Truck and Tractor CNG Fuel System Operation, Maintenance & Inspection Manual

ENP-516 Rev. E

December 10, 2020

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Preface

This manual replaces three individual manuals: “Truck and Tractor CNG System Operation Manual, ENP-007; “CNG Fuel System Inspection Guidelines,” ENP-468 and “CNG Maintenance Interval Guidelines,” ENP-493. The simplified “CNG System Users’ Manual,” ENP-314, is available for download from the Agility® website.

This manual contains general operation, maintenance and inspection information for Agility® compressed natural gas (CNG) vehicle fuel systems. If an original equipment manufacturer (OEM) fuel system manual exists, it shall take precedence over this manual. Systems or specific components may vary slightly from this text, but the operating principles and functions of the components are the same.

No attempt shall be made to fill, install, or maintain the CNG fuel system until this manual and all referenced supporting documentation have been read and fully understood.

Warning Statements Used in this Manual

DANGER indicates a hazardous situation which, if not avoided, will result in death or serious injury.

WARNING indicates a hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

***NOTICE* is used to address practices not related to physical injury, such as best practices or tips to help an operation or procedure go smoothly and prevent equipment damage.**

Critical Characteristic

Manufacturing Characteristic

Product feature directly affects:

- **Safety of vehicle users, people nearby and maintenance personnel, or**
- **Regulatory compliance.**
- **A product feature solely used to improve manufacturability or maintain process control.**
- **A process parameter or step that has a significant effect on achieving a Critical Characteristic or Significant Characteristic, or maintaining material identification/traceability.**

Support, Service or Parts

Fuel system in- or out- of warranty product support may be obtained by calling Agility® Fuel Solutions Customer Care or via email.

Customer Care

+1 877 234 1722 toll-free, U.S. and Canada

+1 949 267-7745

Support

support@agilityfs.com

Parts Orders

parts@agilityfs.com

When calling or emailing, please provide your name, phone number, email address, and complete vehicle information: VIN, , year, make, model, mileage, unit number vehicle owner, and current vehicle location. A service advisor will contact you to arrange vehicle repair or ship a part.

Agility Fuel Solutions

3335 Susan Street, Suite 100

Costa Mesa, CA 92626

USA

www.agilityfuelsolutions.com

⚠CAUTION

All replacement parts must adhere to standards and ratings specified by Agility®. Using any part not approved by Agility® is not recommended and may compromise the integrity and safety of the system.

NOTICE

Do not remove components from original packaging until necessary. Any components to be reinstalled must be thoroughly cleaned, inspected and stored in a satisfactory manner until reinstallation.

1. Safety

⚠WARNING

If vehicle has been in an accident or fire, fuel cylinders and system must be examined by a qualified fuel system inspector.

This section outlines general safety guidelines that must be followed when operating and servicing CNG equipment provided by Agility®.

1.1. Qualified Personnel

CNG systems should be maintained and inspected exclusively by qualified trained personnel. As with all pressure vessels, CNG storage and fuel delivery systems are dangerous.

1.2. Safety Equipment

1. CNG safety signage should be visible at all applicable locations as stipulated by federal, state and municipal law.
2. Natural gas rated fire extinguishers should be accessible and visible throughout all servicing and fueling areas. Be sure all fire extinguishers are charged and up to date.
3. Areas designated for CNG fueling systems must have adequate lighting that complies with NFPA and other applicable codes.
4. Search for leaks using only certified leak detecting solutions and equipment such as Swagelok® Snoop®. Any other product or solutions are unacceptable.
5. Use tools that are in good working order with proper calibration.
6. Wear appropriate attire and personal protective equipment (PPE) while servicing or maintaining any CNG system.

1.3. General Safety Precautions

1. Follow all maintenance procedures in order; do not skip steps unless so noted.
2. Never use an open flame as a source of illumination near a CNG system.
3. CNG fuel systems are to be serviced in designated areas that comply with all federal, state and municipal laws and regulations.
4. CNG servicing and fueling areas must be well ventilated.
5. Perform all maintenance and service procedures in a dust free environment.
6. Never attempt to depressurize or vent a system by loosening a fitting.
7. Standing on cylinders creates a fall hazard and surface damage may occur from debris stuck in shoe treads or soles. Always wear fall arrestment PPE when working on roof- or high-mounted fuel systems.

1.4. CNG Vehicle Safety Precautions

⚠WARNING

Strict compliance with proper safety and handling practices is essential when operating CNG fuel systems.

The following safety precautions should always be followed when operating CNG fuel systems and equipment:

1. A portable fire extinguisher must be installed on the vehicle in an easily accessible location.
2. Do not start engine if a CNG leak is detected.
3. Never attempt to open system components that are under pressure.
4. CNG system service pressure is 3600 psi (25 MPa); maximum allowable working pressure (MAWP) is 4500 psi (31 MPa).
5. Do not smoke or produce an open flame within 30 ft (9 m) of a CNG vehicle or a CNG dispensing/filling station.
6. Always ground vehicle prior to defueling.
7. If a CNG vehicle must be out of service for an extended period, turn cylinder valves to the "OFF/CLOSED" position and run the engine until it stalls. This will consume residual fuel in closed off lines.

1.5. Welding & Hot Work Precautions

⚠WARNING

Before performing any hot work procedure, verify fuel system is leak-free by performing a leak test with a suitable leak detection solution.

NOTICE

Before performing any welding on the vehicle chassis or body, ensure the main battery disconnect switch is turned off. Follow OEM or body builders' manual for welding procedures.

NOTICE

Disconnect CNG fuel system electrical connector at the rear of FMM box or at Agility® ECU to prevent damage.

For any welding in or near a CNG storage system, follow these safety recommendations:

Ensure the vehicle is parked in a well-ventilated area. Do not park the vehicle in an area where CNG may accumulate.

- If welding or hot work is performed **more than** 6 ft (2 m) from the CNG fuel system, it is not necessary to defuel the system. However, the fuel system should be depressurized.
- If performing hot work **closer than** 6 ft (2m) to the CNG system, the system must be de-fueled, and the following additional precautions must be followed:

⚠CAUTION

Cover all CNG components, including cylinders and fuel lines, with fireproof blankets or a metal shield. Isolation must prevent sparks and slag from hitting the cylinders.

NOTICE

A single spark or weld slag could compromise CNG components.

⚠WARNING

If a cylinder is hit by a spark or slag, the vehicle must be taken out of service and inspected.

1.6. Codes and Compliances

USA: NFPA 52

Canada: CAN/CSA B109

North America: ANSI/AGA NGV 3.1/CGA 12.3 and NGV 12.3-M95

1.7. First Responder Guide

NOTICE

Refer to "Agility Fuel Solutions First Responder Guide," ENP-084, for CNG firefighter and first responder information.

A vehicle equipped with a CNG fuel system must have a reflective blue diamond decal on the rear of the vehicle identifying fuel type. The decal may not be affixed to the bumper.

Figure 1. CNG vehicle blue diamond identification decal.

Natural gas possesses unique hazards not present in gasoline or diesel fuel. Unlike gasoline and diesel which are liquids at room temperature and pressure, CNG is in a gaseous state under the same conditions. For storage purposes, natural gas must be compressed to 3600 psi (24.8 MPa). Agility® minimizes these potential hazards with state of the art design and testing practices.

1.8. CNG Cylinder Safety

CNG fuel cylinders are housed in metal frames that are bolted to the truck body or chassis. These structures are designed to protect the cylinders in a collision. Each individual cylinder has a valve at one end which allows the fuel in that cylinder to be isolated from the rest of the system. During normal operation, all cylinder valves should be open.

NOTICE

Agility® CNG systems primarily use Agility® cylinders. However, other types and manufacturers of CNG cylinders may be present. Always check permanent labels on each cylinder to verify manufacturer and expiration date.

⚠WARNING

CNG storage cylinder pressure can reach 4500 psi (31 MPa). DO NOT cut fuel supply plumbing.

⚠WARNING

Pressure relief device (PRD) fuel lines always contain full cylinder pressure and cannot be isolated by cylinder valves. Know PRD fuel line and PRD vent line outlet locations on the vehicle.

1.9. Emergency Response for Gas Leaks

If the vehicle has sustained damage or a gas leak is detected:

1. Do not approach the vehicle if any sources of ignition may exist such as fire, sparks, electrostatic charges, lights or electronic devices.
   a. If ignition sources may be present, vehicle fuel cabinet doors should remain closed.
   b. If no ignition sources are present, keep the vehicle and fuel cabinet doors open to prevent gas accumulation.
2. If the vehicle is indoors, move the vehicle outside and away from any ignition sources.
3. Do not use road flares.
4. Do not smoke or allow anyone else to smoke near the vehicle.
5. Turn ignition switch off, set parking brake and turn off battery at main disconnect.
6. If it is safe to do so, close 1/4-turn manual shutoff valve and cylinder valves. Check the fuel system near damaged area for leaks by smell, sight, and sound. CNG is odorized.
7. Keep traffic and pedestrians away.
8. Beware that gas may continue to leak once ignition is turned off and the manual shutoff valves are closed.
9. Verify leak locations with leak detection fluid such as Swagelok® Snoop®.

1.10. Vehicle Fire Procedures

1. Always call local emergency services (9-1-1) first.
2. Get passengers out of the vehicle as quickly as possible.
3. Evacuate the area.

⚠WARNING

In case of fire, thermally activated pressure relief devices (PRDs) protect cylinders from rupturing. PRDs typically activate between 212°F (100°C) and 220°F (104°C) and will release high-pressure CNG which may ignite and add to the fire.

1.10.1. Emergency Shut Down Procedure

1. Turn ignition switch off.
2. Set parking brake.
3. *If equipped:* Turn off battery disconnect switch.
4. Turn 1/4-turn manual shutoff valve to OFF/CLOSED position.
5. Inform emergency personnel.

2. Fuel Storage, Fuel Flow and System Components

All figures and illustrations are intended for reference only and do not reflect the exact configuration for any given system. All plumbing and fuel management module layouts are consistent across platforms; however, there may be some differences depending on vehicle-specific options. Please contact Agility® Customer Care with any questions not covered in this manual.

⚠WARNING

Failure to perform regular or emergency inspections may create vehicle hazards and put operators and technicians at risk of serious injury or death.

2.1. CNG Fuel Cylinders

⚠WARNING

Cylinders in CNG vehicles involved in an accident or incident must be depressurized prior to inspection.

Periodic inspection is mandatory for safe operation of any fuel cylinder. Safe operation depends upon proper installation, use and maintenance.

2.1.1. Cylinders should be inspected immediately if:

1. Vehicle has been in an accident.
2. Cylinder or vehicle has been subjected to fire, impact, excessive heat or any other condition that may have caused external or internal damage.
3. Unusual behavior is observed. This may include but is not limited to the following: emission of CNG odor, unexpected loss of gas pressure, snapping or hissing sounds, rattling and any indications of loose parts.
4. Cylinder has been transferred to another vehicle or cylinder installation has been altered significantly.

NOTICE

Agility® CNG systems use Type 3 or Type 4 cylinders. Always check permanent labels on each cylinder to verify manufacturer and expiration (do not use after) date.

