CNG Fuel System Inspector

Study Guide

Sponsored by:
National Energy Technology Laboratory
U.S. Department of Energy
DE-FC26-05NT426-08

Contract Manager:

Clean Vehicle Education Foundation

Point of Contact: Doug Horne
President
770-424-8575
FAX: 770-424-8575
dbhorne@cleanvehicle.org

Submitted by:

AFV International LLC

ADVANCED TRANSPORTATION TECHNOLOGY

Acknowledgments

It is a privilege to work on such a relevant and exciting effort as this. Energy independence, environmental, and technology transfer issues are at the heart of a dynamic and mobile society and were at the heart of the project.

Safety issues associated with the health and quality of the natural gas vehicle industry were the initial goals of the project. But a slightly different, perhaps more profound spirit emerged as we began our work. We soon came to recognize a higher purpose to support and encourage a 'movement' to participate in a larger mission, improving an industry that can significantly impact our world. This movement comprised individuals and companies, loosely organized advocates, officials, technical experts, and practitioners – each contributing a positive energy to help place alternative fuels higher on America's agenda.

The material presented in this study guide could not have been collected without the cooperation of numerous alternative fuel industry representatives, committees, and individuals. From these sources, technical details and graphic examples were always forthcoming. Time was freely given to review text or participate in development sessions.

The funding to develop this material came from a grant from the U.S. Department of Energy, under the leadership of Mr. Hank Seiff, Technical Director for the Clean Vehicle Education Foundation.

Additional support came from the United States standards development organization CSA-America, Inc. Spearheading this effort was Mr. Mike Dickerson, Product Manager, Personnel Certification. With his patient guidance throughout the process we were able to complete a rigorous series of meetings and numerous conference calls culminating in a well developed examination and certification program for the CNG Fuel System Inspector.

The following individuals and institutions contributed significantly to this text:

Clean Vehicle Education Foundation	Mr. Hank Seiff
Long Beach Community College	Mr. Cal Macy
Advanced Technology Training Centers	Mr. Peter Davis

To these and all of those who participated in this project, thank you for your efforts and we hope you will find the result a contribution to your good work.

William H. 'Bill' McGlinchey
AFV International Llc
Lancaster, OH
(740) 205-2107
w.mcglinchey@att.net

About CSA America

CSA America, Inc. is well known as the standards writing body in the United States for gas appliances and accessories and alternative energy products. It had its origins in this country as the American Gas Association Labs. Now they are part of CSA-International with laboratories all over the country. The offices for this program are in Cleveland, OH.

CSA America Inc.
8501 East Pleasant Valley Road
Cleveland, OH 44131-5575
Tel: (216) 524-4990
Fax: (216) 520-8979
http://csa-america.org

In 2006 CSA-America assumed the administration of the CNG Cylinder Inspector Certification program from CSA International with the goal of strengthening the content, administration, systems and procedures. Since then, CSA America has been working to update and improve the CNG Cylinder Inspector Certification program. The new program was made available August 1, 2008 as the CNG Fuel System Inspector Certification program and follows the International Organization for Standardization (ISO) 17024 Conformity Assessment standard, the global benchmark for personnel certification programs.

About the Exam

The exam represents the conclusion of two years of development, several workshops convened across the country and many more conference calls among a group of dedicated industry professionals. The CNG Fuel System Inspector Certification is on a three year re-examination cycle. Those CNG Cylinder Inspectors certified under the older version (prior to 8/1/2008) of the test will have to retest at the expiration of their CNG Cylinder Certification to re-certify in the expanded certification program. In non-examination years there will be an annual administration fee to maintain your certification. Unlike the previous program, there will be no minimum cylinder or vehicle inspection requirements to meet in order to renew your CNG Fuel System Inspector Certification.

The CSA test contains approximately sixty multiple choice questions. There may be additional test questions included that are for evaluation purposes only and will not be part of the final scoring. The questions are based on expert opinions from a cross section of the CNG industry after consideration of the skills and knowledge that a minimally qualified applicant should have. They are taken in proportion to their importance from a carefully constructed set of objectives or tasks that inspectors would be expected to perform.

In preparation for taking the exam, you should first evaluate yourself against these objectives. Honestly consider if you are confident that you know each specific task listed in the following Task List. Note the percentage of questions you can expect in each category and check Yes (Y) or No (N) as you grade yourself. This will form the basis for any additional study you need prior to taking the test.

You can learn more about registration requirements, fees, qualifications and training resources from the CSA-America website:

http://csa-america.org/personnel_certification/cng_certification/default.asp?load=getcert

Appendix D has more about taking the test and a sampling of test questions for your review.

Good luck and study hard.

Bill

2008 CSA Exam Objectives			
SECTION 1 PREPARATION FOR INSPECTION	**13%**	**Y**	**N**
Objective 1.1 Assess Vehicle History			
Knowledge			
1. Know types of incidents that may cause damage that may not be detectable by inspection			
Skills			
1. Question the owner/fleet manager about the vehicle			
2. Know how to search service records			
3. Know how to check vehicle for collision damage, fire, etc.			
4. Search VIN number for accident related incidents			
Objective 1.2 Identify potential high-pressure gas safety hazards			
Knowledge			
1. Know the dangers of cylinder rupture and component failure			
2. Know how to assemble and disassemble system			
3. Know the consequences of improperly secured PRD vent lines			
Skills			
1. Listen for leaks			
2. How to operate different types of valves			
Objective1.3 Employ proper cleaning and handling methods to prevent damage to the fuel system			
Knowledge			
1. Know which types of cleaning solutions are appropriate for different materials			

Skills			
1. Demonstrate proper method for lifting and moving cylinders			
2. Know which types and when to use certain cleaning tools			
Objective 1.4 Given a scenario, identify the appropriate sequence of inspection steps			
Knowledge			
1. Know what is required for an inspection			
2. How to look up cylinder specifications			
3. Know which steps are critical in sequence			
Skills			
1. Organize a work plan and use a checklist			
Objective 1.5 Demonstrate a familiarity with natural gas and its characteristics			
Knowledge			
1. Know properties of Natural Gas (NG)			
Skills			
1. Recognize NG odorant			
2. Recognize when un-odorized NG is used			
SECTION 2 DETERMINE INSPECTION REQUIREMENTS	**9%**		
Objective 2.1 Identify the cylinder manufacturer and the standard under which the cylinder was manufactured by looking at the label or serial number			
Knowledge			
1. Know past and present cylinder manufacturing companies			
2. Know the standard under which the cylinder was manufactured			
Skills			
1. Familiarity with label layout, difference between part numbers and serial numbers			

Objective 2.2 Select the proper inspection standard and/or the manufacturer's inspection recommendations based on the label			
Knowledge			
1. Familiarity with inspection standards			
2. Know if there is a manufacturers' standard that's applicable to the vehicle			
3. Know that the manufacturers' standard always goes first			
Skills			
1. Ability to interpret the standards			
Objective 2.3 Determine which NFPA 52 requirements apply to the vehicle being inspected			
Knowledge			
1. Know the dates of the past NFPA 52 revisions			
2. Know how to recognize the labeling of an OEM certified vehicle vs. an aftermarket conversion			
Skills			
1. How to correlate the vehicle with NFPA 52			
Objective 2.4 Verify that the cylinder inspection documents are appropriate to the vehicle			
Knowledge			
1. Know the dates of the past inspection document revisions			
2. Know how to recognize the labeling of an Original Equipment Manufacturer (OEM) certified vehicle vs. an aftermarket conversion			
Skills			
1. How to correlate your vehicle with the inspection documents			
Objective 2.5 Know the sources of additional inspection information and explain where to find them			
Knowledge			
1. Know the cylinder, component, system, vehicle manufacturers			
Skills			
1. Accessing contact information			

SECTION 3 PRESSURE RELIEF DEVICE (PRD) INSPECTION	**7%**		
Objective 3.1 Given a scenario, inspect PRD piping for damage, obstructions, restrictions and verify that it is properly seated to prevent foreign material from entering.			
Knowledge			
1. Know what a venting system looks like			
2. Know function and appearance of venting systems			
3. Know the different types of PRD channel configurations			
Skills			
1. Recognize different types of damage			
2. Recognize probable modifications			
Objective 3.2. Identify visible damage and assess serviceability of PRD's and verify that the PRD has not been recalled			
Knowledge			
1. Know how to recognize a PRD			
2. Know the location of PRD's			
3. Know lists of manufacturers			
Skills			
1. Know how to find the list of recalled PRD's			
Objective 3.3 Recognize if the PRD vent line is properly routed, supported and adequate for venting pressure			
Knowledge			
1. Know what a good PRD looks like			
Skills			
1. Be able to differentiate between original manufacturer versus later extrusion of the eutectic trigger			

SECTION 4.0 PHYSICAL INSPECTION OF BRACKETS AND HIGH-PRESSURE COMPONENTS	**18%**		
Objective 4.1 Identify missing components or damage to guards and covers that could affect cylinder or system integrity			
Knowledge			
1. Know in which situations guard covers are required			
2. Know different designs of guards and covers			
Skills			
1. Rubber gaskets and clearance requirements			
Objective 4.2 Assess the condition of CNG cylinder mounting systems			
Knowledge			
N/A			
Skills			
1. Know how to identify systems that have been degraded			
2. How to identify missing or out of place rubber isolation gaskets			
3. How to identify over tightened brackets			
3. How to identify misaligned brackets			
Objective 4.3 Identify CNG fuel system components and describe their functions			
Knowledge			
1. Know the major components			
2. Know the function of each component based on its appearance and location in the system			
Skills			
1. Recognize defective, damaged or missing components			
Objective 4.4 Recognize system defects that would require a partial or full system defueling			

Knowledge			
1. Know defects associated with system components			
2. Know functions of system components			
Skills			
1. Recognize different degrees of component damage			
Objective 4.5 Verify that the CNG fuel system is free of natural gas leaks			
Knowledge			
1. Know how to identify leaks by sound, smell and sight			
2. Know which leak-detection fluids are safe for use			
3. Know that C-6.4 gives basic guidance of leak detection			
Skills			
1. Proper use of leak-detection fluids, equipment and methods			
SECTION 5 PHYSICAL ASSESSMENT OF CYLINDERS	**38%**		
Objective 5.1 Classify the type of cylinder damage, assess the level of cylinder damage, and then determine the appropriate action			
Knowledge			
1. Know types of damage			
2. Know the three levels of damage			
3. Know where to find the criteria to determine the level of damage			
Skills			
1. Determine levels of damage			
2. How to use a depth guage and tape measure			
Objective 5.2. List the cylinder label information			

Knowledge			
1. Know different types of labels			
2. Know what is required on labels			
3. Know different formats of labels			
Skills			
1. Verify that the cylinder label is present and visible			
2. Verify that the cylinder is marked for CNG use			
3. Verify that the cylinder service life has not expired			
Objective 5.3 Recognize Level II or Level III damage that requires defueling for safety measures			
Knowledge			
1. Know types of damage			
2. Know Level II or III damage			
3. Know where to find the criteria to determine the level of damage			
Skills			
1. Determine levels of damage			
2. How to use a depth gage and tape measure			
Objective 5.4 Select the proper measuring tool to assess the level of cylinder damage			
Knowledge			
1. Know appropriate tools for appropriate uses			
Skills			
1. How to read and calibrate the tools			
Objective 5.5 Determine when you need to consult the cylinder manufacturer to determine the level of damage			
Knowledge			
N/A			

