or vehicle manufacturer, natural gas fuel system component manufacturer, or natural gas fuel system installer, or similar commercial training program designed to train students in natural gas fuel system maintenance or inspection similar to the assigned natural gas fuel system service or inspection tasks; or

(B) Experience performing natural gas fuel system maintenance or inspection similar to the assigned natural gas fuel system service or inspection task in a motor carrier maintenance program; or

(C) Experience performing natural gas fuel system maintenance or inspection similar to the assigned natural gas fuel system service or inspection task at a commercial garage, fleet leasing company, or similar facility.

(e) No motor carrier shall employ any person as a natural gas fuel system maintainer unless the evidence of the inspector's qualifications, required under this section, is maintained by the motor carrier at its principal place of business, or at the location at which the natural gas fuel system inspector is employed. The evidence must be maintained for the period during which the natural gas fuel system maintainer is employed in that capacity and for 1 year thereafter.

Note that one company that participated in the site visits strongly objected to imposing the above requirement for employees who work on LNG fuel systems. Their argument is that low-pressure LNG fuel systems do not pose the same hazards as high-pressure CNG systems and are in fact similar to other liquid fuel systems. While we acknowledge that LNG fuel systems do not typically involve high-pressure hazards, they do introduce hazards related to the very low temperature of LNG fuel, and these hazards and relevant precautions are typically unfamiliar to mechanics that work on diesel and gasoline fuel systems. For that reason, we chose to make no distinction between LNG and CNG fuel systems with respect to minimum standards for mechanic training.

7.1.4 Require NGV Accident Reporting

There is consensus within the industry that CNG fuel containers and fuel systems should be inspected for damage by a qualified inspector whenever a vehicle powered by CNG fuel has been damaged in any way that could affect fuel system integrity, has any leaks other than

(specified) minor leaks, or has been involved in a fire or serious accident. This requirement is included above in Section 7.1.1.[20]

Motor carriers are currently required under 49 CFR 390.15 to maintain a register of vehicle accidents. With respect to this requirement 49 CFR 390.5 defines an "accident" as follows:

> *Accident means—*
>
> (1) Except as provided in paragraph (2) of this definition, an occurrence involving a commercial motor vehicle operating on a highway in interstate or intrastate commerce which results in:
>
> (i) A fatality;
>
> (ii) Bodily injury to a person who, as a result of the injury, immediately receives medical treatment away from the scene of the accident; or
>
> (iii) One or more motor vehicles incurring disabling damage as a result of the accident, requiring the motor vehicle(s) to be transported away from the scene by a tow truck or other motor vehicle.
>
> (2) The term accident does not include:
>
> (i) An occurrence involving only boarding and alighting from a stationary motor vehicle;
>
> (ii) An occurrence involving only the loading or unloading of cargo.

In order to help ensure that CNG fuel system inspections are completed as required after a commercial vehicle is involved in an accident, FMCSA should modify the current language of 49 CFR 390.15 as follows to require additional information to be reported for CNG vehicles. Proposed additions are underlined and italicized:

§390.15 Assistance in investigations and special studies:

> (a) A motor carrier must make all records and information pertaining to an accident available to an authorized representative or special agent of the Federal Motor Carrier Safety Administration, an authorized State or local enforcement agency representative, or an authorized third-party representative upon request or as part of any investigation within such time as the request or investigation may specify. A motor carrier shall give an authorized representative all reasonable assistance in the investigation of any accident, including providing a full, true, and correct response to any question of the inquiry.

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[20] As noted previously, there is no similar industry consensus as to minimum inspection intervals or requalification tests required for LNG fuel containers. Even PHMSA regulations do not include specific inspection and requalification requirements for DOT 4L cylinders, which is the specification currently mandated by NFPA 52 for vehicular LNG fuel containers.

(b) For accidents that occur after April 29, 2003, motor carriers must maintain an accident register for 3 years after the date of each accident. For accidents that occurred on or prior to April 29, 2003, motor carriers must maintain an accident register for a period of 1 year after the date of each accident. Information placed in the accident register must contain at least the following:

(1) A list of accidents as defined at §390.5 of this chapter containing for each accident:

(i) Date of accident.

(ii) City or town, or most near, where the accident occurred and the State where the accident occurred.

(iii) Driver Name.

(iv) Number of injuries.

(v) Number of fatalities.

(vi) Whether hazardous materials, other than fuel spilled from the fuel tanks of motor vehicle involved in the accident, were released.

(vii) Fuel type of vehicle involved: diesel, gasoline, CNG, LNG, LPG (propane), or other (if "other," please specify).

(viii) If the commercial vehicle involved in the accident has a CNG fuel system, the date after the accident that the fuel system was re-inspected for damage by a qualified natural gas fuel system inspector shall be reported with the accident.

(2) Copies of all accident reports required by State or other governmental entities or insurers:

(i) If the commercial vehicle involved in the accident has a CNG fuel system, a copy of the fuel system inspection report completed by a qualified natural gas fuel system inspector after the accident shall be included or attached to the accident report.

7.1.5 Require Labeling for NGV Conversions

In some cases, it is possible to convert a vehicle originally manufactured and sold with a diesel or gasoline fuel system to natural gas operation. This is generally referred to as "conversion," and the companies doing the work are referred to as "converters." If the conversion takes place after a vehicle has been sold to the end customer, the company doing the conversion is not subject to the vehicle certification and labeling requirements included in the Code of Federal Regulations, Title 49, Part 567. These regulations apply only to vehicle manufacturers, including vehicle alterers who manufacture or alter vehicles before the first retail sale.

In order to ensure that commercial vehicles converted to natural gas operation are properly identified, FMCSA should require all vehicle converters to install a permanent, weatherproof label in the vicinity of the fuel fill port which identifies the vehicle as having been converted to natural gas operation and includes the fuel system installer's name or company name, address, phone number, and email address; includes the date of conversion, and indicates that the conversion was completed in accordance with all applicable FMCSRs (with specific references to the Code of Federal Regulations).