2.2. System Configurations

CNG fuel system structures and components are designed to meet or exceed all safety and vehicle standards. Every Agility® system is housed in a protective structure which can be found on the vehicle roof, sides, in front of body, behind the cab, or tailgate mounted. *Figure 2*

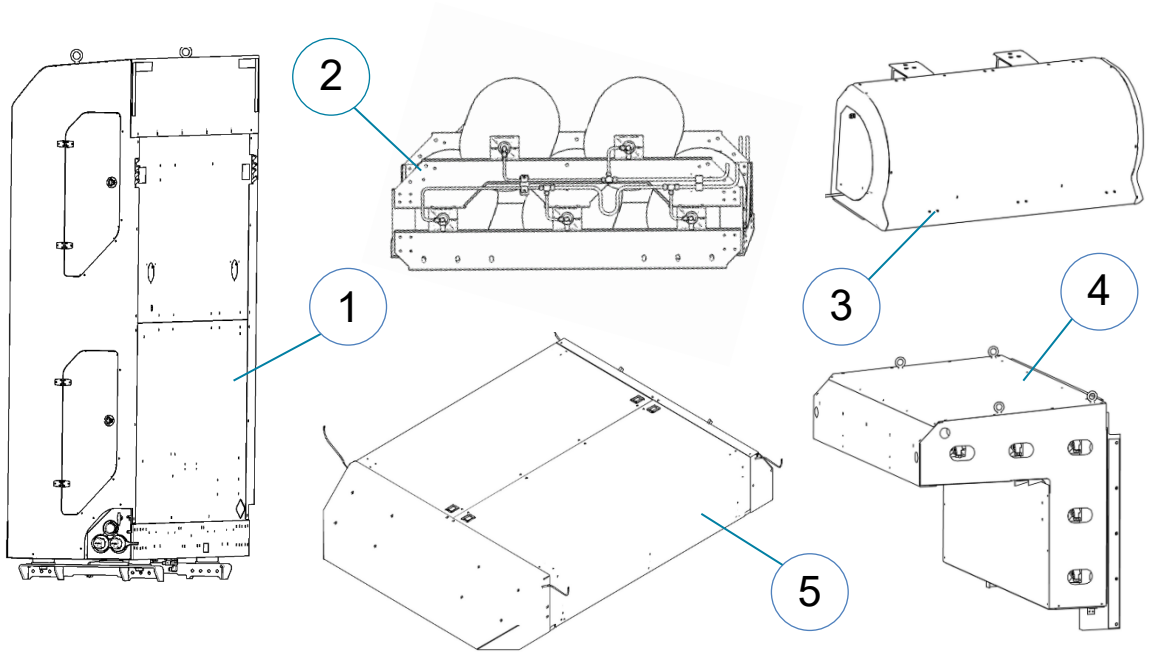


Figure 2. Typical CNG system vehicle configurations: behind the cab (1), side mount (2), refuse tail gate (3), front of body (4), refuse roof mount (5).

2.3. System Overview and Fuel Flow

Fuel is stored in one or more CNG cylinders at a nominal pressure of 3600 psi (24.8 MPa). Each cylinder is protected by one or more pressure relief devices, or PRDs.

Starting from the fuel cylinder(s), high-pressure gas flows through cylinder shutoff valves to the fuel management module (FMM). The FMM houses control valves, a high-pressure coalescing filter and a pressure regulator to condition the fuel for use by the engine.

The CNG pressure regulator reduces fuel pressure to an amount suitable for engine consumption. Gas from the regulator flows through the low-pressure filter and finally to the engine. Low-pressure specifications range from a minimum of 60 psi (413 kPa) to 70 psi (482 kPa) and a maximum of 100 psi (689 kPa) or 150 psi (1.03 MPa). Starting in 2018, Agility® system regulators are adjusted to approximately 85 psi (586 kPa) to 87 psi (600 kPa) to be compatible for all Cummins-Westport CNG engines. *Figures 3 and 4*

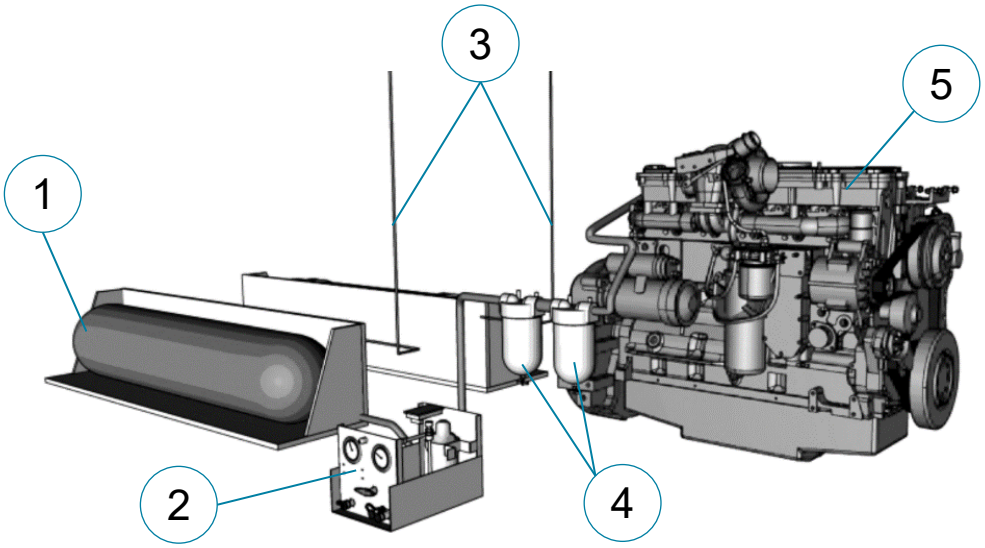


Figure 3. CNG fuel system overview.
Cylinder (1), fuel management module (FMM) (2), PRD vent lines (3). NOTE: Low-pressure fuel filters (4) at engine (5) are not considered part of the Agility® fuel system.

NOTICE

The Agility® CNG fuel system ends at the input side of the low-pressure fuel filter, usually located in the engine bay.

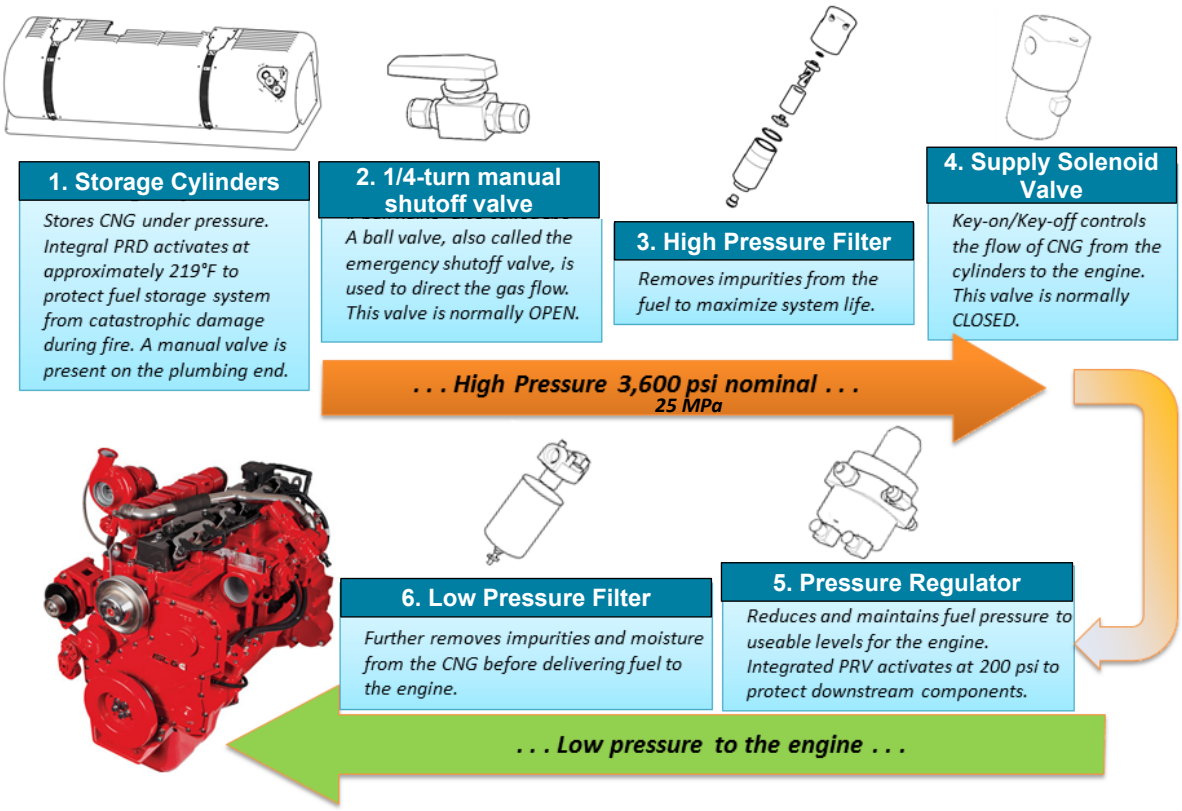


Figure 4. CNG system fuel flow and nominal pressures.
Low pressure to most engines: 125 psi (861 kPa).
Cummins-Westport 6.7L, 9L, 12L and Near Zero 12L require lower fuel pressure: from 85 (586 kPa) to 87 psi (600 kPa).

2.4. Fuel Management Module Components and Function

The FMM is the interface between the vehicle fuel storage and delivery system and the vehicle engine and operator. There are several FMM configurations depending on fuel storage system and vehicle type. FMM can be mounted on either the driver side or passenger side. *Figures 5 and 6*

Typical FMM components and their functions include the following:

1. A red **1/4-turn manual shutoff valve** controls fuel flow from FMM to engine. It is “ON” or open for normal operation.
   a. The 1/4-turn manual shutoff valve isolates fuel cylinders from engine for emergency situations. This valve is **open** for normal operation.

      ⚠CAUTION

      DO NOT use 1/4-turn manual shutoff valve when depressurizing the system. The best practice is to close each cylinder valve to isolate and contain the gas inside the cylinder when depressurizing the system. *Refer to Section 8.1.*
2. The standard **NGV1 fuel fill receptacle** is found across North America. Some Agility® systems also include a “fast” or “transit fill” high-volume flow receptacle.
3. The **defuel receptacle** permits fuel in the cylinders to be removed when necessary.
4. The **high-pressure gauge** indicates pressure in the cylinders and plumbing components flowing to the regulator. Minimum pressure should be 500 psi (3.45 MPa), maximum pressure is 4000 psi (27.5 MPa) and nominal pressure is 3600 psi (24.8 MPa) when full.
5. *If equipped*: the **low-pressure gauge** displays fuel pressure coming out of the pressure regulator and flowing to the engine.
6. **Manifold** is a “plumbing hub” where the gas is distributed to various places in the system.
7. **High-pressure fuel filter** traps potential contaminants in CNG coming from the cylinders.
8. *If equipped:* the **bleed valve** is used to relieve any remaining pressure after the depressurizing process. It is normally closed.
9. **Defuel valve** is opened when defueling; closed for normal operation.
10. **Solenoid valve** is activated by the vehicle ignition key.
11. *If equipped:* **Drive away protection (DAP**) prevents engine starting unless all fuel caps (including fuel system doors and auxiliary fill caps) are securely in place. Two types of DAP systems are in use:
    a. Some DAP systems are an integral part of the fuel receptable cap. A sensor trigger (magnet) in the cap closes a reed switch in the FMM panel to send an “OK to crank” signal to the electronic control unit (ECU).
    b. Other DAP systems use a spring contact on the FMM door or cover. When the FMM door is closed or the cover is installed it completes a circuit to ground, providing an “OK to crank signal” to the FMM ECU.

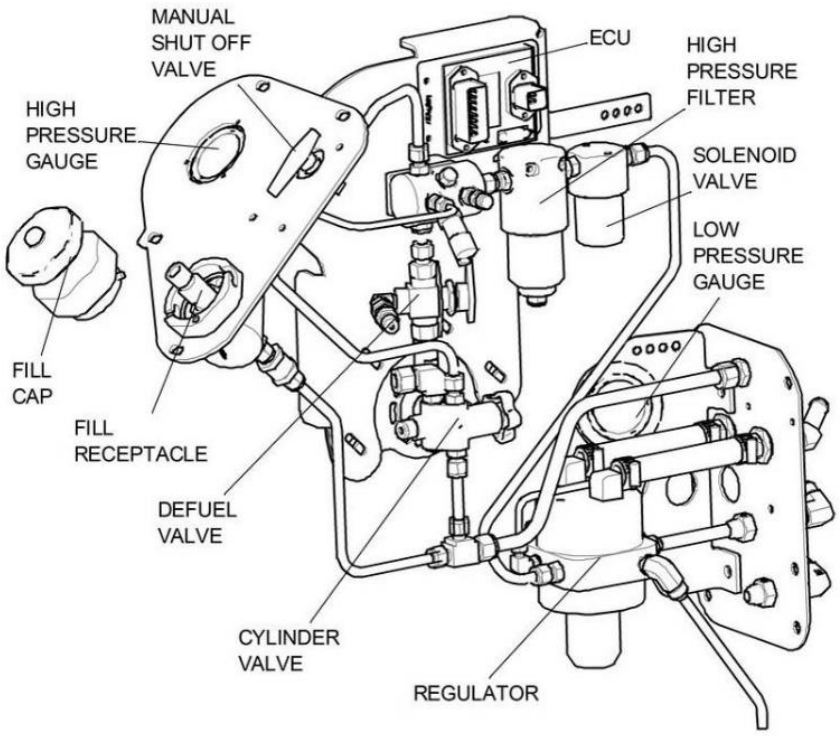


Figure 5. Typical integrated FMM used with side mount systems.
NOTE: some parts are hidden in this view.