Skills			
1. Applying standards to actual situations			
Objective 5.6 Demonstrate familiarity with the concept of pressures and temperature relationships as applied to cylinder operating requirements			
Knowledge			
1. Know temperature/pressure relationship			
2. Know the service pressure may not be the fill pressure			
3. Know maximum permissible fill pressure			
Skills			
1. How to read pressure gages and thermometers			
Objective 5.7 Given a scenario, recognize the different types of CNG cylinder materials and construction			
Knowledge			
1. Know different types of cylinder materials			
2. Know construction methods			
3. Know how different materials respond to damage mechanisms			
Skills			
1. Be able to recognize different cylinder materials and construction methods			
SECTION 6 ORIGINAL CNG FUEL SYSTEM INSTALLATION	**10%**		
Objective 6.1 Determine that cylinders, brackets, components and shielding are installed to prevent damage and safety hazards			
Knowledge			
1. Know components applicable to NG systems			
2. Know which components can be supported by piping			
3. Know ground clearance requirements			
4. Know acceptable locations for cylinders			

5. Know acceptable mounting and bracketing			
6. Know heat shielding requirements			
Skills			
1. Recognize different types of components and their applications			
Objective 6.2. Verify that the pressure ratings of the cylinder and all other labeled system components are equal to or greater than the vehicle pressure rating			
Knowledge			
1. Know how to determine the system pressure rating from the vehicle label			
2. Know where to find and how to read pressure ratings on components			
Skills			
1. How to determine if pressure reading from label matches component pressure ratings			
Objective 6.3 Verify the existence, location and operation of shut off valves as per NFPA 52 or the manufacturer's specifications			
Knowledge			
1. Know when shut off valves are required			
2. Know where shut off valves are likely to be found			
Skills			
1. Know appropriate way to test shut off valves			
2. How hard to you twist the shut off valve handle before you stop?			
Objective 6.4 Verify all required labels are installed and legible			
Knowledge			
1. Know which labels are required under the various codes			
2. Know which parts of labels are required to be legible			
3. Know where labels are to be mounted			
Skills			
1. Understand the marking of the labels			

SECTION 7 INSPECTION REPORTING	**5%**		
Objective 7.1 Know how and when to fill out all areas of applicable inspection forms			
Knowledge			
1. Know which inspection form you need to use			
2. Know to use the checklist during inspection			
Skills			
1. Operate a digital camera			
2. Know how to write a comprehensive description and recommendation			
Objective 7.2 Given an inspection scenario, explain which actions you recommend			
Knowledge			
1. Know the consequences of various defect levels			
2. Know how to communicate to non-technical customers			
3. Know sources for appropriate repair or replacement			
Skills			
1. Communication with public, vendors, manufacturers			

Table of Contents

Section 1 Preparation for Inspection

Natural gas is arguably, the safest, cleanest and most economical transportation fuel available today. While that is a rather bold statement, it can be backed up by the facts. As a CNG Fuel System Inspector, you will be part of this growing movement toward alternative fuels whether your goal is contributing to a cleaner environment, helping alleviate our dependence on foreign petroleum or reducing our national debt. In order for this industry to flourish it must maintain the enviable safety history it has to date. By joining the ranks of certified inspectors you can play a vital role in its development.

Before any CNG fuel system inspection begins, the inspector has quite a bit of work to do. He or she must gather as much information about the vehicle history, previous inspections, any accidents, etc., as is available. This can be done by interviewing the owner and/or operators, searching the existing service records, and looking for any obvious signs of collision damage from accidents or, more importantly vehicle fires.

Inspection forms will require information on the vehicle VIN number as well as any additional identifiers the owner or agency may use, e.g. license plate number. Now is the time to obtain and record these (see Appendix B).

Just as with a pre-flight check of an airplane, it's prudent to do a General Inspection of the fuel system and cylinder installation. A General Inspection is defined as an inspection for any signs of obvious or gross external damage, sounds or smells of possible natural gas leaks or any other potential problems that might require immediate attention. These inspections should also be included in any regular preventive maintenance programs or during any vehicle service or repair.

Figure 1.1 Leak Testing

In the rare event that there would be an urgent safety concern, the inspector should immediately decide on the appropriate action. If leaks are found or more serious levels of damage are suspected, stop and determine how to resolve the issue. This can be something as simple as turning off a cylinder or fuel line shut off valve to recommending CNG defueling and contacting emergency responders, before any further inspection is considered.

More commonly, the next step in preparing for an inspection is gaining access and cleaning all of the CNG fuel system components. This can be done either by the owner or designated staff personnel or by the inspector. Generally, time and money can be saved if the owner of the vehicle performs this operation. Regardless, some care needs to be exercised. Specifically, cylinder coatings and components may be susceptible to caustic cleaning solvents. Avoid soap solutions that contain ammonia as an example. Often questions regarding the use of high pressure washing equipment arise. Even if the cleaning solutions are appropriate care should be taken to avoid water intrusion into the PRD vent lines. The cylinder manufacturer should be consulted first, especially in the case of Type 4 composites. Regular sponges, wash rags, etc. are generally sufficient.


Figure 1.2 Cleaning and Recording

Properties of Natural Gas

Natural gas as provided by Local Distribution Companies (LDC's) or gas utilities has a distinctive odor. Generally, Ethyl Mercaptan is added to give a sulphur smell that allows detection at an early warning level, since pure methane, the major constituent of natural gas is odorless, colorless and tasteless. Any fuel has specific Upper and Lower Flammability Limits. In the case of natural gas, the lower limit is 5% by volume and the upper limit is 15% fuel to air. The Mercaptan concentration is designed to be detectable at 20% of the lower flammability limit or at a 1% level, fuel-to-air ratio, well short of the point of possible combustion.

It should be noted that Liquefied Natural Gas will not include the odorant and either on-board methane detectors will be added or a separate operation to reintroduce Mercaptan into the gas stream will be used.

Other properties that make this fuel safer are:

Natural gas is lighter than air. The specific gravity of natural gas is 0.6 compared to air at 1.0 SG. It will rise into the atmosphere if there is a leak and dissipate quickly.

By comparison, the flammability range for gasoline is 1% to 8%, but remember that leaks from gasoline can accumulate and still be dangerous hours later, while natural gas will have dissipated.

To ignite natural gas, the ignition source must be at least 1,200° F. The ignition temperature of gasoline is 540° - 800° F, or about half of what is required for natural gas.

Below is a table of some of the important fuel characteristics:

CHARACTERISTIC	GASOLINE	NATURAL GAS
Chemical Symbol	C_4H_{10} - $C_{12}H_{26}$	CH_4
Vapor Density (Air=1.0)	3.50	0.6 - 0.7
Flammability Limits in Air	1.4 to 7.6%	5.0 to 15.0%
Flammability Ratio = (Richest Mixture That Will Burn / Leanest Mixture That Will Burn)	5.4:1	3:1
Boiling Point	81°F to 437°F	-260°F
Air-Fuel Ratio	14.7:1	16.5:1
Ignition Temperature	540°F - 800°F	1,200°F
Flame Speed (ft. per sec.)	2.72 FPS	2.20 FPS
Octane Rating	86-93	115+
Fuel Quantity Measurement	Gallons	Gasoline Gallon Equivalent (GGE) (1 GGE = 125 cu. ft.)
Storage Pressure	Atmos. Pressure	3,000-3,600 psi
Energy Content (BTU per lb.)	18,400	20,500

Table 1.1 (*Courtesy General Motors*)

Section 2.0 Determine Inspection Requirements

The United States has led the world in NGV technology, particularly in the area of cylinder design and construction. From their beginnings in the space industry, lighter, composite cylinders have become the 'gold standard.' Several manufacturers have come and gone and as an inspector you should be familiar with them all. Appendix A contains a list of most of the major companies, past and present, that have been a part of that history.

There are four types of construction that are designated, appropriately, Type 1 thru Type 4.

Types of CNG cylinders

Type	Description	% load contained by metal	% load contained by composite
NGV2-1 (Type 1)	All metal cylinders either steel or aluminum	100	n/a
NGV2-2 (Type 2)	Cylinders with metal liner and a hoop (center) wrapped composite	55	45
NGV2-3 (Type 3)	Cylinders with thin metal liner and a fully wrapped composite	20	80
NGV2-4 (Type 4)	Cylinders with a plastic liner and a fully wrapped composite	n/a	100

Beginning with Type 1, all steel or aluminum, each subsequent type reflects efforts to reduce weight by replacing metal with lighter weight composite (fiberglass or carbon fibers in a plastic resin) materials. The relative roles of metal and composites in the four designs can be understood by comparing the portion of the pressures retained by the liner and by the overwrap.

In Type 1 all of the internal force is contained by the metal. In Type 2 and 3, the metal and composite share the pressures. The difference between the two is the coverage of the fiberglass overwrap. Type 2 covers the center of the cylinder only, while Type 3 wraps the entire cylinder. Type 3 will have a significant decrease in the metal liner thickness.

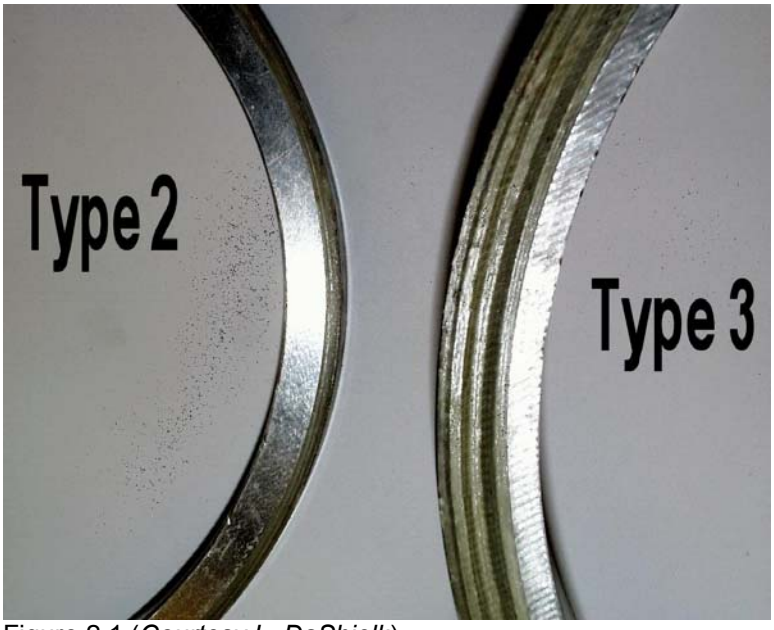


Figure 2.1 (*Courtesy L. DaShiell:*)

Figure 2.2 Type 2 Hoop Wrapped

Figure 2.3 Type 3 Fully Wrapped

Type 4 is a full composite cylinder with no metal, except for the end boss for the valve. NOTE that without information from the manufacturer's label you can't easily tell the difference between a Type 3 and Type 4 cylinder.

Not only must inspectors be knowledgeable about the cylinder companies in the industry (see Appendix A), but they must be intimately familiar with the various standards those companies manufactured to or under. There is a priority to those standards as well.

The first and foremost resource for any inspection is always the manufacturers' guidelines. In the absence of specific manufacturer specification, the next two standards cover, in a generic overview, cylinder inspection and fuel system installation. Those are the Compressed Gas Association's (CGA) document C-6.4 *Methods for External Visual Inspection of Natural Gas Vehicle (NGV) Fuel Containers and Their Installations* and the *National Fire Protection Association (NFPA) 52 Vehicular Fuel Systems Code*.