7.1.6 Modify Requirements for Driver Inspections and Reports, to Include Fuel System

49 CFR 396.11, Driver Vehicle Inspection Report(s), mandates that every commercial driver make a written report at the end of his shift specifying whether or not certain specific components/systems on his vehicle are in good working order. The fuel system is not included in the current list of minimum systems/components that must be checked.

49 CFR 396.13, Driver Inspection, mandates that at the beginning of his shift a commercial driver review the report written by the previous driver, and ensure that the vehicle is "in safe working condition" by, among other things, ensuring that defects noted previously have been repaired.

FMCSA should modify the current language of 49 CFR 396.11 to specifically add the following to the list of components and systems to be checked: "Fuel containers and related fuel system components, including, for natural gas vehicles, pressure relief devices (PRD), pressure relief valves (PRV), and PRD/PRV outlets." This will ensure that commercial vehicle drivers regularly check the condition of fuel containers and fuel system components on CNG and LNG vehicles between triennial inspections.

7.2 NAS INSPECTION PROCEDURES AND OOS CRITERIA

7.2.1 NGV Fuel System Inspection

FMCSA should work with the CVSA to modify the North American Standard Inspection Procedures to clarify what items an inspector should look for when inspecting a natural gas-powered commercial vehicle.

The following is a list of recommended inspection items to add:

- The inspector should verify that each CNG fuel cylinder is equipped with a pressure relief device (PRD) and that each LNG fuel container is equipped with a pressure relief valve (PRV), and that these devices are not damaged.
- The inspector should verify that each PRD or PRV is equipped with a vent line that will direct venting gas in a safe direction such that venting gas will not enter a wheel well, passenger compartment, or cargo compartment, and not be directed toward the vehicle exhaust or components that are hot in normal operation, or toward other ignition sources. The inspector should verify that vent lines are secured to the vehicle and are not broken, dented, crimped, or plugged with dirt or water.

- The inspector should verify that each CNG or LNG fuel container is equipped with a manual or automatic shutoff valve.
- The inspector should verify that the vehicle has the following labels:
  - "Blue diamond" label on front and lower rear of vehicle and below the USDOT number on each side of the power unit.
  - Label containing fuel system technical information in vicinity of fuel fill.
- For CNG vehicles, inspector should review the label near the fuel fill to ensure that the expiration date of the CNG fuel cylinders has not passed, and that the fuel system has been inspected by a qualified inspector within the past 36 months. The inspector should ask the driver to provide the inspection report from the last qualified inspection to verify the date.

  For CNG vehicles, the inspector should verify that if fuel containers are installed underneath a vehicle or next to the cab of the power unit, they are protected by a shield or guard to preclude damage from road hazards and cargo loading/unloading. The inspector should verify that the guard or shield is not touching the fuel container and that no debris has collected between the guard and the container. The inspector should evaluate the exterior surface of the guard or shield for large dents or tears that might indicate damage to the surface of the container.

  NOTE: inspector shall exercise discretion as to thoroughness of fuel container inspection based on relative risk of damage posed by mounting location on the vehicle and general condition of vehicle and fuel container shield.

- For LNG vehicles and CNG vehicles that carry un-odorized gas, the inspector should verify that the vehicle is equipped with a functional methane detection system.

  NOTE: include only if FMCSA mandates such systems—see Section 7.1.1.

- For LNG vehicles, the inspector should verify that each LNG fuel container is equipped with a liquid level gauge, visible to someone fueling the vehicle, or other device to indicate when the container has been filled to its maximum liquid volume.

7.2.2 NGV OOS Criteria

FMCSA should modify the Code of Federal Regulations, Title 49, Chapter III, Subchapter B, Appendix G, to add the following additional "defects or deficiencies in a vehicle fuel system" which would cause it to "not pass an inspection."

- For commercial vehicles equipped with a CNG fuel system:
  - Missing, damaged, or inoperable PRD on any fuel cylinder.
  - Missing, damaged, or inoperable shutoff valve on any fuel cylinder.
  - Missing, damaged, or unsecured PRD vent lines, or PRD vent lines installed such that venting gas would enter a wheel well or the passenger or cargo compartment, or would affect the vehicle exhaust or any part of the vehicle that is hot in normal operation.

  - Missing or illegible blue diamond vehicle labels or fuel system information label.
  - CNG fuel cylinder beyond its manufacturer expiration date.
  - CNG fuel cylinder not inspected by a qualified inspector in the past 36 months.
  - CNG fuel cylinder or other fuel system components with verified Level 2 or Level 3 damage in accordance with Compressed Gas Association publication *CGA C-6.4, Methods for External Visual Inspection of Natural Gas Vehicle (NGV) and Hydrogen Vehicle (HV) Fuel Containers and Their Installations.*

- For commercial vehicles equipped with an LNG fuel system:
  - Missing, damaged, or inoperable PRV on any fuel cylinder.
  - Missing, damaged, or inoperable shutoff valve on any fuel cylinder.
  - Missing, damaged, or unsecured PRV vent lines, or PRV vent lines installed such that venting gas would enter a wheel well or the passenger or cargo compartment, or would affect the vehicle exhaust or any part of the vehicle that is hot in normal operation.
  - Missing or illegible blue diamond vehicle labels or fuel system information label.
  - Missing or inoperable device to indicate when each LNG fuel container has been filled to its maximum liquid volume.
  - Missing or inoperable methane detection system.
    NOTE: include only if FMCSA mandates such systems—see Section 7.1.1.

In addition, FMCSA should work with the CVSA to modify the OOS criteria used with the NAS inspection procedures to identify additional defects in natural gas vehicle fuel systems that would be cause for a vehicle to be issued a repair ticket or put OOS.

Consistent with feedback received during the site visits, we recommend that CVSA identify two levels of defects in natural gas fuel systems: 1) Major Defects that pose an imminent hazard and for which a vehicle would be put OOS, and 2) Minor Defects that do not pose an imminent hazard but which must be corrected within a specific time period.