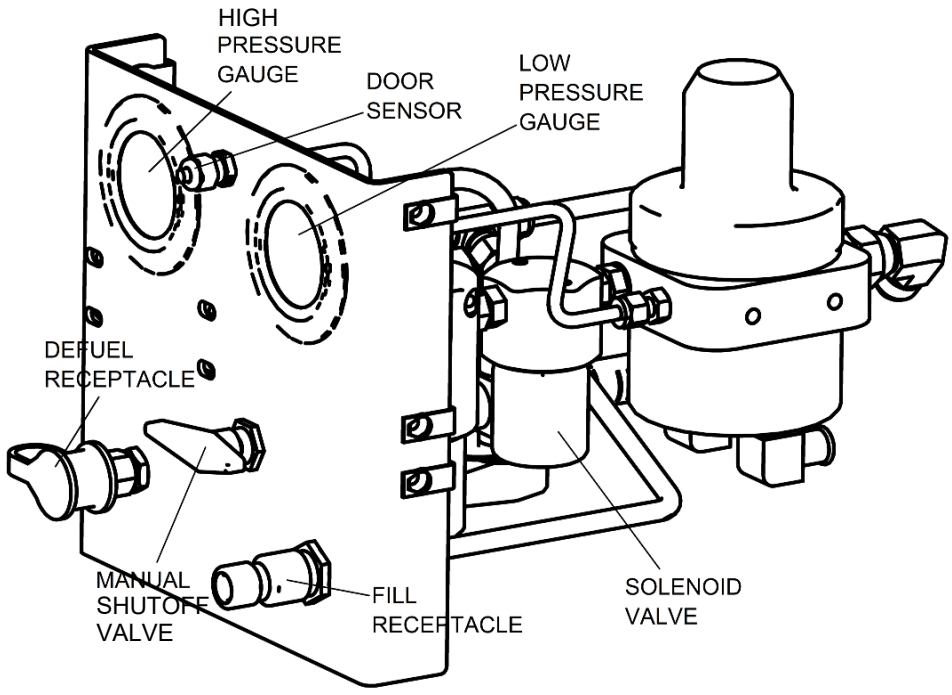


Figure 6. Typical box style FMM front panel with cover removed.

2.5. Fuel Lines and Fittings

2.5.1. Fuel Lines

All fuel system lines are cold finished stainless steel, bright annealed, seamless tube manufactured according to ASTM A269 or ASTM A213. Tubing can be 316 SS or 304 SS, maximum hardness 80 HRB. Fuel lines should be supported a minimum of every 24-in (600 mm).

2.5.2. Fuel Fittings

Fuel system fittings must be stainless steel. Additionally, fuel system fittings must utilize a design incorporating an O-ring or double ferrules to help prevent leaks.

⚠CAUTION

High-pressure fittings and components must be repaired or adjusted by trained and qualified fuel system personnel.

⚠WARNING

NEVER put a wrench on a fuel system fitting if unsure whether the system has been depressurized.

2.5.3. Tube and Fitting Installation and Repairs

Installing tube fittings correctly requires training, correct parts and appropriate tools. Tubes must be bent accurately to minimize stress and lines must be routed and supported properly. Fittings must be assembled according to manufacturer's specifications. Maintenance personnel must receive proper training from Swagelok® or Agility® before attempting fuel line repairs.

2.5.4. Fitting Safety

⚠WARNING

NEVER bleed CNG system by loosening or "cracking" a fitting connection.

NOTICE

NEVER disassemble new fittings prior to use.

⚠WARNING

NEVER attempt to torque fittings while system is pressurized.

NOTICE

When tightening a compression nut on a fitting, verify fitting body is held securely.

3. CNG System Fueling

NOTICE

These are general fueling guidelines. Always follow fuel station specific dispenser operating instructions and procedures.

3.1. Fuel Specifications

NOTICE

Failure to meet fuel requirements may result in poor engine performance and damage that is not covered under warranty.

Fuel quality is crucial for maximum engine performance, life expectancy and emission standards. CNG fuel must meet or exceed the minimum requirements. Refer to SAE J1616 for the latest CNG vehicle fuel standards.

3.2. Fueling Vehicles with CNG

1. Note location of fuel facility emergency fuel shutoff.
2. Open FMM door (if applicable) and remove dust cap from fueling receptacle.
3. Wipe receptacle and nozzle. Check receptacle O-ring and connect fueling station nozzle to fuel receptacle.
4. Turn nozzle valve to “fill” position and fuel will start to flow.
5. Continue filling until fuel station pump shuts off automatically.
6. Remove fueling nozzle by turning nozzle valve to “vent” position and release it from receptacle. Receptacles are designed so the nozzle will not come off under pressure.

   ⚠CAUTION

   Return fuel hose to dispenser.
7. Once fueling is complete, replace dust cap and close FMM door. When Agility® fuel systems are equipped with optional safety interlocks (DriveAway™ Protection), FMM doors and receptacle caps must be in place for the engine to start.

NOTICE

Before adding fuel, swab the station fill nozzle. Look for any signs of oil or other contaminants. An oily or dusty nozzle may be an indication of poor fuel quality or a station that is not well maintained. Report this condition to station operator.

⚠WARNING

If a gas odor is present when filling the system, turn off the station pump and check the O-ring inside the fill receptacle. If it is worn or damaged, clean the receptacle and replace the O-ring with a new one. If the O-ring is OK, contact station operator.

3.3. CNG Fueling: Pressure and Temperature

Typically, stations fill to a service pressure of 3600 psi (24.8 MPa).

During fast filling, gas heats as it compresses inside the cylinders, which is normal. On a hot day, pressure from the filling station will indicate full system pressure, but the fuel cylinders may not be filled completely. This is normal.

NOTICE

Gas pressure increases as temperature increases. When temperature decreases, pressure decreases, but the amount of gas does not change.

An example of the effect of temperature upon fuel system pressure readings:

1. At the end of the workday a delivery truck is fast-filled at a CNG station. The ambient temperature is 120°F (50°C), and the CNG dispenser stops at 3600 psi (24.8 MPa) as expected.
2. The truck is parked in its designated spot. During the night, ambient temperature drops to 70°F (20°C). As the gas cools, pressure in the cylinders decreases. The engine is not run while the vehicle is parked, so no fuel is consumed.
3. The following morning, however, the pressure gauge indicates 3000 psi (20.7 MPa) instead of 3600 psi (24.8 MPa).
4. Later in afternoon, when the ambient temperature rises to 120°F (50°C), the pressure gauge indicates 3600 psi (24.8 MPa) once again.

NOTICE

Fueling stations can partially compensate for the heat generated during fast filling, but generally cannot achieve more than 70% to 80% full.

Slow filling (overnight) results in a nearly 100% full system, because the gas can cool during the filling process. Slow fill stations are practical when fleet vehicles return to a home base at the end of the workday and can re-fuel during the night.

4. CNG Fuel System Operation

Starting a CNG vehicle requires a few seconds delay between battery power (ignition switch) turn-on and starter motor activation (engine crank). This allows time for gas to flow from the storage cylinder, through the solenoid valve and regulator and to the engine.

1. Follow standard manufacturer recommended start-up procedure.
2. If the vehicle is starting from cold, let the engine idle for about five minutes. This allows engine coolant to warm the fuel and ensure low-pressure lines downstream of the primary pressure regulator do not freeze.
3. On extremely cold days, allow vehicle to idle for a longer period until coolant temperature is high enough to warm the fuel. Warm air coming out of the cab heater indicates the coolant is warm.

5. CNG Fuel System Inspections

CNG fuel systems must be inspected regularly to ensure safety, optimum performance and regulatory compliance. Table 1 contains a list of items to be inspected.

5.1. CNG Inspectors: Certified vs Qualified

Agility® Fuel Solutions provides Agility®-specific CNG fuel system training but does not have a certified or certification program. Agility® recommends inspection and service techs receive training and certification by third-party organizations such as the CSA Group or Natural Gas Vehicle Institute (NGVi).

CNG fuel system inspectors are certified by CSA or NGVi after passing a written examination on CSA standards, NFPA 52 Vehicular Natural Gas Fuel Systems Code and CNG vehicle industry best practices.

An acceptable alternative to the certified status is a CNG fuel system inspector who is qualified and trained as described by the Compressed Gas Association (CGA) in its publication CGA C-6.4 “Methods for External Visual Inspection of Natural Gas Vehicle (NGV) and Hydrogen Gas Vehicle (HGV) Fuel Containers and their Installations”:

> A qualified inspector must have at least one of the following qualifications: (a) two years’ experience conducting container inspections on the type of cylinder being inspected; (b) supervision by a person with two years’ experience relevant to the type of cylinder being inspected; (c) approved by manufacturer of the container being inspected; (d) certified as an inspector by one of the organizations with specific OEM-approved training centers with fuel gas cylinder standards’ recommended inspection guidelines; (e) certification as an inspector by a state or nationally recognized organization that tests for specific knowledge of applicable fuel gas cylinder standards’ recommended inspection guidelines; or certification as an inspector by the authority having jurisdiction (AHJ).

Table 1. CNG fuel system component inspection list.

Item	Description and Location	Observation / Action
System and vehicle decals	Various locations on vehicle and fuel system	Must be in place and legible. *Obtain replacement from OEM if missing or damaged.*
Cylinder(s)	Depends on configuration	A. Inspect cylinder per manufacturer's instructions. B. Labels must be in place and legible. *Obtain replacement from OEM if missing or damaged.*
Cylinder valves	Mounted on each cylinder	A. Valves should be fully open. B. Valves should open and close freely by hand. *NOTE: If vehicle range has reduced, a valve may be stuck in the closed position.*
Pressure Relief Devices (PRDs)	Integral PRDs are mounted in cylinder valves and plugs and opposite ends of each cylinder; remote PRDs plumbed to cylinder valve nd plug ends	A. Look for signs of corrosion or damage to the PRD body. B. Verify no water is accumulating in the outlet side of device. C. Confirm glass bulb devices have intact bulbs visible. D. Verify eutectic devices do not show signs of eutectic material extruding.
Cylinder shields and covers	All housings and cabinets	A. Covers should be intact and secure. Tighten loose fasteners or replace missing fasteners. B. Look for signs of rubbing, abrasion or impact damage.
Cylinder mounts, side mount systems with straps	Straps, isolators, brackets and fasteners	A. Examine brackets for damage including corrosion and signs of metal fatigue such as but not limited to cracking or material loss. B. Tighten or replace loose or missing fasteners, displaced or cracked/torn isolators. *Refer to OEM inspection guidelines.* C. Verify cylinder manual valve handle is at 12 o'clock or its original location. D. Confirm no sign of abnormal fuel line bending. *Refer to ENP-524.*
Cylinder mounts: neck blocks and neck bushing	Neck blocks and fasteners, plastic bushing/sleeve in sliding end of cylinder	A. Check for displacement or metal-to-metal contact. *Refer to OEM inspection guidelines.* B. Check for any gaps between cylinder neck and cylinder mounts. C. Verify fasteners are properly torqued and cylinder does not spin.

Item	Description and Location	Observation / Action
System mounts: isolators and fasteners	Fasteners, isolators between system and vehicle chassis	A. Check for displacement or metal-to-metal contact. *Refer to OEM inspection guidelines.* B. Check isolators for visible signs of wear or damage. C. Measure height of each isolator; if isolators vary by 1/8-in (3.18 mm) or more, isolators should be replaced.
Fuel tubing	Delivers CNG from FMM to cylinders to engine	A. Check for damage or abrasion. B. Check for metal-to-metal contact.
Fuel hoses *(if equipped)*	Used to accommodate motion of vehicle components including cab to body or body to frame connections	Inspect monthly (or every 200 hours) for signs of damage: A. Check date of manufacture on the hose; if a braided hose is greater than five years old, it must be replaced. Refer to *Section 5.6.1.* B. Inspect for any signs of damage, including, but not limited to kinks, cuts, abrasion, corrosion, heat, chemical attack, etc. Replace hose if damaged. Refer to *Section 5.6.2.* C. Check hose routing and clipping to verify hose is properly supported does not contact metal parts, electrical harness, battery cables, hydraulic hoses or other components. D. Measure hose proximity to heat sources and verify any heat shields and/or sleeves are properly installed. Refer to *Section 5.7.*
1/4-turn manual shutoff valve (aka emergency valve)	Red handle, 1/4-turn shutoff valve on the FMM	A. Verify proper valve operation. B. Handle must turn easily by hand. *NOTE: 1/4-turn manual shutoff valve must be in ON/OPEN position for normal operation.*
Coolant lines	Route from engine cooling system to pressure regulator	A. Inspect for leaks, kinked hoses, worn or loose clamps. B. If there is damage to protective sleeve or signs of leakage, remove heat sleeve or protective loom to inspect full hose length.
High-pressure gauge	Gauge on or near FMM	Verify proper operation: 400 to 500 psi (2.7 MPa to 3.45 MPa) when system is empty. 3600 psi (24.8 MPa) when system is full.