Before any Detailed Inspection can begin, the inspector must identify which of these standards applies. There are currently two for CNG cylinders:
1. ANSI/CSA: **NGV2** *Compressed Natural Gas Vehicle Fuel Containers*
2. DOT/NHTSA: **FMVSS 304** *Compressed Natural Gas Fuel Container Integrity*
(NOTE: this is a US government standard referenced in 49 CFR 571.304 *Code of Federal Regulations*)

These contain design qualification requirements that apply to manufacturers during production. They outline the allowable materials along with manufacturing and quality control tests. They are interesting to the inspector only for their rigor and as references.

NGV2 is a voluntary, industry driven standard that has been incorporated into the International ISO standard 11439. It details elaborate cycling, burst, impact, environmental, bonfire and rupture tests. FMVSS 304 is a US government (DOT – National highway Traffic Safety Administration) Federal Motor Vehicle Safety Standard and as such does have the force of law. They can be obtained on-line at:
ANSI/CSA NGV2 http://webstore.ansi.org or www.csa-america.org
FMVSS 304 http://edocket.access.gpo.gov/cfr_2003/octqtr/pdf/49cfr571.304.pdf

They both specify periodic visual inspection of cylinders either every three years and/or 36,000 miles and after an accident or fire. They are the basis for the visual inspection protocols used in the United States today.

There were earlier standards, from the Compressed Gas Association, known as FRP-1 and FRP-2. They were used by several cylinder manufacturers on a limited *exemption* basis by the Department of Transportation (see: 'DOT-E' in Fig. 2.4) before the current standards were developed. However, these cylinders are generally beyond their useful life (15 yrs. from the date [Mo-Yr] on the cylinder) and rarely seen.

Cylinder labels can help determine the standards for a particular cylinder. Note the NGV2, DOT or DOT-E designations in the following examples:

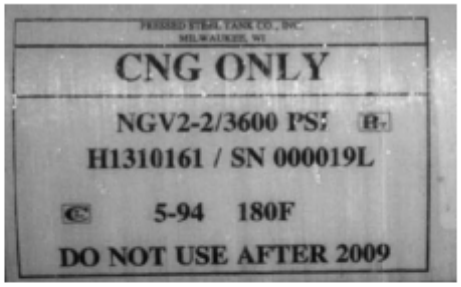
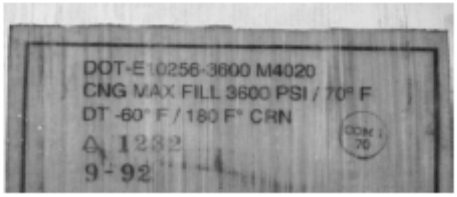
Cylinder Standard	Cylinder Label
NGV2	
FMVSS304	
FRP	

Figure 2.4 (*Courtesy GTI*)

Labels are also required to give critical information regarding the cylinder manufacturer, the service pressure, serial and/or model numbers and the container build date and expiration date.

CGA C-6.4 deals primarily with cylinder inspection whereas NFPA 52 deals with the rest of the fuel system installation. There are overlaps in both but this is generally the distinction between the two. As with any standard, they are dated and undergo periodic revisions. Each edition will generally have a history of the previous revisions or indication of the changes listed in the introductions. Inspectors should be aware of the changes and keep current on the standards.

This raises a common question when dealing with older vehicles. Which version should I use; the latest edition or the one that was in effect when the vehicle was produced? The best advice is to always follow the most current guidelines and if there are discrepancies use good judgment on whether they create a serious safety concern and finally, err on the side of caution. Where a system is built to an earlier standard and not required to be updated to a later version, it should not be faulted for not meeting the later standard unless there is an obvious safety issue.

This issue comes up more with revisions to NFPA 52 and the installations of downstream components. Inspectors should be familiar with these as well. The major components of any NGV fuel system will consist of most, if not all, of the following:

- Fill receptacle
- One-way check valve(s)
- Fuel storage cylinder(s)
- Cylinder shut-off valve
- Pressure relief device (PRD)
- Manual 'Quarter-Turn' shut-off valve
- Annealed stainless steel fuel tubing
- Shut-off valves (Lock-offs)
- Pressure regulator(s)
- Mixer assemblies (older vehicles)
- Gas injectors

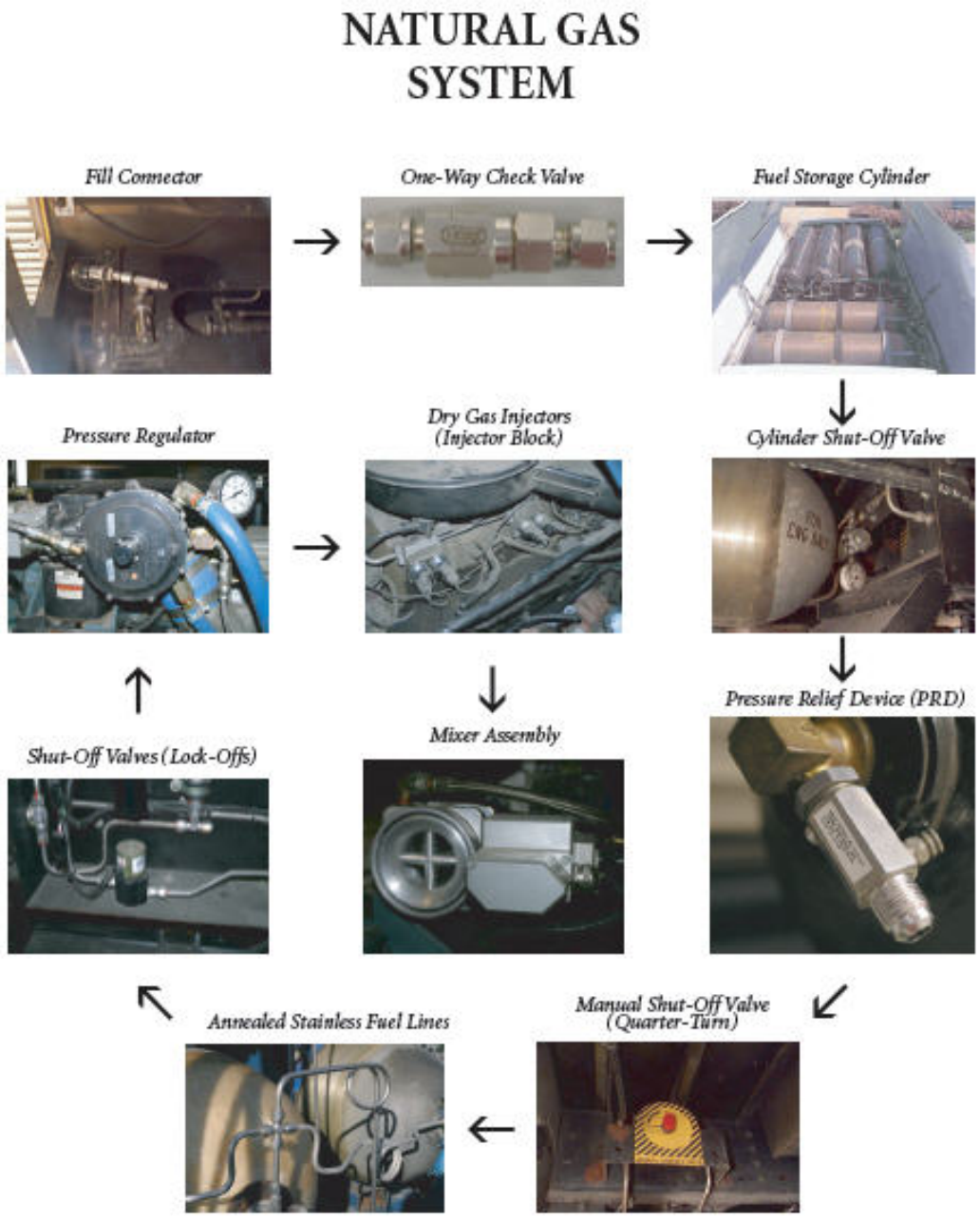


Figure 2.5 Typical Fuel System Components (*Courtesy LBCC*)

In conclusion, these standards; the manufacturers' specifications, CGA C-6.4 and NFPA 52 (in that order) form the basis of the Detailed Visual Inspection protocol. A Detailed Visual Inspection, performed by trained, certified personnel, is the subject of this study guide.

The Clean Vehicle Education Foundation (CVEF) has made available a CD containing all of the manufacturers' specifications they were able to obtain. A copy can be obtained from CSA or CVEF's John Lapetz at jlapetz@cleanvehicle.org)

Section 3.0 Pressure Relief Device (PRD) Inspection

Safety factors on NGV fuel systems are stringent. Cylinders are designed to withstand at least 2.25 times the working pressure. All of the downstream components are safe at three times their working pressures! (The battery of tests that cylinders have to pass in order to be certified can be found in the NGV2 standard) The device that assures cylinders will 'relieve' pressure in a fire is the Pressure Relief Device (PRD).

Pressure Relief Devices have a checkered history. Early versions had high failure rates and several were subject to recall. Today, new designs and improved manufacturing have all but eliminated these problems. The job of these devices is to relieve pressure from NGV cylinders in the event of a fire that could lead to a cylinder rupture. Standards do not require PRD's to vent during overpressurization of a cylinder (CNG fuel dispensers are relied on to control pressure), but they are required to vent during a vehicle fire.

There are many combinations of temperature and pressure mechanisms used in PRDs but two basic types are in wide use for compressed natural gas today.

Thermally Activated
This design is built to protect gas-containing vessels from rupture in case of fire. One style uses an alloy, called a *eutectic*, with a specific melting point, as an integral part of the PRD seal and a newer type that relies on the eutectic material only as a thermal triggering method.

Figure 3.1 (*Courtesy Circle Seal Controls*)

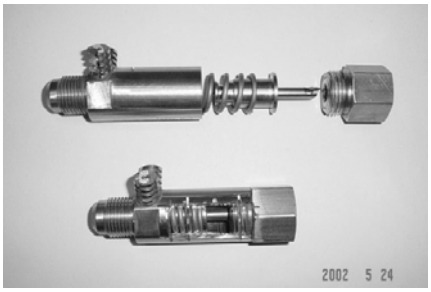


Figure 3.2 (Mirada- *Courtesy L. DaShiell*)

Series Combination

This type has a thin steel 'rupture' or 'burst disc' designed to burst at a predetermined pressure backed by a lead eutectic as a plug or thru a series of channels within a brass body. It requires excessive pressure and temperature to cause it to operate. It cannot prevent an improperly filled (overfilled) cylinder from rupturing due to hydrostatic pressure at room temperature, or any temperature below the melting point of the fusible material. Both the burst pressure and temperature are generally stamped on the PRD body.

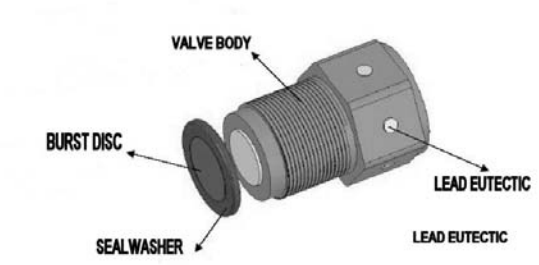
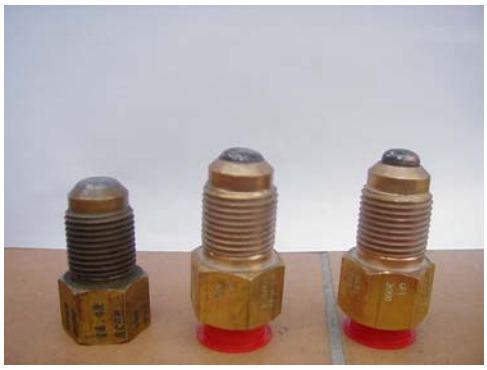


Figure 3.3 Series PRD

There are two conditions, aside from mechanical damage, with PRD's that an inspector must look for, namely leakage and premature extrusion of the eutectic. The first requires some form of leak testing and in the case of attached vent lines may present some challenges to access or assure that the PRD is OK.