The recommended list of Major Defects in natural gas fuel systems includes:

- Any CNG fuel cylinder with missing or damaged PRD, or any LNG fuel container with missing or damaged PRV.
- Any verified leak of natural gas from any fuel system component.
- Any CNG fuel container with verified Level 2 or Level 3 damage in accordance with CGA C-6.4.
- On vehicles with LNG fuel systems: missing, damaged, or unsecured PRV vent lines, or PRV vent lines installed such that venting gas would enter a wheel well or the passenger or cargo compartment, or would impact the vehicle exhaust or any part of the vehicle that is hot in normal operation, or would impact any ignition source.
- Any missing, damaged, or inoperable shutoff valve on any CNG or LNG fuel container.

- Any missing, damaged, or inoperable liquid level gauge on an LNG fuel container (used to indicate when a container has been filled to its maximum liquid volume).
- LNG liquid (not vapor) discharging from a PRV or PRV vent line.

The recommended list of Minor Defects in natural gas fuel systems includes:

- On vehicles with CNG fuel systems: missing, damaged, or unsecured PRD vent lines, or PRD vent lines installed such that venting gas would enter a wheel well or the passenger or cargo compartment, or would impact the vehicle exhaust or any part of the vehicle that is hot in normal operation, or would impact any ignition source.
- Missing or illegible blue diamond vehicle labels or fuel system information label.
- CNG fuel cylinder not inspected by a qualified inspector in the past 36 months.
- Any CNG fuel container beyond its manufacturer expiration date.[21]
- For vehicles with LNG fuel system: missing or inoperable methane detection system. *NOTE: include only if FMCSA mandates such systems—see Section 7.1.1.*
- Any CNG fuel container with suspected Level 2 or Level 3 damage in accordance with CGA C-6.4.
- Visible frost covering greater than some specified percentage (e.g., 25 percent) of an LNG fuel container.[22]

Please note that the above proposed list of minor defects includes any CNG cylinder with suspected Level 2 or Level 3 damage, and the proposed list of major defects includes any CNG cylinder with verified Level 2 or Level 3 damage. Several peer reviewers recommended that both "suspected" and "verified" Level 2 or Level 3 damage be considered a major defect, triggering an OOS order. The performing organization chose to keep the noted distinction in the final recommendations because it recognizes the practical reality that most commercial vehicle law enforcement officials will not be fully trained in CNG cylinder inspection procedures and therefore may not be able to accurately "verify" the level of damage on a CNG cylinder. Nonetheless it is appropriate to allow these officers to exercise professional discretion, based on whatever level of training they have, to issue commercial vehicle operators a ticket that will

[21] Keeping a CNG fuel cylinder in service beyond the manufacturer expiration date does not automatically create an "imminent hazard," which is why this was included in the list of minor, rather than major, defects. However, there is a danger that a vehicle operator might continue to collect "tickets" and never remove the cylinder from service if the penalty for doing so does not increase. It would seem reasonable to give vehicle owners some "grace period"—for example 6 months after expiration—during which time it would be treated as a minor infraction, but that after the grace period an inspector could place the vehicle OOS for an expired cylinder.

[22] The intent of this OOS criterion is that excessive frost on an LNG tank would indicate that the tank insulation had been compromised to the point that the tank would exhibit excessive natural gas venting, thus creating a safety hazard. One peer reviewer recommended a value of 25 percent for this metric, but the authors could not identify an industry-reviewed source or standard to support it. This issue should be raised with appropriate standards organizations, such as NFPA, for consideration.

require them to get an inspection by a qualified inspector if there is “suspected” damage. This seems to be a reasonable compromise that will allow law enforcement officers to remove from service those vehicles which clearly present an imminent hazard, while minimizing “nuisance” OOS designations that are based on inexperience or lack of specific training.

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APPENDIX A—CURRENT FMCSRs RELATED TO NGVs

Title 49: Transportation
PART 392—DRIVING OF COMMERCIAL MOTOR VEHICLES
Subpart A—General

§ 392.7 Equipment, inspection and use.

(a) No commercial motor vehicle shall be driven unless the driver is satisfied that the following parts and accessories are in good working order, nor shall any driver fail to use or make use of such parts and accessories when and as needed:

- Service brakes, including trailer brake connections.
- Parking (hand) brake.
- Steering mechanism.
- Lighting devices and reflectors.
- Tires.
- Horn.
- Windshield wiper or wipers.
- Rear-vision mirror or mirrors.
- Coupling devices.

Title 49: Transportation
PART 392—DRIVING OF COMMERCIAL MOTOR VEHICLES
Subpart F—Fueling Precautions

§ 392.50 Ignition of fuel; prevention.

No driver or any employee of a motor carrier shall:

(a) Fuel a commercial motor vehicle with the engine running, except when it is necessary to run the engine to fuel the commercial motor vehicle;

(b) Smoke or expose any open flame in the vicinity of a commercial motor vehicle being fueled;

(c) Fuel a commercial motor vehicle unless the nozzle of the fuel hose is continuously in contact with the intake pipe of the fuel tank;

(d) Permit, insofar as practicable, any other person to engage in such activities as would be likely to result in fire or explosion.

[33 FR 19732, Dec. 25, 1968, as amended at 60 FR 38747, July 28, 1995]

Title 49: Transportation
PART 392—DRIVING OF COMMERCIAL MOTOR VEHICLES
Subpart F—Fueling Precautions

§ 392.51 Reserve fuel; materials of trade.

Small amounts of fuel for the operation or maintenance of a commercial motor vehicle (including its auxiliary equipment) may be designated as materials of trade (see 49 CFR 171.8).

(a) The aggregate gross weight of all materials of trade on a motor vehicle may not exceed 200 kg (440 pounds).

(b) Packaging for gasoline must be made of metal or plastic and conform to requirements of 49 CFR Parts 171, 172, 173, and 178 or requirements of the Occupational Safety and Health Administration contained in 29 CFR 1910.106.

(c) For Packing Group II (including gasoline), Packing Group III (including aviation fuel and fuel oil), or ORM-D, the material is limited to 30 kg (66 pounds) or 30 L (8 gallons).