Item	Description and Location	Observation / Action
Low-pressure gauge *(if equipped)*	Gauge on or near FMM	Turn ignition ON or start engine to verify proper operation: 115 psi (792 kPa) min. 135 psi (930 kPa) max. 125 psi (85861 kPa) nominal. *NOTE: Some systems 85-87 psi (586-600 kPa) nominal.*
Dashboard fuel gauge	In cab dashboard	Should indicate fuel level accurately.
Leak check	All fittings, PRDs, tubes, hoses and flow control components	Perform leak check with electronic detector or leak detection solution. Leaks to be repaired by qualified technician.
PRD vent caps	At end of each PRD vent tube	Check all PRD vent lines for caps. **⚠CAUTION** **If PRD vent cap(s) are missing, a qualified fuel system technician must inspect PRD lines and the PRD for water/debris entry or corrosion and replace PRD vent cap**.
DriveAway™ prevention (DAP) fill receptacle dust caps / FMM door *(if equipped)*	FMM or remote fuel fill panel	Verify dust caps are in place. OR Verify FMM door is closed. *Necessary for vehicle to start.*
Low-pressure filter	Under hood, at engine	Drain fluid. *Replace per OEM recommendation.*

5.2. CNG System Inspection Interval Recommendations

Agility® recommends the following inspection intervals:

- Inspect CNG cylinder(s) and system after every 1 year
  OR
  after 100000 miles (161000 km), whichever occurs first.
- Inspect CNG cylinders per cylinder manufacturer guidelines.
- Inspect high-pressure CNG hoses monthly or every 200 hours.

⚠CAUTION

Inspections must be performed by qualified fuel system inspectors.

Regardless of which interval is selected, Agility® recommends all inspection regimens include a daily walk-around visual inspection, and the use of all four inspection categories detailed below.

NOTICE

A practical approach to inspection and maintenance of the fuel system matches intervals and procedures with other vehicle maintenance tasks, such as engine oil and filter changes and the annual DOT inspection.

5.2.1. Pre-Service Visual Inspection

The first inspection begins before the vehicle is put into service. It is an examination of all surfaces, components, mounting systems and fuel cylinders. This inspection should confirm the delivered vehicle matches the vehicle specifications and complies with all codes, regulations and best practices. Shields and covers must be removed to ensure complete examination of all surfaces, components, fittings, framework and fasteners. This inspection must be performed by a qualified or certified CNG fuel system inspector.

5.2.2. Cursory Visual Inspection (Daily Pre- and Post-Drive Checks)

Visually check the following items before and after vehicle operation. If all is well, the vehicle is cleared for operation. This check can be performed by the vehicle operator. If anything is wrong, a certified or qualified CNG fuel system technician must make the necessary repairs.

5.2.3. General Visual Inspection

A general visual inspection is performed by a certified or qualified service technician when performing routine maintenance on the vehicle, such as an engine oil and filter change or tire rotation. Although enclosures and access panels may not need to be removed, all shields and components must be checked for damage.

5.2.4. Detailed Visual Inspection

After every year or every 100000 miles (161000 km)—whichever occurs first—a detailed visual check shall be performed on the vehicle by a certified or qualified CNG fuel system inspector. This in-depth examination and inspection includes safety components such as pressure relief devices (PRDs). Inspections may require removing access panels or other items to view entire fuel cylinders and components.

⚠WARNING

If a CNG-fueled vehicle has been involved in an accident or fire, the system and cylinders must be inspected by a certified or qualified CNG fuel system inspector.

5.3. Inspection Points for All Systems: Decals and Labels

5.3.1. Cylinder Labels

⚠CAUTION

If the cylinder label is not attached to the cylinder, and the manufacturer and serial number are not available or cannot be verified, the cylinder must be condemned.

Various vehicle and highway regulatory agencies require warning and informational decals for CNG fueled vehicles. Cylinder manufacturer labels must be in place and legible. If cylinder labels are damaged or missing, contact Agility® Customer Care.

Figure 7. Cylinder manufacturer label must be in place and legible. Verify label is not expired and cylinder is correct for CNG use.

5.3.2. Fuel System and Vehicle Decals

CNG fuel system and vehicle decals must comply with size, shape, color, wording and font requirements. Decals must be present in specific locations, as indicated in the following pictures and captions. All Agility® decals comply with applicable regulations and are available from the Agility® Customer Care Group.

Part numbers shown in this manual are examples only. Decals may be system- or customer-specific. Order decals using the part number and revision printed on the decal. If the part number is not legible, contact Agility® Customer Care for assistance.

This section addresses required decals. Other informational or warning decals are present on Agility® systems, however, not all of them may be required. Local authorities or customers may have additional labeling requirements for CNG vehicles. If in doubt, contact Agility® Customer Care.

5.3.3. Blue Diamond CNG Decal, p/n 10602105

The U.S. Department of Transportation (DOT) and other regulatory agencies require vehicles powered by compressed natural gas to display a blue diamond CNG decal. *Figure 8*

Figure 8. CNG-fueled vehicle blue diamond decal.

The blue diamond CNG decal must be located on the right rear of the vehicle, but not on the bumper. When no body panels exist (e.g., a roll-off chassis refuse tractor), the decal may be placed on a frame member on the right rear of the vehicle. *Figure 9*

Blue diamond CNG decals must also be placed on each side of the vehicle power unit. For vehicles required to display a DOT number in accordance with 49 CFR 390.21, the side CNG decals must be affixed near the DOT numbers on each side of the power unit. *Figure 9*

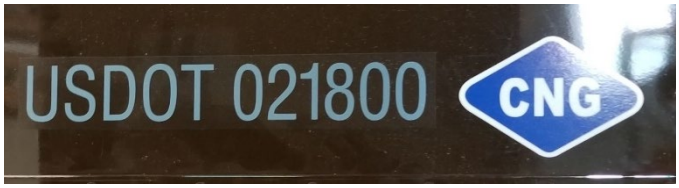


Figure 9. Left: Compressed natural gas powered vehicles are identified by a blue and white CNG diamond decal on the right rear and both sides of the vehicle power unit.
Right: Additional CNG decal may be placed on the front of the cab. Bottom: CNG body side decals must be installed near DOT number on vehicles subject to this requirement.

Agility® fuel system enclosures are typically equipped with blue CNG diamond decals on the driver and passenger sides, and on the right rear on BTC systems for tractor applications.

An additional blue diamond CNG decal may be placed on the front of the vehicle, but this is not a requirement. *Figure 9*

⚠CAUTION

If a blue diamond CNG decal is missing, illegible or damaged, it must be replaced.

5.3.4. Fill Receptacle / Fill Panel / FMM Decals

Fill receptacle and fuel system information are stated on the fuel management module (FMM) decal. Required information includes name of installer, installation date, cylinder storage capacity in water volume, and other information. Back of the cab and roof mount system decals include similar wording, but since there are several configurations, system decals must match the vehicle fuel system. *NOTE: Each decal has a unique Agility® part number.*

Representative examples of decals for current fuel system types follow.

Cabinet Style FMM Face Plate decal, p/n 10600030

Figure 10. Typical box style FMM front panel decal.

One Piece Aluminum Side Mount FMM Face Plate decal, p/n 10602176

Figure 11. One piece aluminum cover side mount system with integrated FMM decal.

Composite Side Mount FMM Face Plate decal, p/n 10602146

Figure 12. Side mount 237 and other similar series composite cover FMM decal.

Composite Side Mount Auxiliary Fill Panel decal, p/n 10602114

An additional decal is required on vehicles with auxiliary fill panels to direct operators and first responders to the presence of the 1/4-turn manual shutoff valve on the main fill panel. *Figure 13*

Figure 13. Auxiliary fill panel decal. Blue arrow indicates warning message directing operators and first responders to 1/4 manual shutoff valve located on main fill panel.

Danger high-pressure decal, p/n 10602108

The danger high-pressure decal alerts operators and technicians to the hazards of high fuel system pressure. One decal is placed in the FMM as a general warning while other decals are placed near cylinder valves or, if equipped, the system bleed valve. *Figure 14*

Figure 14. Place "Danger high pressure" decal (1) in multiple locations: inside FMM (2), on cylinder enclosures (3), adjacent to pressurized lines (4) and near cylinder and bleed valves (not visible).

PRD vent line decal, p/n 10602234

The PRD vent line decal is not required, but it is a reminder from Agility® to prevent potential PRD problems. PRD vent lines must not allow moisture and debris to enter the system. Place this warning decal in two locations:

1. Near the operator interface (FMM) or cylinder valve end. *Figures 16 and 17*
2. Next to or near the "Danger high-pressure" decal, p/n 10602108. *Refer to Section 5.3.5.*

NOTICE

PRD vent line warning decals must be placed in a visible location and not cover any existing decals.

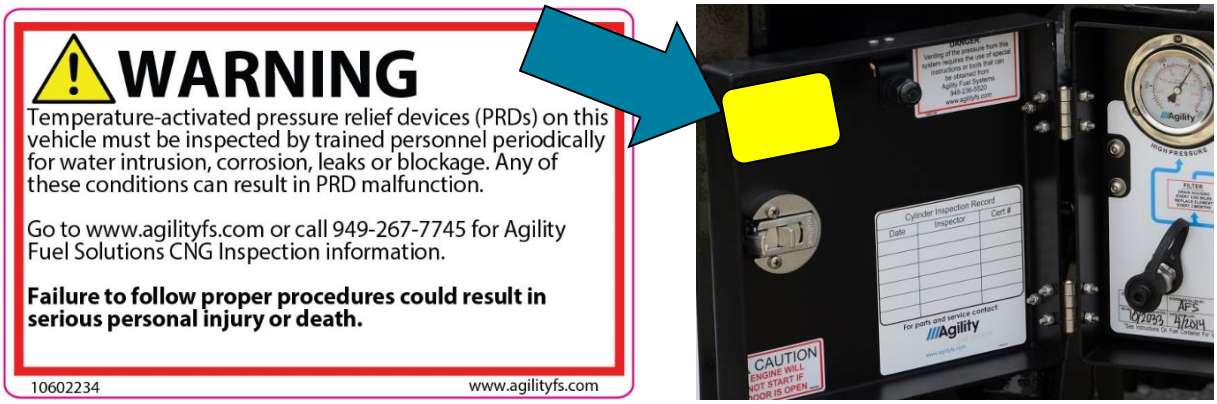


Figure 15. Left: PRD vent line warning decal. Right: PRD vent line warning decal should be placed near the FMM where operator can see at a glance. Position this decal near the "Danger venting gas" decal as indicated in yellow.

Figure 16. PRD vent line decal locations indicated in yellow.

CNG Vent location decal, p/n 10602610

NFPA 52 regulations require CNG PRD vent locations to be identified with labels. *Figure 17*

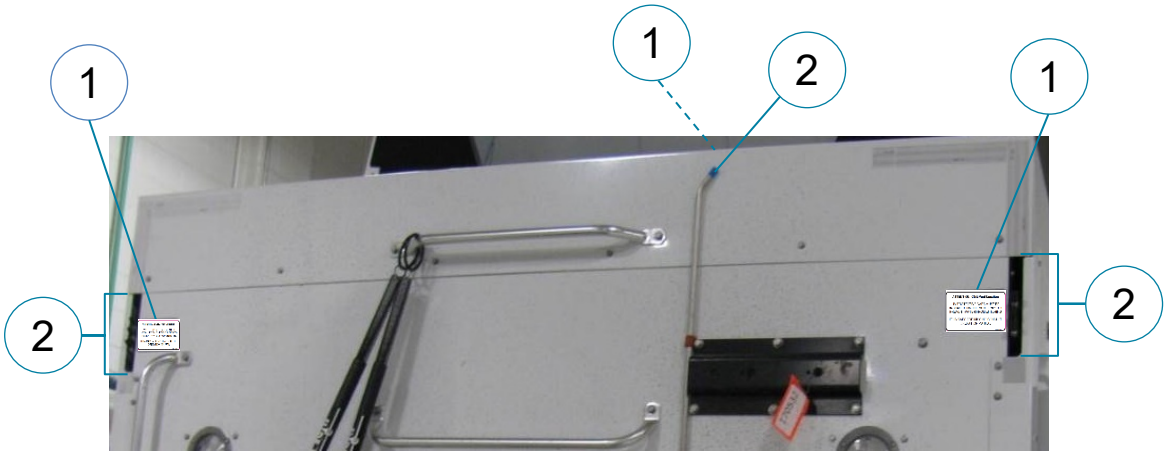


Figure 17. Place a CNG vent location decal (1) near each PRD vent outlet area (2). Dotted line indicates location of additional CNG PRD vent location decal (not visible) on BTC cabinet roof.