By the same token, evaluating an extruded eutectic can be difficult. Consider these three Pressure Relief Devices. It would appear that the lead plug on the right has begun to extrude but the center and right PRD's are both new! So the difference between a manufacturing anomaly and an actual extruded eutectic might not be obvious. You must see evidence of damage or leaking of the fusible material before condemning it.

Figure 3.4 PRD

Mechanical damage can occur when moisture is allowed to collect at the PRD. During freezing weather cases have been reported where the PRD released even though there was no indication of fire. NFPA 52 requires the venting system prevent water, dirt, or any foreign objects from collecting in the vent lines or PRD (see Section 6.4 NFPA 52, 2006).

This is the biggest cause of PRD failure, and many designs overlook this. Check for evidence of water intrusion:

- Loose or stretched PRD's
- Loose fittings on the outlet side
- Leaks
- Water marks (soap scum, lime, etc.) in the vent tube or the PRD
- Evidence of reverse pressure on the PRD (more pressure in the outlet than in the tank) [Ice can generate over 10,000 psi]

NOTE: Rubber caps that have been knocked off, particularly by cleaning brushes or tree branches can cause this.

- Rubber caps that break down in UV.
- Lack of caps or drain holes
- Vent tubes that run straight up. They should have a bend so that any water that does accumulate doesn't fill the PRD.
- Caps that are to tight that allow the inevitable permeation of gas through the PRD causes a pressure build-up that blows off the cap. Caps should have the ability to vent the tiny flow may come through the PRD.

Section 4.0 Inspection of Brackets and High-Pressure Components

Inspection of cylinder mounting assemblies is the second largest portion of the certification exam. This section, along with Section 6 dealing with the rest of the system components, comprises 28% of the questions.

NFPA 52 is the primary resource for requirements on the installation of NGV Fuel Systems. The current edition (2006) devotes the entire Chapter 6 to Installation of cylinders, venting systems, piping and valves, pressure gauges fill receptacles and regulators. The inspector should be familiar with all of them. What follows is a summary (not intended to be complete) of the major points.

Beginning with cylinders,

- **May be located within, below or above the passenger compartment**
- **No portion can be located ahead of the front axle or behind the point of attachment of the rear bumper**
- **Must have the label visible**
- **Cannot be within eight inches of the exhaust system without proper shielding**
- **Must be mounted at least nine inches above the ground for vehicles over 127" wheel base or at least seven inches for vehicles with 127" or less measured with the tires deflated.**
- **Be capable of restraining the cylinder when subjected to a force of eight times the weight of the cylinder in six principle directions without moving over one half inch**

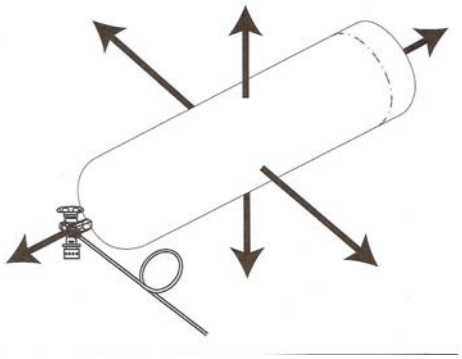


Figure 4.1 Six principle directions

- **Incorporate manufacturer's recommended brackets with rubber gaskets and torque to specification**
- **Be properly shielded from sunlight, cargo or road debris**

Figure 4.2a Bad Mounting

Figure 4.2b No Shielding

- **Cylinder valves and fittings mounted in the passenger compartment must be properly vented to the outside using tubing or a vapor barrier**
- **Rubber gaskets shall be installed under the clamping bands to provide insulation between the bands and the containers**
- **Must not adversely affect the driving characteristics of the vehicle**

Venting systems included here can refer either to high pressure PRD vent lines or low pressure 'vent bags' for the neck of the cylinder and all fittings within the passenger compartment. (The trunk is considered part of the passenger compartment.)

- **All potential leak points must be protected (cylinder valves and fittings)**
- **High pressure PRD vent line must be metallic, and electrically conductive**
- **Cannot vent into a wheel well**
- **Must prevent water, dirt or other contaminants from collecting in the lines or PRD**
- **The PRD and cylinder must be in the same vehicle compartment**
- **Low pressure enclosures must be gastight, made of low-density polyethylene or equivalent, free of tears.**
- **Vent lines must be adequately secured, have a burst pressure at least 1 ½ times the pressure of an activated PRD and capable of withstanding 1120°F for 20 minutes**

Figure 4.3 Polyethylene vent bag *(L. DaShiell)*

Figure 4.4 Formed vent cover *(L. DaShiell)*

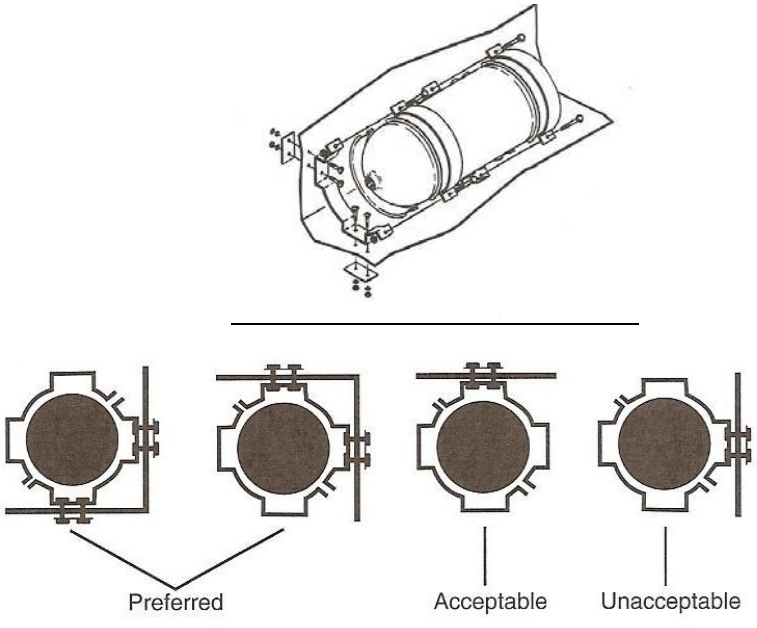


Figure 4.5 Proper and improper cylinder mounting procedures *(Courtesy CNG Cylinder Company)*

Section 5.0 Physical Assessment of Cylinders

This section provides the inspector with a description of some types of damage that can occur with CNG cylinders. As it is not possible to address every possible damage scenario, these are the most common. These guidelines are defined in specific detail in the Compressed Gas Associations' C-6.4 document. This is also the largest portion of the exam – 38%.

The cylinder manufacturer's recommendations (if available) always take precedence and are the primary source for information.

CGA C-6.4 lists general guidelines. CNG cylinder damage is classified in three levels. The levels are as follows:

Level 1 — any scratch, gouge, or abrasion with a damage depth of less than or equal to .010 inch. Level 1 damage is acceptable and does not need to be repaired.* Refer to CGA C-6.4 as a guideline for each type of damage and the allowable limits. Some manufacturers allow different limits over .010 inch for newer tanks. Always consult the manufacturer of the cylinder if damage exceeds .010 inch for their exact requirements.

Level 2 — any scratch, gouge, or abrasion with a damage depth of .011 to .050 inch.
Level 2 damage requires rework (either in the field or by the manufacturer), a more thorough evaluation, or destruction of the cylinder depending on severity.

Level 3 — any scratch, gouge, or abrasion with a damage depth greater than .050 inch. Level 3 damage is severe enough that the cylinder cannot be repaired and must be destroyed. All fire, and chemical damage is Level 3, if it does not wash off.

Level 1 cut or abrasion damage is generally .010 inch or less according to CGA C-6.4. However, the manufacturer is the final authority having jurisdiction over damage levels. Some Level 2 damage may be repaired in the field depending upon manufacturer's guidelines and procedures. Between Level 2 and Level 3, there are acceptable field repairs available to resolve some conditions to a level where they can be resolved to Level 1 and returned to service. There is also Level 2 damage criteria where the manufacturer has to complete the repair, but the cylinder can be re-certified and returned to service. Depending upon the type of cylinder and the manufacturer, the point at which damage becomes Level 3 varies. Some, like Dynetek Type 3 cylinders, allow rework by the manufacturer for cuts from .030 to .050 inch damage. Some Type 4 cylinders, such as the Tuffshell by Lincoln Composites, allow rework by the factory for scratch, gouge, or abrasion damage from .036 to .050 inch and condemn the cylinder after .050 inch. The area where the damage occurs can alter the allowances, e.g., the radius of the dome. When in doubt, check the manufacturer's specific tolerances.

**NOTE: Although Level 1 damage does not require rework, all damage must be recorded.*

Damage Types

1. Surface Corrosion or Pitting

This is most prominent on Type 1 and 2 cylinders due to exposed metals. Many newer cylinders have epoxy painted coatings to help prevent this damage. Corrosion should be cleaned off, evaluated, and resealed to prevent further damage. Corrosion or pitting over .030 inch in depth can be Level 3 damage if it covers considerable surface areas of the cylinder (see §7.6.1.4 of CGA C-6.4). Type 1 cylinders must be evaluated for loss of wall thickness. This will require specifics on the original cylinder. CGA C-6 provides additional guidance and lists wall thicknesses for certain steel cylinders.

Figure 5.1 Corrosion

2. Fatigue or Stress Corrosion Cracking

This occurs when the cylinder is cycled repeatedly causing expansion and contraction of the cylinder, which is usually a sign of age or over pressurization. The fiber wrap cracks longitudinally causing loss of the cylinder pressure safety factor. Any identified stress or fatigue cracking is Level 3 damage. A contributing factor can be chemical attack e.g., battery acid.

Figure 5.2 Stress Corrosion Cracking (SCC)

3. Scuffing or Abrasion Damage

This is very common on cylinders that are mounted underneath the vehicle, if shielding is inadequate or the cylinder is exposed. Type 2, 3, and 4 cylinders with less than 0 .010 in have Level 1 damage.

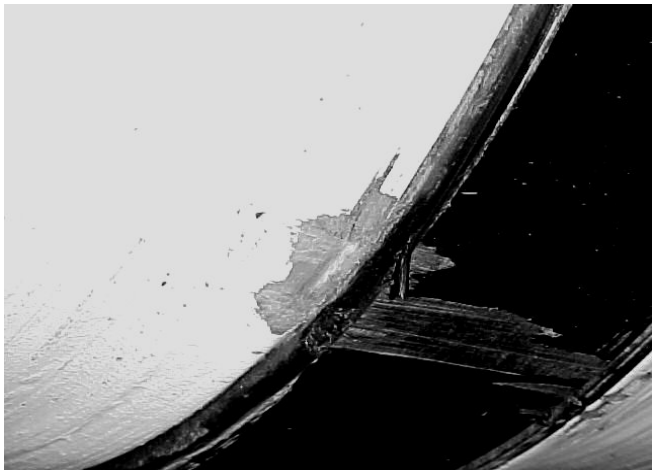


Figure 5.3 Abrasion Damage

4. Surface Cuts and Scratches

These are caused by a foreign object coming in contact with the cylinder. Brackets and other items rubbing against the cylinder can also cause this damage. Cuts or gouges less than 0.010 in. deep are defined as Level 1 damage regardless of length, number or direction. Cuts or scratches greater than or equal to 0.010 in deep are defined as Level 2 or Level 3 damage and may require the use of manufacturer's guidelines (see §7.5.2 of C-6.4).