(d) For diesel fuel, the capacity of the package is limited to 450 L (119 gallons).

(e) A Division 2.1 material in a cylinder is limited to a gross weight of 100 kg (220 pounds). (A Division 2.1 material is a flammable gas, including liquefied petroleum gas, butane, propane, liquefied natural gas, and methane).

[63 FR 33279, June 18, 1998]

Title 49: Transportation
PART 393—PARTS AND ACCESSORIES NECESSARY FOR SAFE OPERATION
Subpart E—Fuel Systems

Authority: Sec. 204, Interstate Commerce Act, as amended, 49 U.S.C. 304; Sec. 6, Department of Transportation Act, 49 U.S.C. 1655; delegation of authority at 49 CFR 1.48 and 389.4.

§ 393.65 All fuel systems.

(a) *Application of the rules in this section.* The rules in this section apply to systems for containing and supplying fuel for the operation of motor vehicles or for the operation of auxiliary equipment installed on, or used in connection with, motor vehicles.

(b) *Location.* Each fuel system must be located on the motor vehicle so that—

(1) No part of the system extends beyond the widest part of the vehicle;

(2) No part of a fuel tank is forward of the front axle of a power unit;

(3) Fuel spilled vertically from a fuel tank while it is being filled will not contact any part of the exhaust or electrical systems of the vehicle, except the fuel level indicator assembly;

(4) Fill pipe openings are located outside the vehicle's passenger compartment and its cargo compartment;

(5) A fuel line does not extend between a towed vehicle and the vehicle that is towing it while the combination of vehicles is in motion; and

(6) No part of the fuel system of a bus manufactured on or after January 1, 1973, is located within or above the passenger compartment.

(c) *Fuel tank installation.* Each fuel tank must be securely attached to the motor vehicle in a workmanlike manner.

(d) *Gravity or syphon feed prohibited.* A fuel system must not supply fuel by gravity or syphon feed directly to the carburetor or injector.

(e) *Selection control valve location.* If a fuel system includes a selection control valve which is operable by the driver to regulate the flow of fuel from two or more fuel tanks, the valve must be installed so that either—

(1) The driver may operate it while watching the roadway and without leaving his/her driving position; or

(2) The driver must stop the vehicle and leave his/her seat in order to operate the valve.

(f) *Fuel lines.* A fuel line which is not completely enclosed in a protective housing must not extend more than 2 inches below the fuel tank or its sump. Diesel fuel crossover, return, and withdrawal lines which extend below the bottom of the tank or sump must be protected against damage from impact. Every fuel line must be—

(1) Long enough and flexible enough to accommodate normal movements of the parts to which it is attached without incurring damage; and

(2) Secured against chafing, kinking, or other causes of mechanical damage.

(g) *Excess flow valve.* When pressure devices are used to force fuel from a fuel tank, a device which prevents the flow of fuel from the fuel tank if the fuel feed line is broken must be installed in the fuel system.

[36 FR 15445, Aug. 14, 1971, as amended at 37 FR 4341, Mar. 2, 1972; 37 FR 28752, Dec. 29, 1972]

§ 393.67 Liquid fuel tanks.

(a) *Application of the rules in this section.* The rules in this section apply to tanks containing or supplying fuel for the operation of commercial motor vehicles or for the operation of auxiliary equipment installed on, or used in connection with commercial motor vehicles.

(1) A liquid fuel tank manufactured on or after January 1, 1973, and a side-mounted gasoline tank must conform to all rules in this section.

(2) A diesel fuel tank manufactured before January 1, 1973, and mounted on a bus must conform to the rules in paragraphs (c)(7)(iii) and (d)(2) of this section.

(3) A diesel fuel tank manufactured before January 1, 1973, and mounted on a vehicle other than a bus must conform to the rules in paragraph (c)(7)(iii) of this section.

(4) A gasoline tank, other than a side-mounted gasoline tank, manufactured before January 1, 1973, and mounted on a bus must conform to the rules in paragraphs (c)(1) through (10) and (d)(2) of this section.

(5) A gasoline tank, other than a side-mounted gasoline tank, manufactured before January 1, 1973, and mounted on a vehicle other than a bus must conform to the rules in paragraphs (c)(1) through (10), inclusive, of this section.

(6) Private motor carrier of passengers. Motor carriers engaged in the private transportation of passengers may continue to operate a commercial motor vehicle which was not subject to this section or 49 CFR 571.301 at the time of its manufacture, provided the fuel tank of such vehicle is maintained to the original manufacturer's standards.

(7) Motor vehicles that meet the fuel system integrity requirements of 49 CFR 571.301 are exempt from the requirements of this subpart, as they apply to the vehicle's fueling system.

(b) *Definitions.* As used in this section—

(1) The term *liquid fuel tank* means a fuel tank designed to contain a fuel that is liquid at normal atmospheric pressures and temperatures.

(2) A *side-mounted* fuel tank is a liquid fuel tank which—

(i) If mounted on a truck tractor, extends outboard of the vehicle frame and outside of the plan view outline of the cab; or

(ii) If mounted on a truck, extends outboard of a line parallel to the longitudinal centerline of the truck and tangent to the outboard side of a front tire in a straight ahead position. In determining whether a fuel tank on a truck or truck tractor is side-mounted, the fill pipe is not considered a part of the tank.

(c) *Construction of liquid fuel tanks—*

(1) *Joints.* Joints of a fuel tank body must be closed by arc-, gas-, seam-, or spot-welding, by brazing, by silver soldering, or by techniques which provide heat resistance and mechanical securement at least equal to those specifically named. Joints must not be closed solely by crimping or by soldering with a lead-based or other soft solder.

(2) *Fittings.* The fuel tank body must have flanges or spuds suitable for the installation of all fittings.

(3) *Threads.* The threads of all fittings must be Dryseal American Standard Taper Pipe Thread or Dryseal SAE Short Taper Pipe Thread, specified in Society of Automotive Engineers Standard J476, as contained in the 1971 edition of the "SAE Handbook," except that straight (non-tapered) threads may be used on fittings having integral flanges and using gaskets for sealing. At least four full threads must be in engagement in each fitting.