Additionally, UV-protective PRD vent caps must be in place to prevent water and debris entry into the PRD system. The CNG Vent location decal also serves as a reminder to maintain the PRD vent system and caps to prevent PRD damage. *Figures 17 and 18*

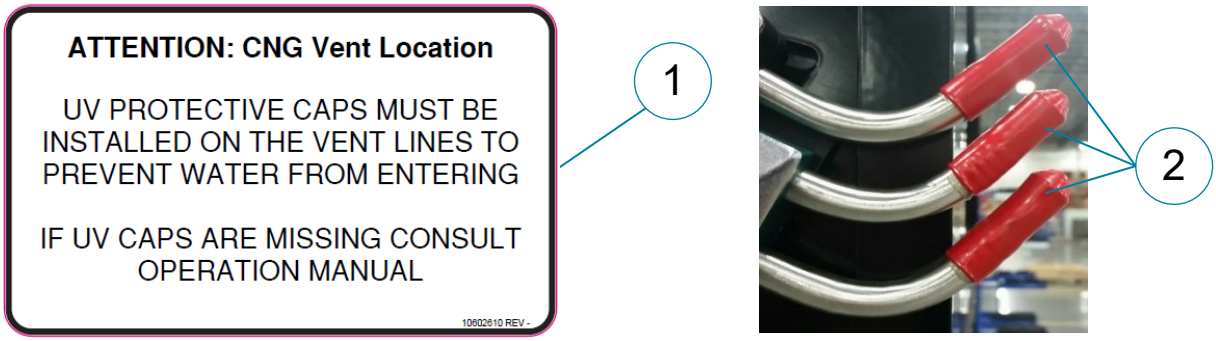


Figure 18. CNG vent line location decal (1).
NOTE: PRD vent caps (2) may vary in color.

⚠WARNING

If a PRD vent cap is missing or damaged, the PRD vent lines and PRDs should be inspected by a qualified technician for blockage, water intrusion, corrosion or other damage. DO NOT simply replace the PRD vent cap.

⚠WARNING

Replace PRD vent cap and/or PRD vent line as determined by a qualified technician.

Natural gas filter decals, p/n 10602239 (L), 10602240 (R)

Inside the FMM, the high pressure filter assembly carries a decal detailing fuel flow direction, pressure and temperature capacities, and regulatory compliance. The decal also includes the part number of the replacement filter, filter service interval and torque specification. *Figure 19*

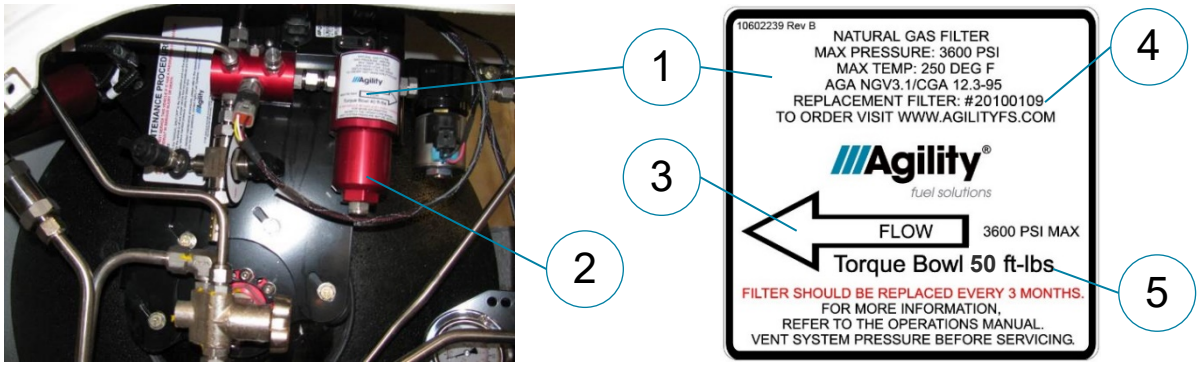


Figure 19. Natural gas filter decal (1) placement on high-pressure filter (2). Decal indicates direction of fuel flow (3), filter p/n replacement (4) and maximum torque (5).

Conspicuity marker decals, p/n 10602039

This white, reflective decal is not unique to CNG vehicles, but is a U.S. DOT requirement for any tractor-trailer. Conspicuity markers are mounted at the top of the BTC cabinet as shown. This decal is supplied as a single, straight strip. Each corner must have the L-shape as shown. Reference: FMCSA Federal Motor Carrier Safety Association, Section 393.11: “Lamps and reflective devices.” Other agencies mention conspicuity markers. *Figure 20*

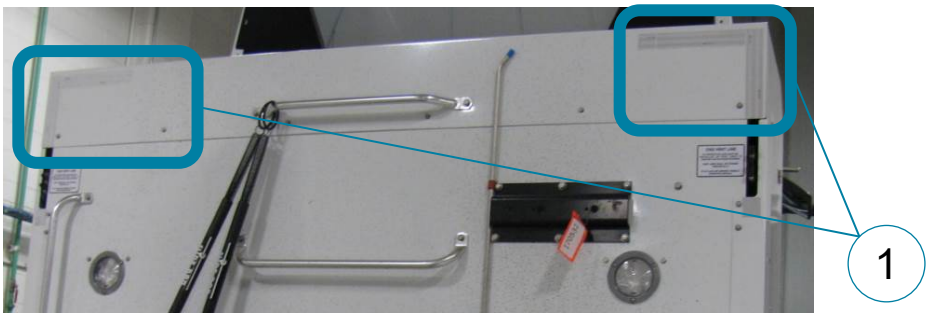


Figure 20. Conspicuity reflector decals [inside rounded rectangles (1)]

Maximum total height decal, p/n 10602304

Figure 21. Maximum total height decal for roof-mount systems must be permanently mounted in the driver’s compartment and be clearly visible to the driver when seated.

5.4. System Covers and Framework Inspection

Agility® CNG systems are housed in a variety of protective enclosures comprising a robust frame and covers. *Figure 22*

Figure 22. Typical behind the cab (BTC) fuel system cabinet.

Access to the fuel system may be via hinged doors *(Figure 22)* while other enclosures have panels which require simple hand tools to open or remove.

1. Verify all cabinet or enclosure fasteners are present and not loose. Tighten fasteners and replace as needed.
2. Measure clearance between cylinders and support framework and covers. Spacing should range from 1/2-in (12.7 mm) to 3/8-in (9.53 mm).

   NOTICE

   Always measure fuel system pressure when assessing clearance around cylinders; a full cylinder will be larger than an empty one.
3. Look for scratches or other abrasion damage to inside surfaces of cabinet doors and panels as well as fuel cylinders. Correct clearances before conditions worsen.
4. Verify metal heat shields and coverings are in place between exhaust components and fuel lines or wiring.
5. Open and close door hinges and latches to verify proper operation.

5.5. Pressure Relief Devices (PRDs)

⚠WARNING

If a PRD vent cap is missing or damaged, the PRD vent lines and PRDs should be inspected by a qualified technician for blockage, water intrusion, corrosion or other damage. DO NOT simply replace the PRD vent cap.

⚠WARNING

Replace PRD vent cap and/or PRD vent line as determined by a qualified technician.

Pressure relief devices (PRDs) cannot be repaired. However, they must be inspected for leaks and corrosion. Each cylinder has a PRD located either remotely or as an integral part of the manual valve . The PRD is a sub-system, since the PRD and its associated plumbing (such as vent lines) are needed for proper operation. Two PRD types are used in Agility® installations: area PRDs and point PRDs.

5.5.1. Area PRDs

Area PRDs consist of a PRD body connected to a long trigger line to detect temperature extremes over a large area. *Figures 23 and 24*

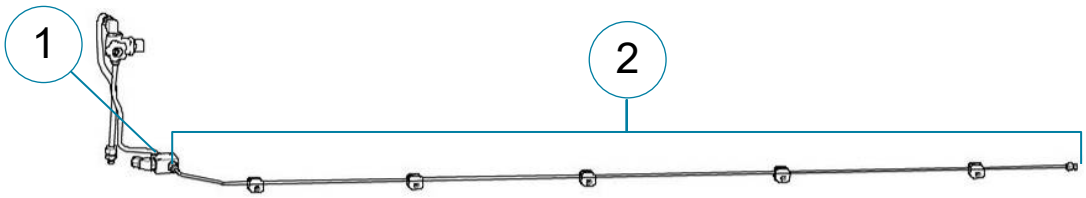


Figure 23. Side mount area PRD systems include a PRD body (1) and a trigger line (2) that monitors the entire length of the cylinder. A vent tube (not shown) routes the high-pressure gas away from the vehicle if the PRD is activated.

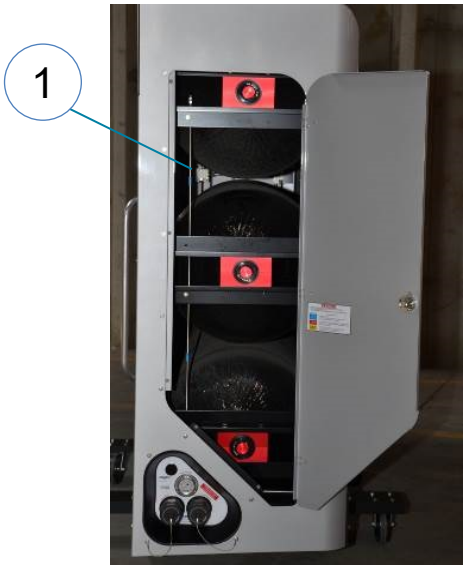


Figure 24. Back of cab system showing area PRD trigger line (1) behind the side door. Similar trigger lines are routed on the opposite side.

5.5.2. Point PRDs

Point PRDs respond directly to temperature extremes with which they come into contact. *Figure 25*

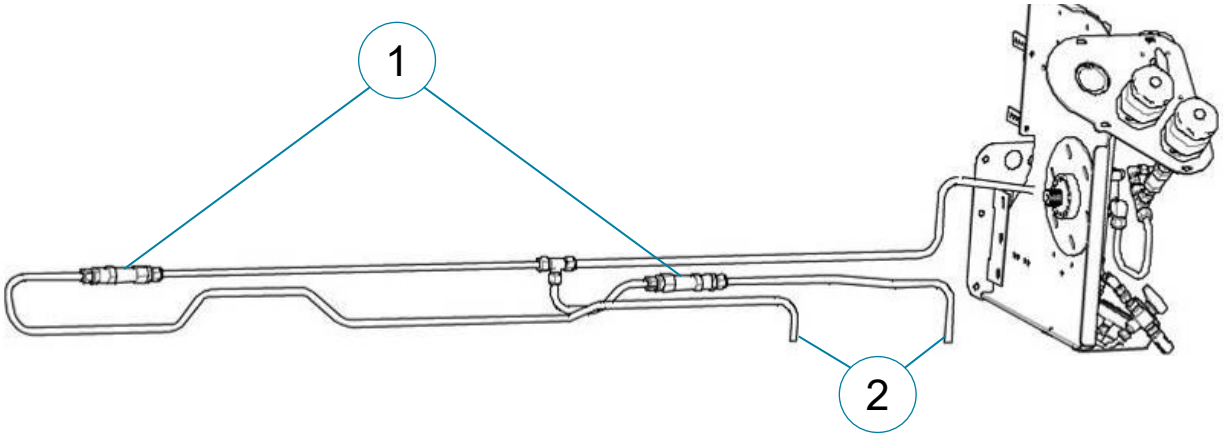


Figure 25. Side mount point PRD system PRDs (1) and vent lines(2).