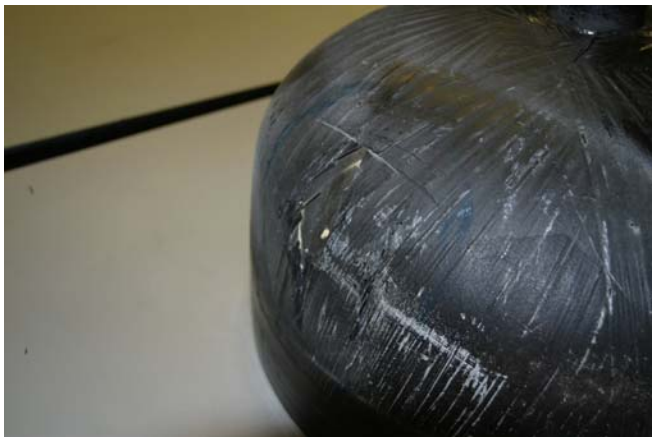


Figure 5.4 Cuts

5. Blunt or Sharp Object Impact Damage

Minor dents up to 1/16" inch and greater than 2 in. diameter on Type 1 cylinders can be tolerated. However, blunt impact damage on Type 2, 3, and 4 cylinders is very hard to evaluate and can be dangerous, especially on Type 4 cylinders. Extreme care must be taken to determine if any deformation of the cylinder is present indicting fiber damage. This is a sign that the cylinder may not be structurally sound and is considered Level 2 or 3 damage.

Figure 5.5 Impact damage

6. Collision, Fire or Heat Damage

Any indication that the vehicle has been involved in an accident or fire requires careful examination of the cylinders. Follow the manufacturer's guidelines for such damage. Generally, if Type 2, 3, or 4 cylinders are exposed to excessive heat, or any discoloration occurs that does not wash off, it is considered Level 3 damage.

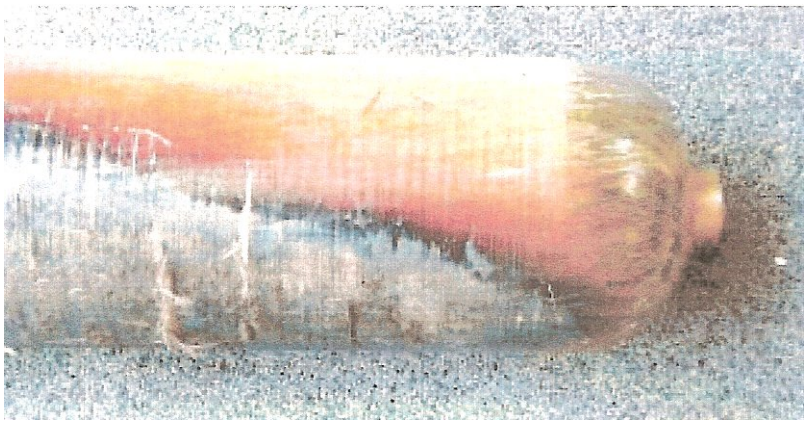


Figure 5.6 Heat damage

7. Chemical Attack

Acids and other chemicals can severely damage the cylinder wrap and possibly the metal itself. Extreme care should be taken to identify and neutralize any chemicals spilled on the cylinder. Only minor discoloration is allowed after neutralization and a very careful inspection should be performed to make sure the chemical did not get between the wrap and the cylinder where unseen damage could progress. Chemical attack can also lead to Stress Corrosion Cracking (see No.2 above). Comdyne cylinders suspected of being exposed to acid should be depressurized as soon as possible to prevent rupture. The cylinders should then be removed from service, rendered unusable, and disposed of. Any other CNG cylinder that has been exposed to acid should be examined in accordance with either the vehicle or cylinder manufacturer's recommendations. Ref. CVEF Safety Advisory.

Figure 5.7 Chemical damage

8. Bulging, Bowing of Cylinder Wall

All visible outward bulges indicate a problem with the cylinder material and should be considered Level 3 damage (§7.6.2 CGA C-6.4). This is most prominent on Type 1 and the exposed surfaces of Type 2 cylinders.

9. Weathering/UV Damage

Ultraviolet light can cause damage to the wrap which must be addressed. In most cases the manufacturers have coatings on the cylinder to prevent this damage. Excessive weathering results in Level 3 damage, as the fibers are damaged.

Figure 5.8 UV damage

10. Over-Pressurization, Leaks

Any cylinder that leaks or has been exposed to over 1.25 times its service pressure is to be considered to have Level 3 damage. Bubbles on the surface of Type 4 cylinders may be indications of leaking of the liner and could be Level 3 damage. Further tests to determine if it is trapped air between the liner and the overwrap or is, in fact, leaking gas should be performed.

11. Labeling

A label that cannot be seen requires repair and, if it is missing or illegible it becomes Level 3 damage.

It should be noted that in addition to the cylinder label OEM manufacturers or after-market conversions must also have a label (usually located in the engine compartment) that identifies the vehicle as being CNG-fueled and includes; service pressure, the installers name or company, the cylinder retest or expiration date and the total container(s) water volume in gallons or liters.

According to NFPA 52, another label is required at the fill connection receptacle that specifies CNG, the system working pressure and the cylinder retest or expiration date. Most OEM's also follow this recommendation.

All the following are to be considered Level 3 damage:

- A missing cylinder label
- All fire damage, if it leaves discoloration
- All chemical damage, if it leaves discoloration
- Any noticeable discoloration that cannot be washed off
- Stress corrosion cracking
- Impact damage on Type 4 cylinders

The following table reprinted from CGA-6.4 by permission gives a detailed breakdown of generic cylinder damage limits.

Condition	Level 1	Level 2	Level 3	C-6.4 ref.
Composite and metal containers (All container types)				
Labeling	Legible and clean. Required information all legible. Information correlates with vehicle service	Only manufacturer and serial number is clear. Other required information is illegible [1]	Serial number illegible or untraceable, or unidentified manufacturer or model/part number. Beyond service life.	7.9
Cuts/scratches/gouges	<0.01 in (.025 mm)	[2]	≥0.01 (0.25mm) deep[2]	7.5.2
Charring/sooting	None	Washes off[2]	Permanent marking	7.5.3
Gas leakage	None	Bubble test negative	Bubble test confirms leak	7.5.4
Chemical attack	Cleans off. No residue or affect. Chemical is know not to affect container type	Discoloration is minor after cleaning, no material loss[2]	Permanent discoloration, loss/disruption of material[1]	7.5.5
Weathering (UV effects)	None	Coating disruption and/or loss[2]	Excessive. Look for other condition effects	7.5.6
Involved in a collision, accident or fire. Container subjected to high or unknown heat.	No indications and vehicle owner know of no accident, fire or heat exposure	Owner reports vehicle was in a fire, accident or exposed to heat[1]	Indications of vehicle an/or container impact or heat damage[1]	7. 7.2 7.5.3
Overpressurization	No indication or knowledge by inspector		Cylinder reported to have been pressurized above the applicable design standard	7.5
Composite containers (Type 2,3 and 4)				
Impact	None	Dents, fiber breaking, cuts, etc.[1]	Permanent deformation of container[1]	7.7.2
Stress corrosion cracking	None	Questionable or unsure[1]	Any identified SCC	7.5
Abrasion	<0.010 in (0.25 mm) deep	[2, 3]	≥0.01 in (0.25 mm) deep	7.7.1
Metal containers (Type 1 and the exposed metallic portions of Type 2)				
Bulging/bowing	None or shape can be identified as 'banana' or bower (Type 1 containers only)	All visible bulges are Level 3 damage. See [1] for questionable bow	Visible bulge or bowed shape interferes with proper mounting	7.6.2
Corrosion, pits	<0.035 in (0.889 mm) deep	[1]	≥0.035 in (0.889 mm) deep	7.6.1.1
Corrosion, line pits	<0.03 in (0.76 mm) deep	[1]	≥0.03 in (0.76 mm) deep. Any depth over 6 in long (15.2 cm)	7.6.1.4
Dents	None	Minor dent(s)[1]	≤in (51 mm) diameter or ≥0.0625 in (1.588 mm) deep	7.6.3
Abrasions	None	Minor	Depths that reduces wall thickness below minimum allowable	7.6.4

[1] Contact container manufacturer for criteria and procedure(s), or get the needed information from product literature, instruction manual(s), written recommendations, advertisements, etc.

[2] Specified by manufacturer. Repair may be possible if directed by container manufacturer.

[3] Exposed fibers may be coated. Contact manufacturer.

Measuring Damage

Measuring damage is very difficult with the normal differences in the cylinder wrap thickness. Cuts tend to have a flared edge to them, which makes them also stick up on the edges. A depth gauge or dial caliper that has been sharpened to a point is needed to accurately measure the damage while bridging the gap accurately.

Sometimes, it is necessary to use a straight edge across a gouge to seek a level from which to measure. With this method you must subtract the thickness of the straight edge from your reading.

Figure 5.10

Section 6.0 Original Fuel System Installation

This section deals with the rest of the fuel system components. It includes fuel lines, valves, fittings, pressure regulators and filling receptacles. Beyond the first stage or high-pressure regulator, systems diverge in their approach and technologies. As such there will not be any questions on underhood fuel mixing strategies, either mechanical or computer controlled.

Again, NFPA 52 is the primary resource for the installation of NGV Fuel Systems. What follows is a summary (not intended to be complete) of the major points. The latest edition should always be consulted for more detail. NOTE: NFPA 52 is designed as a minimum guideline for aftermarket conversions. The OEM's, however, build to a different set of standards that may go beyond the requirements of aftermarket converters.