(4) *Drains and bottom fittings.*

(i) Drains or other bottom fittings must not extend more than three-fourths of an inch below the lowest part of the fuel tank or sump.

(ii) Drains or other bottom fittings must be protected against damage from impact.

(iii) If a fuel tank has drains, the drain fittings must permit substantially complete drainage of the tank.

(iv) Drains or other bottom fittings must be installed in a flange or spud designed to accommodate it.

(5) *Fuel withdrawal fittings.* Except for diesel fuel tanks, the fittings through which fuel is withdrawn from a fuel tank must be located above the normal level of fuel in the tank when the tank is full.

(6) [Reserved]

(7) *Fill pipe.*

(i) Each fill pipe must be designed and constructed to minimize the risk of fuel spillage during fueling operations and when the vehicle is involved in a crash.

(ii) For diesel-fueled vehicles, the fill pipe and vents of a fuel tank having a capacity of more than 94.75 L (25 gallons) of fuel must permit filling the tank with fuel at a rate of at least 75.8 L/m (20 gallons per minute) without fuel spillage.

(iii) For gasoline- and methanol-fueled vehicles with a GVWR of 3,744 kg (8,500 pounds) or less, the vehicle must permit filling the tank with fuel dispensed at the applicable fill rate required by the regulations of the Environmental Protection Agency under 40 CFR 80.22.

(iv) For gasoline- and methanol-fueled vehicles with a GVWR of 14,000 pounds (6,400 kg) or less, the vehicle must comply with the applicable fuel-spitback prevention and onboard refueling vapor recovery regulations of the Environmental Protection Agency under 40 CFR part 86.

(v) Each fill pipe must be fitted with a cap that can be fastened securely over the opening in the fill pipe. Screw threads or a bayonet-type point are methods of conforming to the requirements of paragraph (c) of this section.

(8) *Safety venting system.* A liquid fuel tank with a capacity of more than 25 gallons of fuel must have a venting system which, in the event the tank is subjected to fire, will prevent internal tank pressure from rupturing the tank's body, seams, or bottom opening (if any).

(9) *Pressure resistance.* The body and fittings of a liquid fuel tank with a capacity of more than 25 gallons of fuel must be capable of withstanding an internal hydrostatic pressure equal to 150 percent of the maximum internal pressure reached in the tank during the safety venting systems test specified in paragraph (d)(1) of this section.

(10) *Air vent.* Each fuel tank must be equipped with a nonspill air vent (such as a ball check). The air vent may be combined with the fill-pipe cap or safety vent, or it may be a separate unit installed on the fuel tank.

(11) *Markings.* If the body of a fuel tank is readily visible when the tank is installed on the vehicle, the tank must be plainly marked with its liquid capacity. The tank must also be plainly marked with a warning against filling it to more than 95 percent of its liquid capacity.

(12) *Overfill restriction.* A liquid fuel tank manufactured on or after January 1, 1973, must be designed and constructed so that—

(i) The tank cannot be filled, in a normal filling operation, with a quantity of fuel that exceeds 95 percent of the tank's liquid capacity; and

(ii) When the tank is filled, normal expansion of the fuel will not cause fuel spillage.

(d) *Liquid fuel tank tests.* Each liquid fuel tank must be capable of passing the tests specified in paragraphs (d)(1) and (2) of this section. The specified tests are a measure of performance only. Alternative procedures which assure that equipment meets the required performance standards may be used.

(1) *Safety venting system test—*

(i) *Procedure.* Fill the tank three-fourths full with fuel, seal the fuel feed outlet, and invert the tank. When the fuel temperature is between 50° F and 80° F, apply an enveloping flame to the tank so that the temperature of the fuel rises at a rate of not less than 6° F and not more than 8° F per minute.

(ii) *Required performance.* The safety venting system required by paragraph (c)(8) of this section must activate before the internal pressure in the tank exceeds 50 pounds per square inch, gauge, and the internal pressure must not thereafter exceed the pressure at which the system activated by more than 5 pounds per square inch despite any further increase in the temperature of the fuel.

(2) *Leakage test—*

(i) *Procedure.* Fill the tank to capacity with fuel having a temperature between 50° F and 80° F. With the fill-pipe cap installed, turn the tank through an angle of 150° in any direction about any axis from its normal position.

(ii) *Required performance.* Neither the tank nor any fitting may leak more than a total of 1 ounce by weight of fuel per minute in any position the tank assumes during the test.

(e) *Side-mounted liquid fuel tank tests.* Each side-mounted liquid fuel tank must be capable of passing the tests specified in paragraphs (e)(1) and (2) of this section and the test specified in paragraphs (d)(1) and (2) of this section. The specified tests are a measure of performance only. Alternative procedures which assure that equipment meets the required performance criteria may be used.

(1) *Drop test—*

(i) *Procedure.* Fill the tank with a quantity of water having a weight equal to the weight of the maximum fuel load of the tank and drop the tank 30 feet onto an unyielding surface so that it lands squarely on one corner.

(ii) *Required performance.* Neither the tank nor any fitting may leak more than a total of 1 ounce by weight of water per minute.

(2) *Fill-pipe test—*

(i) *Procedure.* Fill the tank with a quantity of water having a weight equal to the weight of the maximum fuel load of the tank and drop the tank 10 feet onto an unyielding surface so that it lands squarely on its fill-pipe.

(ii) *Required performance.* Neither the tank nor any fitting may leak more than a total of 1 ounce by weight of water per minute.

(f) *Certification and markings.* Each liquid fuel tank shall be legibly and permanently marked by the manufacturer with the following minimum information:

(1) The month and year of manufacture,

(2) The manufacturer's name on tanks manufactured on and after July 1, 1989, and means of identifying the facility at which the tank was manufactured, and

(3) A certificate that it conforms to the rules in this section applicable to the tank. The certificate must be in the form set forth in either of the following:

(i) If a tank conforms to all rules in this section pertaining to side-mounted fuel tanks: "Meets all FMCSA side-mounted tank requirements."