5.5.3. PRD Vent Tubes and Caps

⚠WARNING

If a PRD vent cap is missing or damaged, PRD vent lines and PRDs should be inspected for blockage, water intrusion, corrosion, or other damage. DO NOT simply replace the PRD vent cap.

PRD vent tubes must be kept free from debris and moisture. Two key maintenance and inspection points for PRD vent lines are as follows:

1. Weep hole at the lowest portion of each vent tube must be kept clear and open to drain moisture from the vent tube.
2. UV-protected vent tube caps must be in place. If PRD caps are missing, the vent lines and PRDs must be inspected for moisture and corrosion and the PRD vent caps replaced. Agility® p/n 10702028 fits both 3/8-in and 1/2-in PRD vent tubes. The caps are heat-shrinkable and must be installed using a hot air gun. *Figure 26*

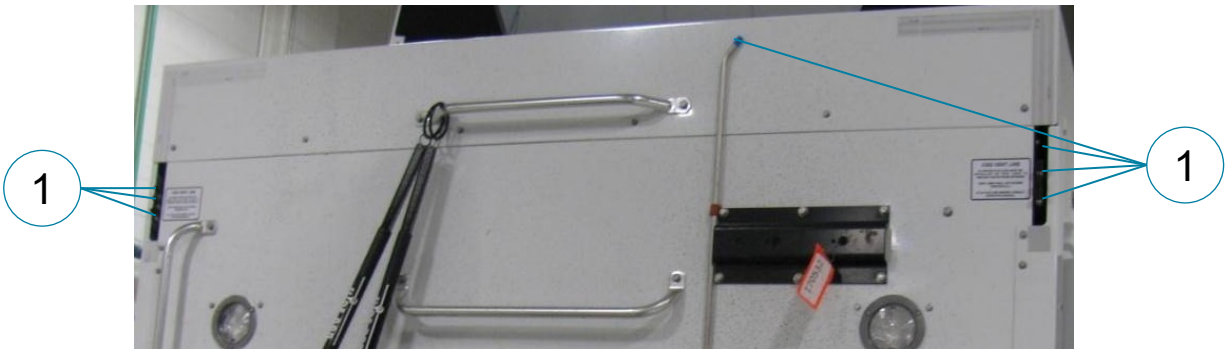


Figure 26. PRD vent caps (1) must always be in place to prevent water and debris from entering the PRD vent lines.

5.6. Fuel Lines and Flow Control Components

Inspect fuel system lines and control components using the following techniques:

1. Visually check all fuel system components for corrosion and wear.
2. Touch and grasp fuel tubes and fittings to identify loose mounts or connections. *Figure 27*
3. Smell for natural gas (mercaptan) odor.
4. Perform a leak test on all components, fittings, tubes and hoses.

   ⚠CAUTION

   Leaks must be repaired by a qualified CNG fuel system technician.
5. Verify manual shutoff valves on each cylinder are fully open for normal operation. All valve handles must be easy to open or close by hand, without tools.

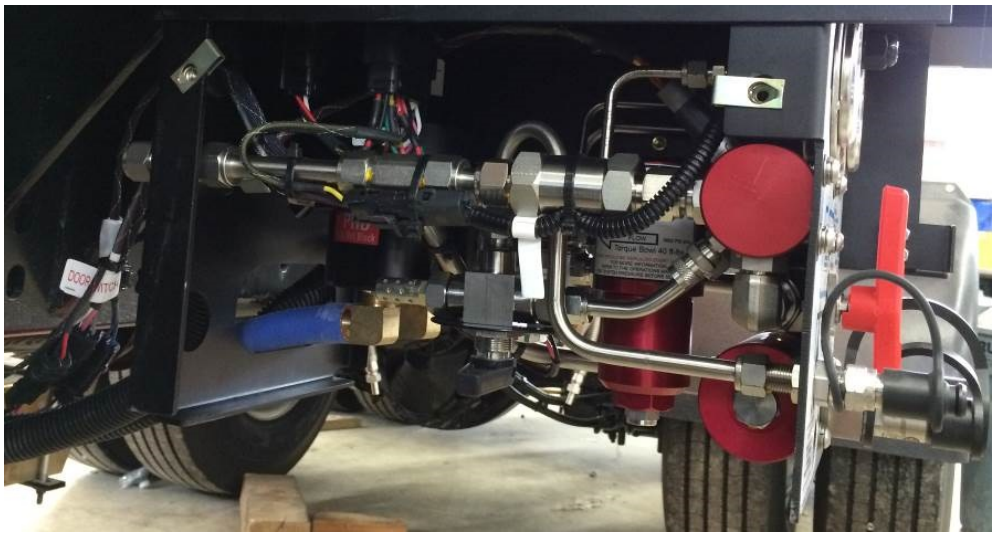


Figure 27. Box style FMM with covers removed to show most flow control components and tubing located in or near FMM.

5.6.1. Fuel Hoses

High-pressure, flexible CNG fuel hoses can become compromised if exposed to corrosive chemicals such as road de-icing products, excessive heat or if hoses are altered or moved during or following repair. Fuel hoses are also vulnerable to damage from vibration and subsequent wear; always verify hoses are routed and clipped properly for maximum performance and reliability.

5.6.1.1. High Pressure Flex Hose Identification

Agility® CNG fuel systems may include high-pressure hoses approved for CNG use manufactured by several suppliers including Motion Industries, Titeflex, Parker, and Swagelok®.

Motion Industries hose – stainless steel braid

Motion Industries high-pressure CNG hoses are electrically conductive and coated with a thermoplastic outer jacket. A typical high-pressure CNG hose manufactured by Motion Industries *(Figure 28)* may be identified by the following characteristics:

- Exposed stainless steel braid between outer jacket and collet
- Indentations on collet crimp area
- Metal ID tag with manufacturing and date code. *Figure 29*

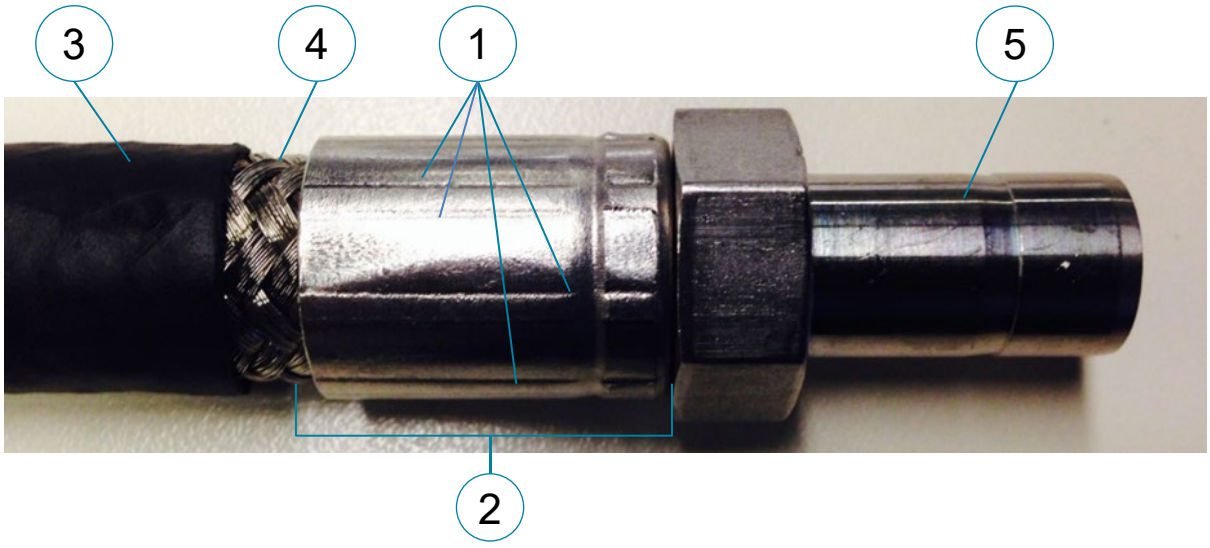


Figure 28. Motion Industries flexible CNG fuel hose. Note longitudinal crimp marks (1) on collet (2), unmarked plastic cover (jacket) (3), exposed stainless steel braid (4), tube stub (5).

Figure 29. Motion Industries CNG hose metal ID tag includes date of manufacture (circled).

Titeflex hose – stainless steel braid

Titeflex high-pressure CNG hoses consist of an electrically conductive PTFE inner core with a DuPont Hytrel® thermoplastic outer jacket, and are temperature rated from -40°F to 250°F (-54°C to 121°C). Titeflex hoses *(Figures 30 and 31)* typically possess the following distinguishing features:

- Exposed stainless steel braid between outer jacket and collet
- Plastic coated paper tag (may or may not be present)
- Titeflex marking and information specific to the hose properties and fuel type on the jacket

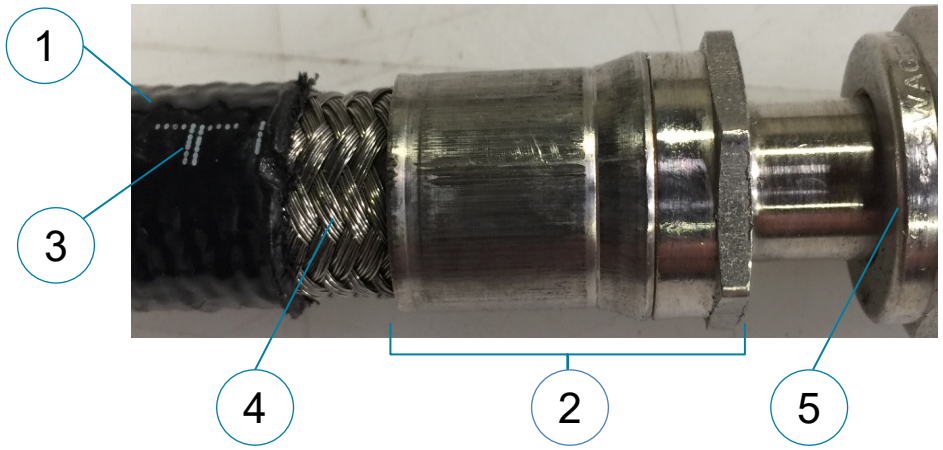


Figure 30. Titeflex flexible CNG fuel hose. Notice collet style (2) and crimp marks, the plastic cover (jacket) (1) with markings (3) and exposed metal braid (4). A swaged compression fitting (5) is attached to this example.

Figure 31. Left: Titeflex plastic coated paper tag may or may not be present. Right: Titeflex hose outer jacket is imprinted with "TITEFLEX" branding, date of manufacture (circled), and maximum pressure and temperature range ratings. NOTE: Hose sample shown for illustration purposes; markings will vary with application.

Parker Parflex® 5CNG – fiber reinforced hose

Parker Parflex® 5CNG reinforced nylon hoses do not have a stainless steel braid and may be identified partially by the red polyurethane cover. Parflex hoses are electrically conductive and temperature rated from -40°F to 180°F (-40°C to 82°C). *Figures 32 and 33*

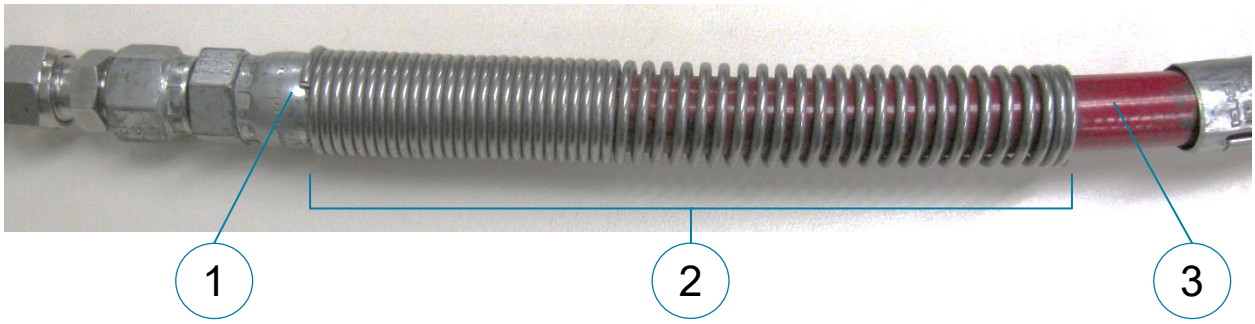


Figure 32. Parker Parflex 5CNG fiber reinforced nylon CNG hoses feature a crimped collet (1), and red plastic outer jacket (3). NOTE: Coiled spring strain relief (2) may not be present in all applications.)