Fuel lines (piping) considerations:

- **When passing through a panel shall be protected by grommets or the equivalent**
- **Shall be mounted or supported to minimize vibrations and breakage due to strain or wear.**
  (This suggests stress loops or vibration loops between moving parts.)
- **Fittings or joints should be located in accessible positions.**

Installation of valves:

- **Every cylinder must have a manual or normally closed automatically-actuated (e.g., electric), shutoff valve**
- **Every cylinder on an on-road vehicle must have a second valve, either manual or automatically actuated, that allows isolation of the cylinders from the rest of the fuel system***

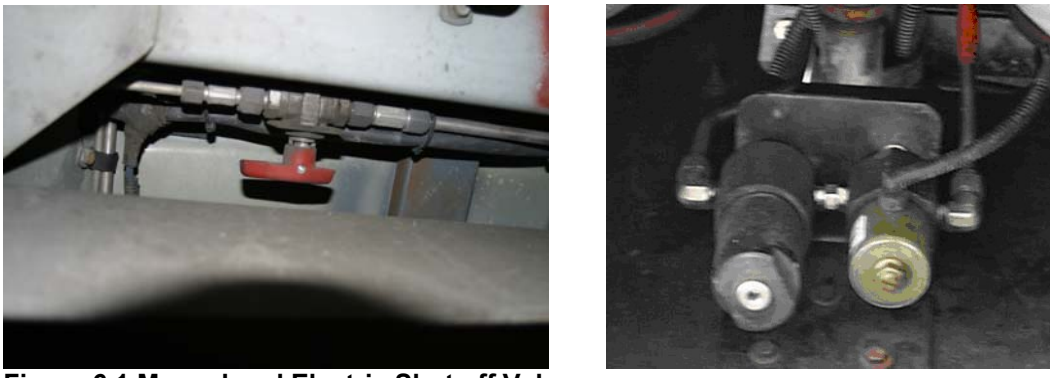


Figure 6.1 Manual and Electric Shut off Valves

- **If a manual shutoff valve is used, it must not require more that 90 degrees rotation (quarter turn valve) to close**[1]
- **Access to the manual shutoff valve shall not require the use of any tool or key**
- **The 'quarter turn' valve must be indicated with a label or decal**
- **A final valve that automatically prevents the flow of gas to the engine when the engine is not running, even with the key on, is also required. NOTE: electronic fuel injectors meet this requirement**
- **Valves must be securely mounted and protected**
- **The fuel system must have a backflow check valve between the cylinders and the fill receptacle. This is incorporated into the NGV1 fill receptacle**

[1] In the case of shutoff valves this has caused confusion in that most OEM Natural Gas Vehicles do NOT require an additional manual or quarter turn shutoff valve beyond the cylinders. The OEM's, however, build to a different set of standards that go well beyond the requirements of aftermarket converters.

- **The check valve mounting must be able to withstand the breakaway force (150 lbs) of the fill hose.**
- **There must be an additional check valve located between the cylinders and the fill point.**

Pressure gauges:

While pressure gauges are optional, they do serve to give technicians the best information on system status before any service is performed. If used they:

- **Cannot allow gas into the passenger compartment**
- **Must be equipped with shatterproof lens, and an internal pressure relief**
- **Must have a limiting orifice (that reduces dial fluctuation)**
- **Shall be securely mounted and shielded**

Pressure Regulators:

- **Must have a means to prevent refrigeration effects**
- **Must be installed so that their weight is not placed on the attached gas lines.**

Fueling Connections:

- **Fueling receptacles must be mounted to withstand a breakaway force beyond that specified for the dispenser hose (currently 150 lbs)**
- **Must have clearance around the fueling connection to prevent interference with the fueling nozzle**

Early in the development of the NGV industry, several different fill connection profiles were used. Adapters were used to switch between them. These are no longer allowed. Today they have all been replaced by the current industry standard known as NGV1. This applies to fill nozzles on dispenser hoses and receptacles on vehicles. The design allows for three different fill pressures still found around the country: 2400 psi, 3000 psi and 3600 psi. The connector on the fill hose is usually color coded to reflect these pressures:

Green: 2400
Blue: 3000
Yellow: 3600

The unique feature is that you can always connect a lower pressure hose to a higher pressure fuel system, but you can't hook a higher pressure hose to a lower pressure system.

Section 7.0 Inspection Reporting

Proper documentation, communication and reporting are the final steps in the process. The ability to convey your findings to both owners and agencies will impact both them and the industry.

Several checklists are available as guidelines for a complete inspection (See Appendix B). These are primarily for the benefit of the owner of the vehicle, not to report findings to the certifying agency or any other entity. However, the inspector should retain a copy for his or her records as a matter of due diligence. They all include details of the vehicle, an itemized list of inspection criteria and areas to record your results.

At the present time, CSA-America is NOT requiring that copies of the inspection form be sent to them at the completion of the inspection. But, customers will want a copy as evidence of your work. Beyond the written form and results, many owners appreciate a photo attachment of the system condition. This can aid in the description of any damage and serve as a benchmark at the time of the examination. Digital photographs and electronic files can easily be added to the reports.

The last question that may arise is how to handle disposition of cylinders or systems that have potentially serious damage that would require immediate action. There are two situations where cylinders would need to be defueled or depressurized - scheduled or intended defueling such as removal or return of a out-of-date cylinder and emergency defueling in the case of confirmed or suspected Level 3 cylinder damage.

The use of atmospheric venting must be done with care. A static electrical charge can build up when releasing gas that can cause a spontaneous ignition. There are several documents that cover the necessary precautions to prevent this including CGA C-6.4 Appendix C; NFPA 52 Section 6.14 (2006) and the GTI Cylinder Care and Maintenance Handbook. All indicate that this should be done only by trained personnel. Atmospheric defueling should only be done with approval of local authorities, as natural gas (methane) is a potent greenhouse gas.

Figure 7.1 Intended defueling

Cylinder defueling is not the responsibility of the fuel system inspector, however, your advice may be helpful in guiding the authorities having jurisdiction in the proper procedures. CGA P-22 details the disposition of compressed gases and their containers. It recommends necessary training, handling, decommissioning (including removing all identifying marks), purging and rendering the cylinder unusable by drilling or cutting one or two half inch diameter holes. Also see CGA C-6.4 Appendix C for an additional sample procedure.

CAUTION: Certain Type 4 plastic-lined cylinders may be sensitive to rapid defueling. Consult the cylinder manufacturer for guidance. PARTICULAR ATTENTION should be paid to defueling cylinders with internal electronic solenoid valves. Always follow the manufacturers' instructions.

Appendix A

*Cylinder Manufacturers**

CNG Cylinder Corp. In a letter dated September 14, 2006, CNG Cylinder Corp. DOT-Exemptions have been granted to SCI, Pomona, CA. See SCI below for contact information.

Comdyne Comdyne Cylinder Co. is no longer in business. See CVEF Safety Warning dated Nov. 6, 2007 (http://www.cleanvehicle.org/technology/Comdyne_Warning.pdf).

Dynetex Industries
4410 46th Ave SE
Calgary, Alberta, Canada T2B 3N7
Tel. 888-396-3835
http://www.dynetek.com/cng.php

Faber Industrie SpA
Zona Industriale
33043 Cividale del Friuli (Udine) - Italy
http://www.faber-italy.com/cng.htm

Lincoln Composites
4300 Industrial Avenue
Lincoln, NE 68504
Tel. 800-279-8265
http://www.lincolncomposites.com/

Lucas Aerospace Power Equipment Co. is no longer in the CNG cylinder business. That division has changed hands several times, including TRW and AeroVantix. Some information can be obtained from the Clean Vehicle Education Foundation.

Luxfer Gas Cylinders, USA
3016 Kansas Avenue,
Riverside, California 92507, USA
Tel: +1 951 684 5110 or 1-800-764-0366
http://www.luxfercylinders.com/products/cng/

NGV Systems Inc. is no longer in business, however information can be obtained from SCI.

PST (Pressed Steel Tank Company, Inc.)
Tel. 414-476-0500
http://www.pressedsteel.com/index.html
No longer producing CNG cylinders but information is still available.

Quantum Fuel Systems Technologies
17872 Cartwright Road
Irvine, CA 92614
Tel. 949-399-4500
http://www.qtww.com

SCI (Structural Composites Industries)
325 Enterprise Place
Pomona, CA 91769
Tel. 909-594-7777
http://www.scicomposites.com/

Taylor-Wharton-Cylinders
521 Green Cove Road
Huntsville, AL 35803-3033
Tel: +1-256-650-9100 or 800-898-2657
http://www.taylorwharton.com

*OEM Manufacturers**

Blue Bird	Tel. 912-822-2091	http://www.blue-bird.com/
Daimler Chrysler	Tel. 248-576-4117	http://www.dcbusna.com/
El Dorado National	Tel. 909-591-9557	http://www.enconline.com/
Ford	Tel. 313-322-4771	http://www.ford.com/
Freightliner	Tel. 503-745-5219	http://www.freightlinertrucks.com/
GM	Tel. 905-644-5020	http://www.gm.com/
Honda	Tel. 310-781-5718	http://www.honda.com/
NABI	Tel. 256-831-6155	http://www.nabiusa.com/
New Flyer	Tel. 402-464-6611	http://www.newflyer.com/
Orion	Tel. 905-403-1111	http://www.orionbus.com/
Thomas Built Buses	Tel. 336-881-7243	http://www.thomasbus.com/

*Equipment Manufactures/Converters**

BAF	Tel. 214.231.1450	http://www.BAFtechnologies.com
Baytech	Tel. 415-949-1976	http://www.baytechcorp.com
Campbell-Parnell USA	Tel. 623-581-8335	http://www.usealtfuels.com
ECO Fuel Systems	Tel. 604-888-8384	http://www.ecofuel.com/
FAB Industries	Tel. 256.831.6155	http://www.fabind.com/
Teleflex/GFI	Tel. 519-576-4270	http://www.teleflexgfi.com/
ITT Conoflow	Tel. 843-563-9281	http://www.conoflow.com
NaturalDrive	Tel. 801-768-2986	http://www.naturaldrive.com/
Parker	Tel. 256-881-2040	http:// www.parker.com
Sherwood Valves	Tel. 724-225-8000	http://www.sherwoodvalve.com/
SSP Fittings	Tel. 330-425-4250	http://www.sspfitings.com
TransEco Energy	Tel. 828-654-8300	http://www.transecoenergy.com

This list is not all inclusive. Any entities wishing to be added should contact:
AFV International at (740) 205-2107

Appendix B Sample Checklists

1. CSA-America CNG Cylinder Inspection Form

Date: _____

CNG CYLINDER INSPECTION FORM

Vehicle Make	Model	Mileage	Year	VIN#

Cylinder No.	1	2	3	4
Manufacturer				
Serial #				
Location				
Label Serial # (Applied)				

P = Pass F = Fail

NFPA 52 Sect.	CGA sect.	CNG Cylinder Examination	1	2	3	4
3-3	7.4.2.4	Cylinder and mounting bracket are clean				
3-3	7.4.1	Cylinder installation compliant with NFPA-52				
3-3	7.4.1	Minimum ___ inch clearance around cylinder and 3/8 inch from shields				
3-3	7.4.2.4	Rubber mounting pads in place and in good condition				
3-3	7.4.2.4	Cylinder firmly restrained by the brackets (no rocking, looseness or cracks)				
3-3	7.4.2.4	ALL the bracket securing bolts present and tight				
3-3	7.4.2.4	Bracket and strap bolts torqued to proper specifications				
3-3	7.4.2.4	Mounting brackets in good condition (not bent, no deformation)				
3-3	7.4.2.4	Mounting bracket area free of damage				
3-3	7.4.2.4	Check bracket-to-vehicle mounting for signs of stress				
3-3	7.4.2.4	Brackets and straps corrosion free				
	7.5.3	Cuts, gouges and abrasions on the cylinder are less than 0.010 inch in depth				
	7.5.4.1	No signs of cylinder exposure to fire or extreme heat				
	7.3	No signs of cylinder involvement in an accident				
	7.5.1.3	Cylinder is free of impact damage (surface discoloration, cracked resin, chipping, loose fibers)				
3-3	7.9	Cylinder service pressure markings not less than vehicle service pressure.				
2-5	7.9	Cylinder has not exceeded the marked service life.				
3-4	7.4.1	Cylinder is properly externally vented (cylinders enclosed in vehicles only)				
	7.5.1.3	Cylinder is free of rust, corrosion or etching of outer surface				
	7.6.2	External paint, composite layer or metal surface is free of bubbles or bulges				
2-8	7.8	Valves, lines and/or Pressure Relief Device (PRD) assemblies are damage free				
2-5	7.8	PRD is in good condition (with no visible extrusion of eutectic material)				
3-5	7.4.2.1	Fuel and vent lines are properly attached to the vehicle				
	7.3	Vehicle history (no incidents possibly damaging the cylinder)				
	7.11.2	Installation of new inspection sticker				

Summary of examination and description of damage and/or adverse findings:_____

_____

_____

_____

Repairs or replaced brackets or other components as follows:_____

_____

_____

_____

Cylinder Inspection Results (check one)

____ Return Cylinder(s) to service.

____ Repair Cylinder(s) as follows:_____

_____

_____

____ Send Cylinder(s) to Mfr. for further inspection as follows:_____

_____

_____

_____

____ REMOVE CYLINDER(S) FROM SERVICE AND DESTROY

Certificate No. _____ Inspector Signature:_____

2. CGA Sample Inspection Form

Vehicle Inspector Name: _____

Vehicle Inspector Organization: _____

Date: _____ Vehicle Mileage: _____

Vehicle Make and Model: _____ Vehicle Identification Number (VIN): _____

NGV Container: _____ Manufacturer: _____

Part Number: _____ Serial Number: _____

Location: _____

NOTE—An examination form shall be filled out for each fuel container in an installation.