(ii) If a tank conforms to all rules in this section pertaining to tanks which are not side-mounted fuel tanks: "Meets all FMCSA requirements for non-side-mounted fuel tanks."

(iii) The form of certificate specified in paragraph (f)(3)(i) or (ii) of this section may be used on a liquid fuel tank manufactured before July 11, 1973, but it is not mandatory for liquid fuel tanks manufactured before March 7, 1989. The form of certification manufactured on or before March 7, 1989, must meet the requirements in effect at the time of manufacture.

(4) *Exception.* The following previously exempted vehicles are *not* required to carry the certification and marking specified in paragraphs (f)(1) through (3) of this section:

(i) Ford vehicles with GVWR more than 10,000 pounds identified as follows: The vehicle identification numbers (VINs) contain A, K, L, M, N, W, or X in the fourth position.

(ii) GM G-Vans (Chevrolet Express and GMC Savanna) and full-sized C/K trucks (Chevrolet Silverado and GMC Sierra) with GVWR over 10,000 pounds identified as follows: The VINs contain either a "J" or a "K" in the fourth position. In addition, the seventh position of the VINs on the G-Van will contain a "1."

§ 393.68 Compressed natural gas fuel containers.

(a) *Applicability.* The rules in this section apply to compressed natural gas (CNG) fuel containers used for supplying fuel for the operation of commercial motor vehicles or for the operation of auxiliary equipment installed on, or used in connection with commercial motor vehicles.

(b) *CNG containers manufactured on or after March 26, 1995.* Any motor vehicle manufactured on or after March 26, 1995, and equipped with a CNG fuel tank must meet the CNG container requirements of FMVSS No. 304 (49 CFR 571.304) in effect at the time of manufacture of the vehicle.

(c) *Labeling.* Each CNG fuel container shall be permanently labeled in accordance with the requirements of FMVSS No. 304, S7.4.

[70 FR 48053, Aug. 15, 2005]

Title 49: Transportation
PART 396—INSPECTION, REPAIR, AND MAINTENANCE

§ 396.3 Inspection, repair, and maintenance.

(a) *General.* Every motor carrier and intermodal equipment provider must systematically inspect, repair, and maintain, or cause to be systematically inspected, repaired, and maintained, all motor vehicles and intermodal equipment subject to its control.

(1) Parts and accessories shall be in safe and proper operating condition at all times. These include those specified in part 393 of this subchapter and any additional parts and accessories which may affect safety of operation, including but not limited to, frame and frame assemblies, suspension systems, axles and attaching parts, wheels and rims, and steering systems.

§ 396.7 Unsafe operations forbidden.

(a) *General.* A motor vehicle shall not be operated in such a condition as to likely cause an accident or a breakdown of the vehicle.

(b) *Exemption.* Any motor vehicle discovered to be in an unsafe condition while being operated on the highway may be continued in operation only to the nearest place where repairs can safely be effected. Such operation shall be conducted only if it is less hazardous to the public than to permit the vehicle to remain on the highway.

§ 396.9 Inspection of motor vehicles in operation.

(a) *Personnel authorized to perform inspections.* Every special agent of the FMCSA (as defined in Appendix B to this subchapter) is authorized to enter upon and perform inspections of a motor carrier's vehicles in operation and intermodal equipment in operation.

(b) *Prescribed inspection report.* The Driver Vehicle Examination Report shall be used to record results of motor vehicle inspections and results of intermodal equipment inspections conducted by authorized FMCSA personnel.

(c) *Motor vehicles declared "out of service."* (1) Authorized personnel shall declare and mark "out of service" any motor vehicle which by reason of its mechanical condition or loading would likely cause an accident or a breakdown. Authorized personnel may declare and mark "out of service" any motor vehicle not in compliance with §385.811(d). An "Out-of-Service Vehicle" sticker shall be used to mark vehicles "out of service."

§ 396.11 Driver vehicle inspection report(s).

(a) *Report required—*

(1) *Motor Carriers.* Every motor carrier shall require its drivers to report, and every driver shall prepare a report in writing at the completion of each day's work on each vehicle operated, except for intermodal equipment tendered by an intermodal equipment provider. The report shall cover at least the following parts and accessories:

—Service brakes including trailer brake connections.

—Parking brake.

—Steering mechanism.

—Lighting devices and reflectors.

—Tires.

—Horn.

—Windshield wipers.

—Rear vision mirrors.

—Coupling devices.

—Wheels and rims.

—Emergency equipment.

§ 396.13 Driver inspection.

Before driving a motor vehicle, the driver shall:

(a) Be satisfied that the motor vehicle is in safe operating condition;

(b) Review the last driver vehicle inspection report; and

(c) Sign the report, only if defects or deficiencies were noted by the driver who prepared the report, to acknowledge that the driver has reviewed it and that there is a certification that the required repairs have been performed. The signature requirement does not apply to listed defects on a towed unit which is no longer part of the vehicle combination.

[44 FR 76526, Dec. 27, 1979, as amended at 48 FR 55868, Dec. 16, 1983; 63 FR 33280, June 18, 1998]

§ 396.17 Periodic inspection.

(a) Every commercial motor vehicle must be inspected as required by this section. The inspection must include, at a minimum, the parts and accessories set forth in appendix G of this subchapter. The term *commercial motor vehicle* includes each vehicle in a combination vehicle. For example, for a tractor semitrailer, full trailer combination, the tractor, semitrailer, and the full trailer (including the converter dolly if so equipped) must each be inspected.

(b) Except as provided in §396.23 and this paragraph, motor carriers must inspect or cause to be inspected all motor vehicles subject to their control. Intermodal equipment providers must inspect or cause to be inspected intermodal equipment that is interchanged or intended for interchange to motor carriers in intermodal transportation.