Figure 33. Left: Parflex 5CNG hose metal ID tag includes a plant code, manufacturing location, and manufacturing date code (not visible).
Right: Red Parflex 5CNG outer jacket is marked "ELECTRICALLY CONDUCTIVE" along with fuel type, and hose ratings

Parker recommends visual inspection of hose assemblies on at least a monthly basis.

⚠WARNING

Any of the following conditions require immediate shut down and replacement of a hose assembly:

1. Fitting slippage on hose
2. Damaged, cut or abraded cover (any reinforcement exposed)
3. Hard, stiff, heat cracked or charred hose
4. Cracked, damaged or badly corroded fittings
5. Leaks at fitting or in hose
6. Kinked, crushed, flattened or twisted hose
7. Blistered, soft, degraded or loose cover

Refer to Parker Safety Guide, Parker Publication No. 4400-B.1*, for more information.*

Swagelok® NG Series – fiber reinforced hose

Swagelok NG Series hoses do not have a stainless steel braid and may be identified partially by a perforated polyurethane cover. Nylon Swagelok NG hoses feature fiber reinforcement, are electrically conductive, and are temperature rated from -40°F to 150°F (-40°C to 65°C). *Figures 34 and 35*

Figure 34. Swagelok NG Series hoses feature crimped collets (1), perforated polyurethane outer jacket (2), stainless steel ends (3).

Figure 35. Left: Swagelok NG Series hose outer jacket marked "SWAGELOK®" with size and pressure rating and "ELECTRICALLY CONDUCTIVE".
Right' Swagelok hose decal includes date of manufacture (DOM) (circled).

5.6.2. Inspection Procedure for All Hose Types

Regardless of hose type or manufacturer, use the following inspection procedure:

1. Inspect CNG flexible hoses on a periodic basis
   A. Once per month
      OR
   B. Every 200 hours
2. Clean hose ends and fittings with mild soap and water; *if applicable*: use a soft bristled brush to expose hose braid.
3. If hose end is covered by protective loom or fire sleeve, the sleeve may be temporarily moved to expose the hose for inspection. *Figure 36.* Inspect the entire length of hose and sleeve: if there is any damage to the sleeve, remove sleeve and inspect the hose underneath at the damaged area.

   ⚠WARNING
   Replace hose immediately if any damage to the hose is present.

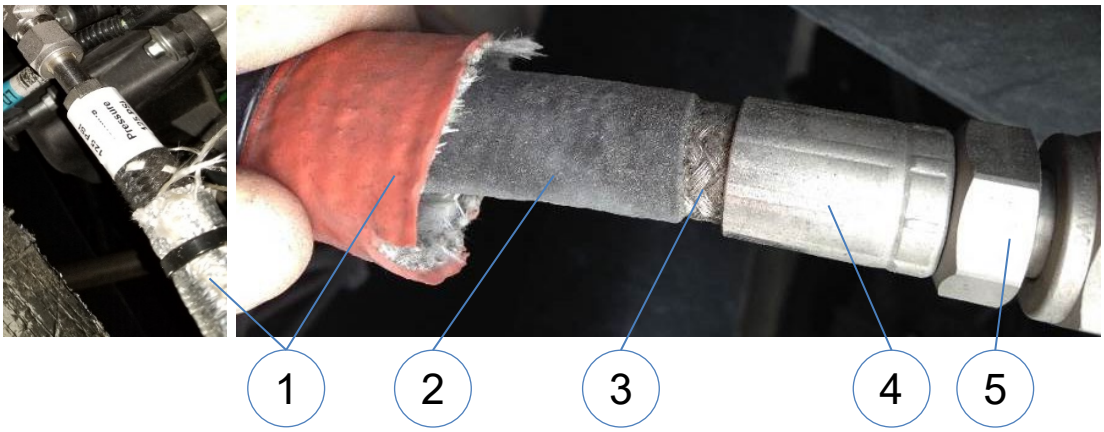


Figure 36. If hose is covered with a fire sleeve (1) or split loom, remove sleeve or loom to enable inspection of hose cover (2), braid (3), collet (4) and fitting (5). Always inspect fire sleeve (1) or slip loom for damage.

4. Inspect hose routing by verifying there is no potential for rubbing or strain and hose is away from heat sources. *Refer to ENP-524*. Verify that hoses do not contact any metal parts, electrical parts, battery cables, hydraulic hoses, or any other item.
5. Confirm mounting clips are present and properly installed. *Refer to ENP-524*.
6. For metal braided hose:
   A. Inspect hose for date of manufacture (DOM). For hoses covered in fire sleeve or split loom, remove a section of the sleeve to verify date of manufacture. if the DOM is five years or greater, replace the hose assembly immediately.
   B. Inspect for any signs of damage, including, but not limited to: broken wire braid strands, corrosion, kinks, cuts, abrasion, heat, chemical attack, etc.
   C. Replace hose immediately if any damage is present, or every 5 years, whichever comes first.
   D. Use DOM on the hose to establish 5-year replacement date.

   ⚠WARNING

   Neglecting to replace hoses at recommended intervals may lead to sudden hose failure.
   E. Check for leaks from hose or fittings.

   ⚠WARNING

   Any of the above conditions require immediate shut down and replacement of the hose assembly.
7. For fiber reinforced hose:

   A. Inspect for any signs of damage, including, but not limited to: cracks, abrasions, cuts, kinks, bulges, blisters, heat damage, chemical attack, etc.

   B. Replace hose immediately if any damage is present. There is no replacement schedule for fiber-reinforced hoses.

5.7. Hose, Tube, Harness & Cable Routing and Clipping

Fuel system hoses, tubing, harnesses, cables and other components must be properly shielded, routed and secured to protect them from the heat of the engine exhaust system. Clip these items as prescribed according to regulatory requirements and OEM literature. Observe the following minimum spatial and clearance requirements for specific items regarding proximity to engine exhaust components.

Application	Minimum distance to heat source	Heat shielding* required?
Metal fuel tubing	2-in (50.8 mm)	No
Hoses, harnesses, cables**	2-in (50.8 mm)	Yes
	8-in (203.2 mm)	No
Fuel system with metal cover	2-in (50.8 mm)	Yes
	3.5-in (90 mm)	No

**Heat shielding shall be reflective metal shielding*

***Fire sleeve required in engine compartment or near exhaust*

⚠WARNING

Heat shields must be undamaged and firmly in place. Replace shields or fasteners if missing or damaged.

⚠WARNING

Verify any additional protection devices—heat sleeve, tubing or other outer wraps—are in place and in good condition.

- Verify wire harnesses and supporting clips are in place and do not show signs of abrasion or wear.
- Replace clipping hardware with identical or better UV resistant materials.

5.8. Fuel System Mounts, Straps and Isolators

Agility® fuel systems employ a variety of mounting methods for cylinders and other components. Cylinders may be mounted using neck blocks at each end or straps around the circumference. Systems bolt to the chassis frame or body using rubber isolators and fasteners.

5.8.1. Behind the Cab (BTC) Flat Isolators

Rubber isolators are used between the vehicle chassis and BTC cabinet mounting brackets to dampen vibration. *Figure 37.* The isolator is a maintenance item, but vehicle duty cycle, use/application and road conditions vary significantly.

Inspection Guidelines

1. Isolator service lifetime varies widely and is independent of vehicle mileage, so isolator wear is best observed visually.

   NOTICE

   Some isolator movement is considered normal. *Figure 38*

2. Isolators that are in place and do not allow metal to metal contact are acceptable. *Figure 39.*
3. Excessive push-out, metal to metal contact and cracks are indications an isolator must be replaced.

Torque specification for BTC flat isolators depends on fastener finish. The preferred finish for all fasteners is aluminum-zinc. Yellow zinc is not used in current systems.

5/8-in Grade 8 bolt settled torque range:

Aluminum Zinc: 120–135 ft-lbs (162.7–183 Nm)

Yellow Zinc: 159–185 ft-lbs (215.6–250.8 Nm)

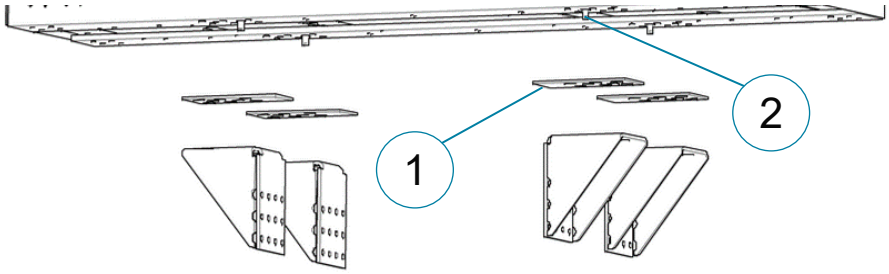


Figure 37. BTC rubber isolators, p/n 22400136 (1), located under each mounting point (2) as shown.

Figure 38. Rubber isolator (circled) between the BTC cabinet and vehicle chassis on a four year old system with 316,000-plus miles. A quick look indicates the rubber pad is in good condition.

Figure 39. There should be no metal to metal contact between the mounting bracket or vehicle chassis (1) and fuel system cabinet. (2)

5.8.2. BTC & Tail Gate Mounts: Ring and Bushing Type Isolators

Ring and bushing isolators are used to insulate behind the cab (BTC) and tail gate fuel systems from the vehicle chassis or body. *Figure 40*

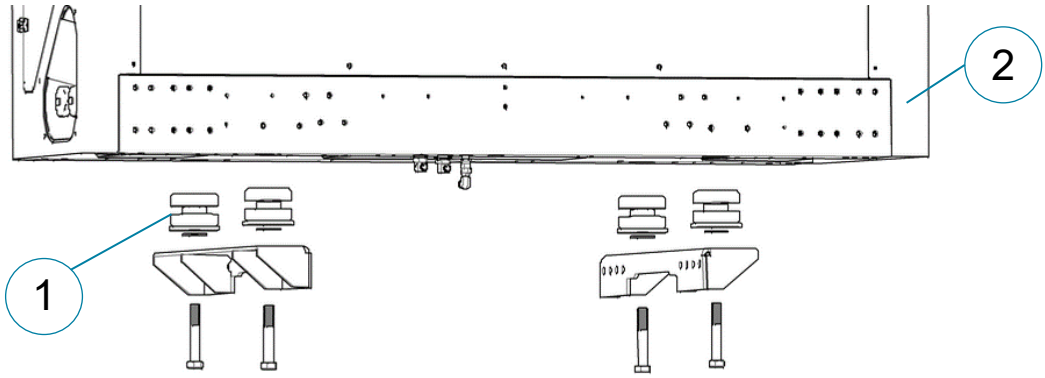


Figure 40. Ring and bushing isolator (1), p/n 10712233, for BTC cabinet (2) mounts.

The gap between mounting bracket and lower frame should be within 1/8-in (3.18 mm) of each other on BTC systems with ring and bushing isolation mounts. *Figure 41*

⚠CAUTION

If the gap difference between isolators is greater than 1/8-in (3.18 mm), the fuel system may have experienced loads exceeding normal operating conditions: inspect entire fuel system for signs of damage.

Measure the system cabinet and verify it is square. If there are no signs of damage, remove and replace out of spec isolators. *Figure 41*

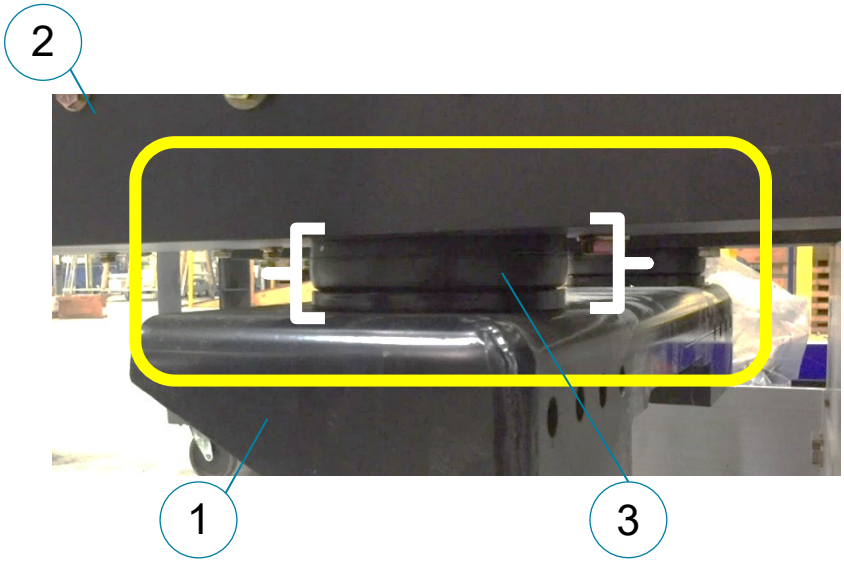


Figure 41. Measure gap (white brackets) between system mounting bracket (1) and lower frame (2) at each isolator (3) and compare. Refer to text for inspection details.