Y	N		Examination
		1	Is the container and mounting bracket area clean, free of dirt, and ready for examination?
		2	Is the container free from evidence of fire or exposure to extreme temperatures?
		3	Is the container free from indications that the container has been involved in an accident?
		4	Has the owner been questioned about any conditions or incidents that may have caused damage to the container? (Report adverse findings below.)
		5	Is the installation in compliance with applicable regulations (e.g., NFPA 52 or CSA B109)?
		6	Is this inspection being conducted before the expiration of the container service life?
		7	Are the container service pressure markings greater than or equal to the vehicle service pressure markings?
		8	Is there a minimum of 0.5 in (12.7 mm) clearance around the container when mounted? (A minimum standoff of 0.375 in [9.52 mm] is recommended for shields.)
		9	If containers are enclosed in the vehicle, are they properly vented externally to the vehicle?
		10	Are fuel and vent lines properly and securely attached to the vehicle?
		11	Is the rubber pad between the mounting bracket and fuel container in place and in good condition?
		12	Is the container firmly restrained by the brackets (i.e., no rocking or looseness)?
		13	Are the bolts that secure the brackets to the vehicle present and tight?
		14	Is the mounting bracket in good condition and not bent or deformed?
		15	Is the vehicle free of damage where the mounting brackets are attached?
		16	Are bolts on brackets or straps torqued to proper levels?
		17	Are the valve and/or relief device assemblies free of damage?
		18	Are the valves and relief devices tightly seated? *(**Caution:** Do not loosen valves or relief devices while the tank is pressurized.)*
		19	Are the interfaces between the valves or relief devices and the container free of leaks?
		20	If there are cuts, gouges, or abrasions present, are they less than 0.01 in (0.25 mm) deep?
		21	Is the container free of impact damage (e.g. surface discoloration, cracked resin, chipping, loose fibers)?
		22	Is the container free of surface dents?
		23	Is the container free of rust, corrosion, or etching of the outer surface?
		24	Is the container surface free of discoloration?
		25	Is the external paint, composite layer, or metal surface free of bubbles or bulges?
		26	Is the pressure relief device (PRD) in good condition with no visible extrusion of fusible metal?
		27	Are all relief devices in place?
		28	Are brackets or straps free of corrosion?
		29	Has the area under the straps been examined?
		30	Has a new examination sticker or stamp/mark been applied?
		31	Has the cylinder been pressurized above the applicable design standard?

(continued on next page)

CGA Sample Inspection Form (con't.)

Summary of examination and description of any damage or adverse findings:		
Repair or replace brackets or other components as follows:		
Recommended disposition for fuel container:		
	1	Repair fuel container as follows:
	2	Send fuel container to manufacturer for further inspection as follows:
	3	Remove fuel container from service and condemn
	4	Return fuel container to service

Signature of inspector:_____

3. ATT Sample CNG Cylinder Inspection Form

ADVANCED TRANSPORTATION TECHNOLOGY

Date: _____

CNG CYLINDER INSPECTION FORM

Bus # _____ Model # _____ Mileage: _____ Year: _____ VIN# _____

Cylinder No.	1	2	3	4	5	6	7	8
Manufacturer								
Serial #								
Location								
Pass/Fail Visual Inspection	Pass/Fail	Pass/Fail	Pass/Fail	Pass/Fail	Pass/Fail	Pass/Fail	Pass/Fail	Pass/Fail

NFPA 52 sect		CNG CYLINDER EXAMINATION	Pass	Fail
3-3		Cylinder and mounting bracket are clean		
3-3		Minimum ½ inch clearance around cylinder and 3/8 inch from shields		
3-3		Rubber mounting pads in place and in good condition		
3-3		Cylinder firmly restrained by the brackets (no rocking, looseness or cracks)		
3-3		All the bracket securing bolts present and tight		
3-3		Bracket and strap bolts torqued to proper specifications		
3-3		Mounting brackets in good condition (not bent, no deformation)		
3-3		Mounting bracket area free of damage		
3-3		Check bracket-to-vehicle mounting for signs of stress		
3-3		Brackets and straps corrosion free		
-		Cuts, gouges and abrasions on the cylinder are less than 0.010 inch in depth		
-		No signs of cylinder exposure to fire or extreme heat		
-		No signs of cylinder involvement in as accident		
-		Cylinder is free of impact damage (surface discoloration, cracked resin, chipping, loose fibers)		
3-3		Cylinder service pressure markings not greater than vehicle service pressure		
2-5		Cylinder has not exceeded the market service life		
3-4		Cylinder is properly externally vented and vent caps in place and functional		
-		Cylinder is free of rust, corrosion or etching of outer surface		
3-3		Cylinder installation currently compliant with NFPA-52		
-		External paint, composite layer or metal surface is free of bubbles or bulges		
2-9		Valves, lines and/or Pressure Relief Device (PRD) assemblies are damage free		
2-5		PRD is in good condition (with no visible extrusion of eutectic material)		
3-5		Fuel and vent lines are properly attached to the vehicle		
		Vehicle history (No incidents possible damaging the cylinders)		

Summary of examination and description of damage and/or adverse findings: _____

_____

Repair or replaced brackets or other components as follows: _____

_____

Cylinder Inspection Results (check one)

☐Return Cylinder(s) to Service

☐ Repair Cylinder #(s) as follows: _____

_____

☐ Send Cylinder #(s) to Mfr. For further inspection as follows: _____

_____

☐ REMOVE CYINDER #(S) FROM SERVICE AND DESTROY _____

Inspector/Tech # _____ _____

Inspector Signature

JANUARY 2004

Appendix C

6812 Haycock Road
Falls Church, VA 22043, USA
1-703-534-6151
www.cleanvehicle.org

Codes, Standards and Advisories Applicable to Natural Gas Vehicles and Infrastructure

(N.B. This list is not all-inclusive)

Document	Applicability	Comments
NFPA 52 – Vehicular Fuel Systems Code - 2006	CNG vehicles (incl. marine) and fueling facilities,	Probably single best source of guidance for CNG vehicles and fueling facilities.
NFPA 57 – Liquefied Natural Gas Vehicular Fuel System Code - 2002	LNG and L/CNG vehicles (incl. marine) and fueling facilities	Single best source of guidance for LNG vehicles and fueling facilities
NFPA 88A – Standard for Parking Structures – 2007	Open, enclosed, basement and underground parking structures	No special requirements for NGVs other than reference to NFPA 52 and 57
NFPA 30A – Code for Motor Fuel Dispensing Facilities and Repair Garages - 2007	Facilities dispensing **both** gaseous **and** liquid fuels at the same facility	Includes requirements of old 88B on repair garages.
NFPA 59A – Standard for the Production, Storage, and Handling of Liquefied Natural Gas - 2009	Site selection, design, construction, and fire protection for LNG facilities.	
SAE J1616 – Recommended Practice for Compressed Natural Gas Vehicle Fuel - 1994	CNG motor vehicle fuel	Recommendations on vehicular fuel composition.
SAE J2343 – Recommended Practices for LNG Powered Heavy-Duty Trucks- 2007	LNG powered heavy duty trucks	Primarily heavy truck recommendations but some maintenance facility equipment and procedures.
SAE J2406 – Recommended Practices for CNG Powered Medium and Heavy- Duty Trucks - 2002	CNG powered medium and heavy duty trucks (>14,000 GVWR)	Published in 2002.

Document	Applicability	Comments
SAE J2645 - Liquefied Natural Gas (LNG) Vehicle Metering and Dispensing Systems	LNG Vehicular Fuel Metering and Dispensing.	Published in 2008
Design Guidelines for Bus Transit Systems Using Liquefied Natural Gas (LNG) as an Alternative Fuel (3/97)	Transit Facilities but useful reference for other fleets	FTA Report - Not only references required codes (e.g., NFPA) but also suggests additional precautions and provides general information.
Design Guidelines for Bus Transit Systems Using Compressed Natural Gas as an Alternative Fuel (6/96)	ditto	ditto
Compressed Natural Gas Safety in Transit Operations (10/95)	ditto	ditto
Liquefied Natural Gas Safety in Transit Operations (3/96)	ditto	ditto
NFPA 1 – Fire Code - 2009	"Adopted in jurisdictions throughout North America"	May be the fire code used in your area. Check with local fire marshal.
International Fire Code - 2006	"regulations governing the safeguarding of life and property from all types of fire and explosions hazards."	Check with local fire marshal on applicability.
CSA B108-99 (R2006) Natural Gas Fuelling Stations Installation Code	Canadian Std. applicable to fleet and public stations	
CSA B109-01 – Natural Gas for Vehicles Installation Code	Canadian Std. Applies to "installation, servicing and repair of NG fuel systems on self-propelled vehicles."	
ANSI NGV1-2006 – Compressed Natural Gas Vehicle (NGV) Fueling Connection Devices	CNG vehicular fueling connection devices	Assures standardized nozzles and receptacles
ANSI NGV 2-2007 – Compressed Natural Gas Vehicle Fuel Containers	CNG fuel containers	Container requirements in addition to FMVSS 304.
ANSI NGV3.1-1995 – Fuel System Components for Natural Gas Powered Vehicles	Fuel system components for NGVs (excludes LNG components upstream of vaporizer)	Primarily for converted vehicles.
ANSI NGV4.1/ CSA 12.5 -1999 – NGV Dispensing Systems	CNG vehicular fuel dispensing systems	

Document	Applicability	Comments
ANSI NGV4.2/CSA 12.52 -1999 – Hoses for NGVs and Dispensing Systems	CNG dispenser and vehicular hose assemblies	
ANSI NGV4.4/CSA 12.54 -1999 – Breakaway Devices for Natural Gas Dispensing Hoses and Systems	CNG dispenser shear valves and fueling hose emergency breakaway shutoff devices	
ANSI NGV4.6/CSA 12.56 -1999 – Manually Operated Valves for Natural Gas Dispensing Systems	Manually operated CNG valves, excluding cylinder shut-off valves	
ANSI NGV4.8/CSA 12.8 -2002 – Natural Gas Vehicle Fueling Station Reciprocating Compressor Guidelines	Compressor packages containing reciprocating compressors used in CNG fueling station service.	
ANSI PRD1-1998 (with 1999 & 2007 addenda) – Basic Requirements for Pressure Relief Devices for Natural Gas Vehicle Fuel Containers	Pressure Relief Devices for CNG Fuel Containers	
CGA C-6.4-2007 – Methods for External Visual Inspection of Natural Gas Vehicle Fuel Containers and Their Installations	CNG vehicular fuel containers	Referenced in ANSI NGV2
49 CFR 178.56 – Specification 4AA welded steel cylinders	CNG cylinders for fueling stations.	Generally not used for new CNG fueling stations. ASME vessels now generally used.
49 CFR 178.57 – Specification 4L welded insulated cylinders	LNG vehicular fuel tank requirement called out in NFPA 57.	Option is meeting ASME Boiler and Pressure Vessel Code.
49 CFR 571.304, FMVSS 304 – Compressed Natural Gas Fuel Container Integrity	CNG motor vehicle fuel containers	DOT Federal Motor Vehicle Safety Standard for CNG motor vehicles.
49 CFR 571.303, FMVSS 303 – Fuel System Integrity of Compressed Natural Gas Vehicles	CNG vehicles $\leq$10,000 lbs. GVWR and school buses	DOT Federal Motor Vehicle Safety Standard for crash test of light duty vehicle and school bus CNG fuel systems.
49 CFR 393.65, FMCSR – All Fuel Systems	Commercial vehicles in interstate commerce	DOT Federal Motor Carrier Safety Regulations. May have been adopted by states for intrastate application. Wasn't written w NGVs in mind but may be legally applicable.