(f) Vehicles passing roadside or periodic inspections performed under the auspices of any State government or equivalent jurisdiction or the FMCSA, meeting the minimum standards contained in Appendix G of this subchapter, will be considered to have met the requirements of an annual inspection for a period of 12 months commencing from the last day of the month in which the inspection was performed. If a vehicle is subject to a mandatory State inspection program, as provided in §396.23(b)(1), a roadside inspection may only be considered equivalent if it complies with the requirements of that program.

(h) Failure to perform properly the annual inspection required by this section shall cause the motor carrier or intermodal equipment provider to be subject to the penalty provisions of 49 U.S.C. 521(b).

[73 FR 76825, Dec. 17, 2008]

Title 49: Transportation
PART 399—EMPLOYEE SAFETY AND HEALTH STANDARDS

Appendix G to Subchapter B of Chapter III—Minimum Periodic Inspection Standards

A vehicle does not pass an inspection if it has one of the following defects or deficiencies:

(4) *Fuel System.*

(a) A fuel system with a visible leak at any point.

(b) A fuel tank filler cap missing.

(c) A fuel tank not securely attached to the motor vehicle by reason of loose, broken or missing mounting bolts or brackets (some fuel tanks use springs or rubber bushings to permit movement).

Comparison of Appendix G, and the new North American Uniform Driver-Vehicle Inspection Procedure (North American Commercial Vehicle Critical Safety Inspection Items and Out-Of-Service Criteria)

The vehicle portion of the FMCSA's North American Uniform Driver-Vehicle Inspection Procedure (NAUD-VIP) requirements, CVSA's North American Commercial Vehicle Critical Safety Inspection Items and Out-Of-Service Criteria, and Appendix G of subchapter B are similar documents and follow the same inspection procedures. The same items are required to be inspected by each document. FMCSA's and CVSA's out-of-service criteria are intended to be used in random roadside inspections to identify critical vehicle inspection items and provide criteria for placing a vehicle(s) out of service. A vehicle(s) is placed out of service only when by reason of its mechanical condition or loading it is determined to be so imminently hazardous as

to likely cause an accident or breakdown, or when such condition(s) would likely contribute to loss of control of the vehicle(s) by the driver. A certain amount of flexibility is given to the inspecting official whether to place the vehicle out of service at the inspection site or if it would be less hazardous to allow the vehicle to proceed to a repair facility for repair. The distance to the repair facility must not exceed 25 miles. The roadside type of inspection, however, does not necessarily mean that a vehicle has to be defect-free in order to continue in service.

In contrast, the Appendix G inspection procedure requires that all items required to be inspected are in proper adjustment, are not defective, and function properly prior to the vehicle being placed in service.

Differences Between the Out-of-Service Criteria & FMCSA's Annual Inspection:

4. *Fuel System.*

Same for Appendix G and the out-of-service criteria.

Title 49: Transportation
PART 390—FEDERAL MOTOR CARRIER SAFETY REGULATIONS; GENERAL
Subpart B—General Requirements and Information

§ 390.15 Assistance in investigations and special studies.

(a) Each motor carrier and intermodal equipment provider must do the following:

(1) Make all records and information pertaining to an accident available to an authorized representative or special agent of the Federal Motor Carrier Safety Administration, an authorized State or local enforcement agency representative, or authorized third party representative within such time as the request or investigation may specify.

(2) Give an authorized representative all reasonable assistance in the investigation of any accident, including providing a full, true, and correct response to any question of the inquiry.

(b) For accidents that occur after April 29, 2003, motor carriers must maintain an accident register for 3 years after the date of each accident. For accidents that occurred on or prior to April 29, 2003, motor carriers must maintain an accident register for a period of 1 year after the date of each accident. Information placed in the accident register must contain at least the following:

(1) A list of accidents as defined at §390.5 of this chapter containing for each accident:

(i) Date of accident.

(ii) City or town, or most near, where the accident occurred and the State where the accident occurred.

(iii) Driver Name.

(iv) Number of injuries.

(v) Number of fatalities.

(vi) Whether hazardous materials, other than fuel spilled from the fuel tanks of motor vehicle involved in the accident, were released.

(2) Copies of all accident reports required by State or other governmental entities or insurers.

(Approved by the Office of Management and Budget under control number 2126–0009).

[69 FR 16719, Mar. 30, 2004, as amended at 73 FR 76821, Dec. 17, 2008].

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APPENDIX C—LIST OF SITE VISIT PARTICIPANTS

Meeting 1: Sacramento, CA, October 27, 2011

NAME	COMPANY	TITLE
Dana Lowell	M.J. Bradley & Associates	Senior Consultant
Quon Kwan	Federal Motor Carrier Safety Administration	General Engineer
LT. George Steffanson	California Highway Patrol, Commercial Vehicle Section	Commander
Josh Clements	California Highway Patrol, Commercial Vehicle Section	Motor Carrier Specialist
Cullen Siskind	California Highway Patrol, Commercial Vehicle Section	Motor Carrier Specialist
Lee Bretney	California Highway Patrol, Commercial Vehicle Section	Commercial Vehicle Equipment Coordinator

Meeting 2: Washington DC, January 25, 2012

NAME	COMPANY	TITLE
Dana Lowell	M.J. Bradley & Associates	Senior Consultant
Quon Kwan	Federal Motor Carrier Safety Administration	General Engineer
Tim Blubaugh	Truck & Engine Manufacturers Association	Executive Vice President
Tahra Jutt	Westport Innovations, Inc.	Manager, Government & Regulatory Affairs
Mihai Ursan	Westport Innovations, Inc.	Senior Engineer
Gregory Rymarz	Federal Transit Administration	TRI-Bus Testing

Meeting 3: Washington DC, February 1, 2012

NAME	COMPANY	TITLE
Dana Lowell	M.J. Bradley & Associates	Senior Consultant
Quon Kwan	Federal Motor Carrier Safety Administration	General Engineer
Luke Loy	Federal Motor Carrier Safety Administration	Senior Engineer
Greg Powell	National Highway Traffic Safety Administration	
Shashi Koppa	National Highway Traffic Safety Administration	