Document	Applicability	Comments
40 CFR 80.33 - Controls applicable to natural gas retailers and wholesale purchaser-consumers	Retailer and wholesale purchaser-consumers of NG	EPA 1.2 gm limit on atmospheric venting per refueling.
40 CFR 86.098-8 - Emission standards for 1998 and later model year light-duty vehicles	Light-Duty Vehicles	Requires NGV1 receptacles.
ASME Boiler and Pressure Vessel Code, Section VIII (Pressure Vessels)	Sections applicable to LNG containers used on vehicles and in fueling stations. Sections applicable to containers used in CNG fueling stations.	
CA Code of Regulations, Title 13, Div 2, Ch 4, Article 2	Fuel systems using LNG in 13 CCR 935, CNG in 13 CCR 934	CA vehicle requirements
CA Code of Regulations, Title 8, Div 1, Ch 4, Subchapter 1	CNG and LNG Storage Tanks	CA fuel storage requirements
CA Code of Regulations, Title 13, Div 3, Ch 5, Article 3, Sec 2292.5	CNG sold in CA	CA CNG composition requirements
TX Administrative Code, Title 16, Part 1	CNG regulations in Chapter 13, LNG regulations in Chapter 14	TX requirements

Availability:

National Fire Protection Association (NFPA) documents – contact NFPA at 1-800-344-3555 or http://catalog.nfpa.org

Society of Automotive Engineers (SAE) documents – contact SAE at 774-726-0790 or www.sae.org/products

Federal Transit Administration (FTA) documents – contact William Hathaway at 617-494-2081 or the National Technical Information Service at 703-605-6050 or www.ntis.gov

Uniform Fire Code – Contact Western Fire Chiefs Association/Uniform Fire Code Association at 760-723-6911 or www.wfca.com/ufca or buy from a bookstore, such as Amazon.Com

International Fire Code – Contact International Codes Council at 703-931-4533 or www.intlcode.org

Canadian Standards Association (CSA) documents – Contact CSA at 1-800-463-6727 or www.csa.ca

ANSI NGV documents – May be purchased from CSA at http://www.csa-intl.org/onlinestore/getcatalogdrilldown.asp?Parent=0&k=3&l=1 or ANSI at http://webstore.ansi.org/ansidocstore/default.asp

Compressed Gas Association (CGA) documents – Contact CGA at 703-788-2700 or www.cganet.com

Code of Federal Regulations (CFR) – Can be obtained on the web at www.access.gpo.gov

California Code of Regulations (CCR) – Can be obtained on the web at http://ccr.oal.ca.gov

Texas Administrative Code – Can be obtained on the web at http://info.sos.state.tx.us:80/pub/plsql/readtac$ext. ViewTAC

ASME Boiler and Pressure Vessel Code – Contact ASME at 800-843-2763 or www.asme.org updated 9/11/08

Appendix D

There are 60 questions on the test that are graded toward certification although there may be additional sample questions inserted for evaluation but not graded. They are proportioned according to the Objectives as follows:

	Percentage Of Coverage	Number of Questions
Section 1 Preparation for Inspection	**13%**	**8**
Section 2 Determine Inspection Requirements	**9%**	**5**
Section 3 Pressure Relief Device Inspection	**7%**	**4**
Section 4 Physical Inspection of Brackets and HP Components	**18%**	**11**
Section 5 Physical Assessment of Cylinders	**38%**	**23**
Section 6 CNG Fuel System Installation	**10%**	**6**
Section 7 Inspection Reporting	**5%**	**3**
	100%	**60**

The test is offered throughout the year as a computer-based exam offered at designated centers all across the country and as a paper and pencil exam offered during scheduled, semi-annual exam sessions. Candidates for certification may download the personnel certification guide and application form from CSA America's website at: http://www.csa-america.org/personnel_certification/cng_certification/.

Completed application forms can be submitted via email to: personnelcertification@csa-america.org or by faxing to (216) 520-8979. Once the application and payment are received and processed, CSA will send the candidate information to the test vendor. The test vendor will email the candidate the "Notice to Schedule" or NTS which includes instructions on scheduling their exam session. Once the candidate receives their NTS, they will be able to register for the exam at the test site/date they choose. Candidates must submit the scheduling request at least 10 business days prior to the requested examination date. Testing sites are located throughout the United States and are normally within a short driving distance from most potential inspectors.

Taking the Test

All of the questions are direct multiple choice or of the type ”given a scenario…what would you recommend.” Unlike the ASE tests, there are no “True/False” questions, no “Technician A or Technician B” questions, no ”fill in the blank” and no negative questions (e.g.:. “All of the following are true EXCEPT” or ”none of the above”). Each question will have only one correct answer.

You will have more than enough time and there is no need to feel rushed, but as with all test taking, keep track of the time and monitor your progress. Read each question thoroughly and carefully. Answer all of the questions you are confident of quickly and then go back and concentrate on those that you need more time to think about. Make sure you attempt an answer on all of the questions.

Sample Questions

1. The cylinder service pressure is the pressure measured at
a. 70 deg. F
b. 140 deg. F
c. 180 deg. F
d. Ambient Temperature

2. The primary purpose of the liner in a Type 4, all composite cylinder is to
a. prevent the absorption of water vapor
b. absorb the gas
c. prevent gas leakage
d. contain gas pressure

3. An undamaged CNG cylinder with a service pressure of 3,600 psig is designed with a safety factor so as not to rupture:
a. in excess of 4500 psig
b. in excess of 8,000 psig
c. in excess of 15,000 psig
d. will not rupture at any pressure

4. In a Type 4 all-composite cylinder, the portion of pressure load due to internal pressure, taken up by the plastic liner is
a. 100%
b. 10%
c. 5%
d. 0%

5. A composite wrap consists of
a. fibers embedded in a resin
b. a resin system
c. a hoop wrapped resin system
d. metal cords in a rubber base

6. The pipe or tubing attached to the pressure release device is commonly known as
a. the pressure overflow line
b. the high pressure line
c. the vent line
d. none of the above

7. The agency having jurisdiction over the FMVSS 304 standard is
a. the National Highway Traffic Safety Administration (NHTSA)
b. the Federal Transit Administration (FTA)
c. the U.S. Department of Energy (DOE)
d. the Clean Cities network

8. What is the useful life of most cylinders made to the NGV 2 standard currently in service
a. 5 years
b. 15 years
c. 30 years
d. indefinite

9. NGV 2 recommends that as a minimum, cylinders should be subject to a detailed visual inspection
a. every year
b. every two years
c. during every refueling
d. every three years

10. In addition to setting forth cylinder inspection requirements, the CGA C-6.4 standard also addresses the following topic:
a. cylinder installation
b. fueling connectors
c. fueling station ground storage
d. emission requirements

11. A cylinder mounted inside a vehicle must be
a. protected from road debris
b. mounted in locations that minimize damage
c. vented to the outside
d. NFPA 52 does not allow this type of installation

12. During the detailed visual inspection a cut on the cylinder was found. What would you recommend?
a. the cylinder should be condemned
b. the cylinder manufacturer should be contacted
c. the level of damage should be determined
d. the cylinder should be immediately defueled

13. To perform the general visual inspection, how much training is required?
a. ASE Certification
b. two years of hands-on training
c. understanding and knowledge of cylinder damage
d. CSA Fuel System Inspection certification

14. The primary inspection method in the NGV 2 and the DOT FMVSS 304 standard is
a. detailed visual inspection
b. hydrostatic testing
c. ultrasonic testing
d. acoustic emission testing

15. One of the major safety concerns with venting natural gas from a cylinder is
a. overheating the vent pipe
b. static build-up
c. pollution of the environment
d. cuts due to high pressure

16. You notice an installation that does not comply with the current version of NFPA 52. What would you recommend?
a. remove the installation
b. ground the vehicle
c. determine if non-compliance creates a safety hazard and if so modify it
d. use the version of NFPA 52 that was in use at the time of the installation
It seems to me that “d” should be the correct answer here. I’m not comfortable with inspectors

17. An older Type 4 fiberglass wrapped cylinder is mounted under the bed of a cargo van used to transport car batteries for recycling. During inspection, there is evidence of chemical attack on the cylinder.

Based on this information, what action would you recommend?
a. Clean any residue from the cylinder after the inspection is completed
b. Remove the cylinder for visual inspection
c. Contact the container manufacturer for guidance
d. Defuel the cylinder immediately and condemn it.

18. Refer to the illustration.

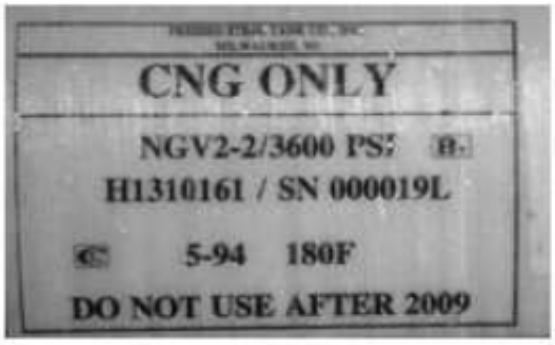
The driver of a converted passenger van states that he drove over a large curb and heard a loud sound. The abrasion is inspected and found to have a depth of 0.060 inches.

What is the level of damage and recommended action?

a. Level 1: no action required
b. Level 2: contact the vehicle manufacturer for a recommend procedure
c. Level 3: contact the vehicle manufacturer for a recommend repair procedure
d. Level 3: condemn the cylinder

19. A surface cut in a cylinder is 2 inches long and 0.040 inches deep. What should be done?
a. condemn the cylinder
b. consult the cylinder manufacturer's guidelines to determine the damage level
c. remove the cylinder and consult the cylinder manufacturer's guidelines
d. approve the cylinder for service

20. Refer to the illustration.



Identify the type of cylinder.
a. Type 1
b. Type 2
c. Type 3
d. Type 4

ANSWER KEY: 1.a, 2.c, 3.b, 4.d, 5.a, 6.c, 7.a, 8.b, 9.d, 10.a, 11.c, 12.c, 13.c, 14.a, 15.b, 16.c, 17.d, 18.d, 19.b, 20.b