Check Kam	National Highway Traffic Safety Administration	
James MacIsaac	National Highway Traffic Safety Administration	General Engineer
Barb Hennessey	National Highway Traffic Safety Administration	Physical Scientist

Meeting 4: Denton, TX, February 7, 2012

NAME	COMPANY	TITLE
Dana Lowell	M.J. Bradley & Associates	Senior Consultant
Andy Hoflich	Peterbilt Motors Company	Senior Design Engineer
Brian Fuerstenberg	Peterbilt Motors Company	Engineering Group Lead
Frank Schneck	Peterbilt Motors Company	Engineering Manager
Rod Curbo	Peterbilt Motors Company	Product Safety & Compliance Manager
Joey Wilson	Peterbilt Motors Company	Assoc. Design Engineer
Wayne Wilson	Peterbilt Motors Company	Senior Project Engineer
Chris Paris	Kenworth Truck Company	
Bob Griffith	Kenworth Truck Company	
Alejandro Mosarra	Kenworth Truck Company	

Meeting 5: Dallas, TX, February 8, 2012

NAME	COMPANY	TITLE
Dana Lowell	M.J. Bradley & Associates	Senior Consultant
Mike Luzader	BAF Techologies	Engineering Manager
Neil Chilvers	BAF Techologies	Service Director
Brent Pope	BAF Techologies	Sales Director
Jim Ellis	BAF Techologies	Quality Manager
Paul Shaffer	BAF Techologies	VP Operations

Meeting 6: Compton, CA, March 7, 2012

NAME	COMPANY	TITLE
Dana Lowell	M.J. Bradley & Associates	Senior Consultant
Quon Kwan	Federal Motor Carrier Safety Administration	General Engineer
Frank Spingola	Ryder Systems, Inc.	Group Director, Safety
Cheryl Sunshine	Ryder Systems, Inc.	Director, Operations
Travis Homer	Ryder Systems, Inc.	Sr. Manager, Safety
Jerry Conrad	Ryder Systems, Inc.	Director, Operations

Meeting 7: Los Angeles, CA, March 8, 2012

NAME	COMPANY	TITLE
Dana Lowell	M.J. Bradley & Associates	Senior Consultant
Quon Kwan	Federal Motor Carrier Safety Administration	General Engineer
James Pachan	Los Angeles County Metropolitan Transportation Authority	Director, Customer Programs
Philip Rabottini	Los Angeles County Metropolitan Transportation Authority	Sr. Engineer, Vehicle Technology
John Drayton	Los Angeles County Metropolitan Transportation Authority	Manager, Vehicle Technology
Mike Strange	Los Angeles County Metropolitan Transportation Authority	Deputy Executive Officer, Operations
George Karbowski	Foothill Transit	Director, Operations and Maintenance
Vicky Vargas	Foothill Transit	Operations Manager

Meeting 8: San Pedro, CA, March 8, 2012

NAME	COMPANY	TITLE
Dana Lowell	M.J. Bradley & Associates	Senior Consultant
Quon Kwan	Federal Motor Carrier Safety Administration	General Engineer
Tim DeMoss	Port of Los Angeles	Clean Truck Program Manager
Chris Cannon	Port of Los Angeles	Director, Environmental Management Division

Meeting 9: Ball Ground, GA, April 12, 2012

NAME	COMPANY	TITLE
Dana Lowell	M.J. Bradley & Associates	Senior Consultant
Peter Murray	Chart, Inc.	Product Manager LNG Vehicle Fuel Systems
Bruce Keneagy	Chart, Inc.	Manager LNG Vehicle Fuel Systems
Kema Gusapoon	Chart, Inc.	

Meeting 10: Conference call, April 13, 2012

NAME	COMPANY	TITLE
Dana Lowell	M.J. Bradley & Associates	Senior Consultant
Quon Kwan	Federal Motor Carrier Safety Administration	General Engineer
Tim Blubaugh	Truck & Engine Manufacturers Association	Executive Vice President

Meeting 11: Portland, OR, April 25, 2012

NAME	COMPANY	TITLE
Dana Lowell	M.J. Bradley & Associates	Senior Consultant
Quon Kwan	Federal Motor Carrier Safety Administration	General Engineer
Mike Mallott	Daimler Trucks North America, LLC	Manager Training Development
Sean Waters	Daimler Trucks North America, LLC	Director Compliance
Nasser Zamani	Daimler Trucks North America, LLC	Senior Manager Compliance & Regulatory Affairs
Bob Johnson	Daimler Trucks North America, LLC	Senior Designer Compliance & Regulatory Affairs
Tobiah Halter	Daimler Trucks North America, LLC	Project Manager Engineering
Mark Siddall	Daimler Trucks North America, LLC	Senior Team Leader Compliance & Regulatory Affairs
Leah Goodman	Daimler Trucks North America, LLC	
Jason Tim	Daimler Trucks North America, LLC	Power Train Engineer

Meeting 12: Bellevue, WA, April 26, 2012

NAME	COMPANY	TITLE
Dana Lowell	M.J. Bradley & Associates	Senior Consultant
Steven Smith	Federal Motor Carrier Safety Administration	Director, Office of Analysis, Research, and Technology
Luke Loy	Federal Motor Carrier Safety Administration	Senior Engineer
Members of Commercial Vehicle Safety Alliance Vehicle Committee		

Meeting 13: Rancho Dominguez, CA, May 7, 2012

NAME	COMPANY	TITLE
Dana Lowell	M.J. Bradley & Associates	Senior Consultant
Brian Griley	Southern Counties Express	President
Yoshio Coy	Agility Fuel Systems	Program Manager
Fred Johring	Golden State Express	President
Toby Slayman	Green Fleet Systems	General Manager
Robert Lilja	The Dependable Companies	Director
Vic LaRosa	TTSI	President
Paul Kerwin	Southern Counties Express	Director
Elias Gonzales	Southern Counties Express	
Sophia Park	Harbor Express	Director

Meeting 14: Long Beach, CA, May 7, 2012

NAME	COMPANY	TITLE
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