5.8.3. BTC Cylinder Block Mounts – 203 Series Systems

Cylinder mounting blocks on 203 series BTC systems should be inspected for loose fasteners or excessive movement.

Refer to CNG Field Service Bulletin ENP-640, "Behind the Cab 'Tank Spin,' Cylinder Block Inspection and Replacement 203 Series Systems" for repair procedures.

5.8.4. Side Mount Systems, General Guidelines

Because of normal cylinder expansion and contraction, side- and rail-mount system straps and brackets may loosen over time and can lead to cylinder "spin" (rotation within the strap) or other preventable damage that is not covered under warranty.

Although some cylinder movement is normal, excessive movement must be corrected as soon as it is observed. Use cylinder valve install orientation specification (typically 12 o'clock position) to measure any possible cylinder spin within straps. *Figure 42*

Front and bottom covers should be removed from the system for proper access. If rubber isolators are loose, displaced, damaged or missing they must be replaced.

Inspection Guidelines

1) Perform leak check of all high-pressure components and cylinder valve.
2) Check for changes in cylinder valve position. *Figure 42*
3) Examine for changes in routing of tubing connected to the cylinder valve. *Figure 42.* Look for kinks or bends in the tubes.
4) Look for evidence of loose, displaced, damaged or missing rubber isolators around the fuel cylinder and mounting straps. *Figure 43*
5) View and feel brackets and tubing connections for signs of loose, damaged or missing fasteners. *Figures 42 and 43*

⚠CAUTION

Correct any of the above conditions immediately to prevent cylinder damage.

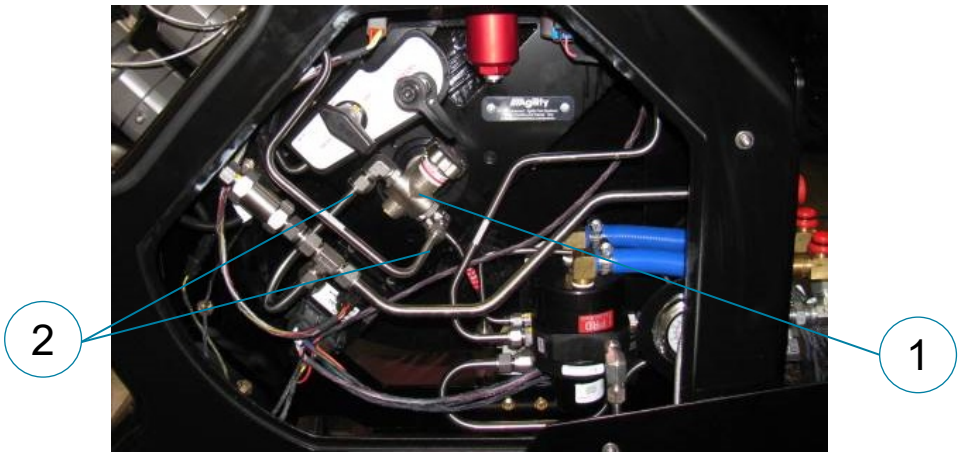


Figure 42. Cylinder valve (1) must remain its original as-installed orientation, fuel lines (2) connected to valve should not show signs of movement and fasteners should be snug and in place. Fittings and components must be leak-free. NOTE: Systems may vary from photo.

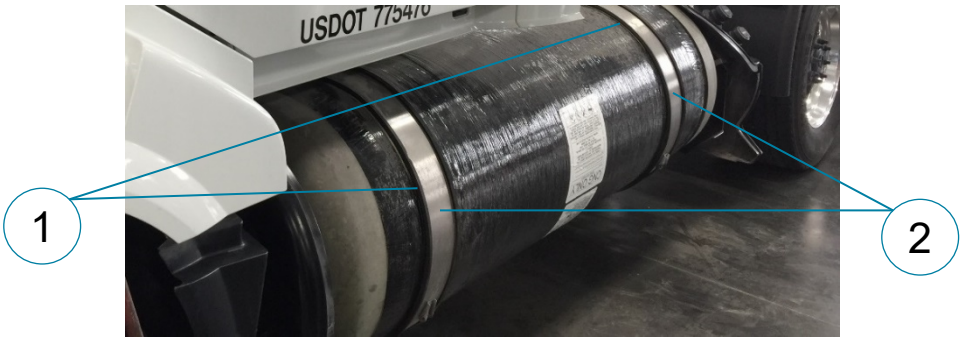


Figure 43. Cylinder brackets, straps and rubber isolators must be in place and secure. Rubber isolators (1) must be centered beneath the straps (2) and brackets (not visible) and must not be displaced or distorted on the mounts.

NOTE: ProRail™ system cover removed to reveal cylinder and mounts.

5.8.5. Side Mount Bracket, Straps and Isolators

Various mounting systems are used for side mount fuel systems. Belleville washer stacks, straps and isolators maintain clamping pressure yet allow for normal cylinder expansion and contraction.

The isolator is a maintenance item, but vehicle duty cycle, use/application and road conditions vary significantly. Since isolator service lifetime varies widely and is independent of vehicle mileage, isolator wear is best observed visually. *Figures 44 and 46*

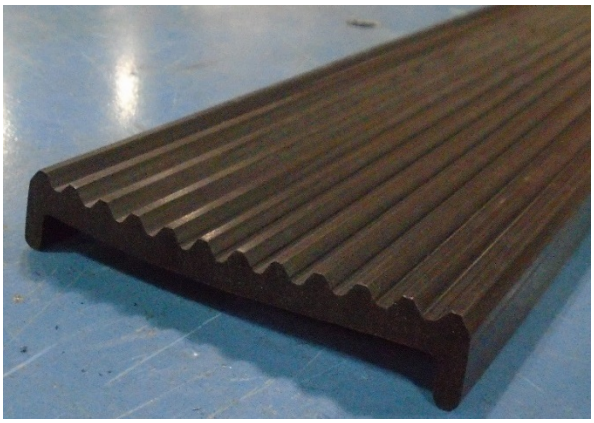


Figure 44. New rubber isolator material; ribbed side should be installed against the cylinder.

Inspection Guidelines

1. Verify strap mount hardware is properly torqued. *Refer to Section 10.1.8. Figure 45*
2. Isolators that are in their proper place and that do not allow contact between the cylinder and the metal bracket are acceptable.

   NOTICE

   Some isolator movement is considered normal.
3. Excessive push-out or compression, contact between cylinder and metal bracket, and cracks are indications an isolator must be replaced.
4. Maximum isolator crack / tear length should not exceed 1/2-in (12.7 mm) past the outside edge of bracket. *Figure 46*
5. Isolators with cracks and tears over 1/2-in (12.7 mm) past the outside edge of the bracket should be removed and replaced.
6. Isolators that are displaced (moved) away from their mating surfaces by more than 1-in (25.4 mm), must be replaced. *NOTE: Isolators may be displaced up to 1/4-in (6.35 mm) during normal assembly procedures.*
7. Isolators with excessive compression must be replaced: minimum remaining thickness should be 1/16-in (1.6 mm) or greater.

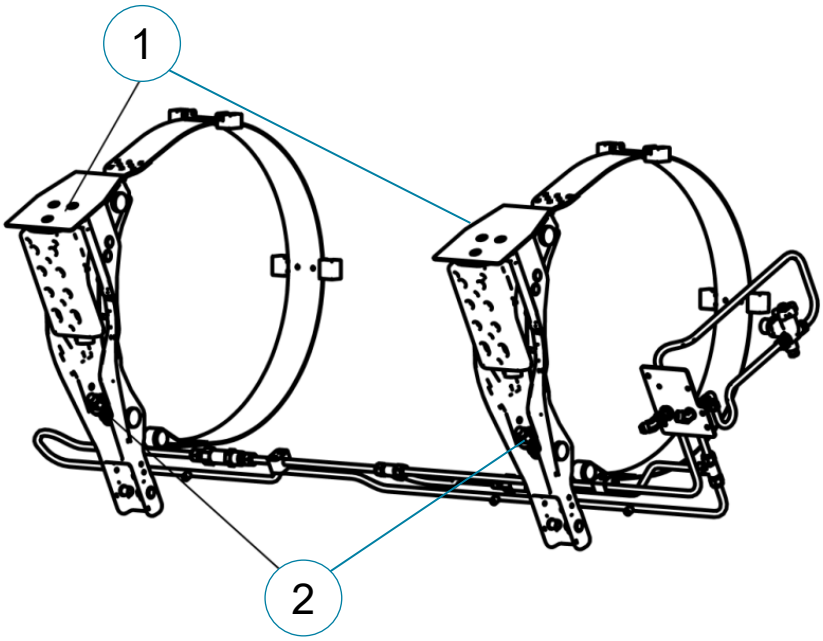


Figure 45. Check top plate bolts (1) and cylinder strap Belleville washer stack bolts (2) for proper torque. Always observe cylinder pressure when applying torque.

⚠CAUTION

Observe cylinder pressure when applying torque to cylinder strap Belleville washer mounting bolts and top plate mounting bolts.

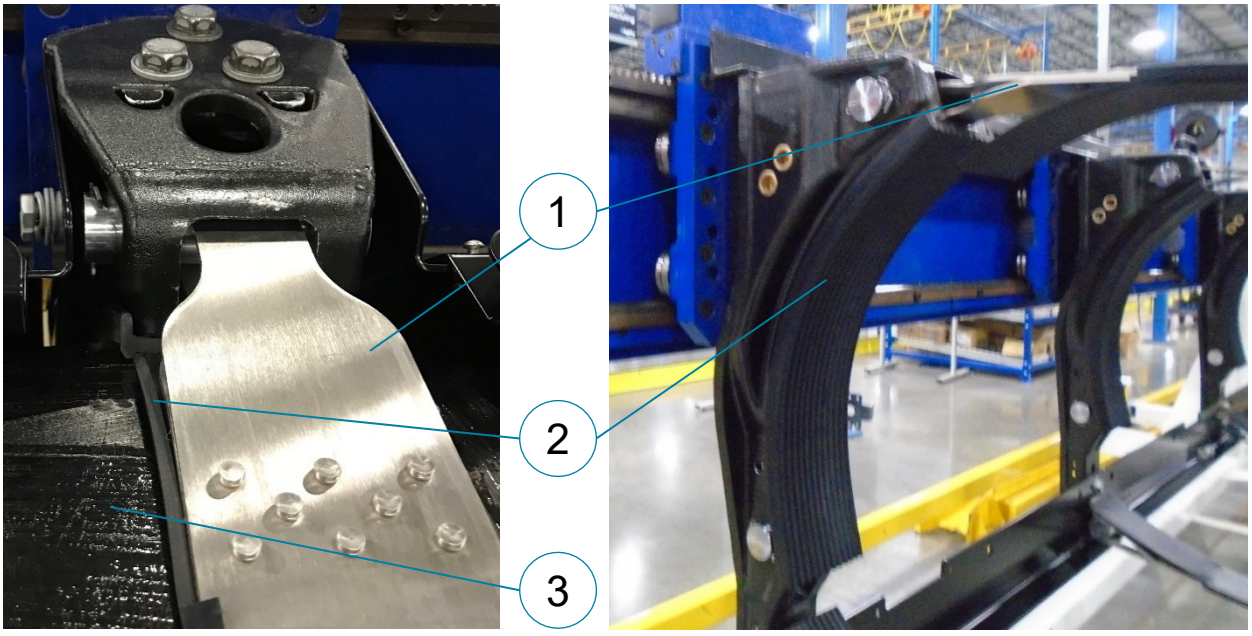


Figure 46. New rubber isolators (2) between the brackets (1) and cylinder (3).

5.8.6. Sliding Block Cylinder Mounts

CNG fuel systems using sliding block cylinder mounts (p/n 240105-01 engraved on the block), commonly used with 16-in and 21-in cylinder families should be checked periodically for Delrin bushing wear to prevent cylinder damage. *Figure 40*

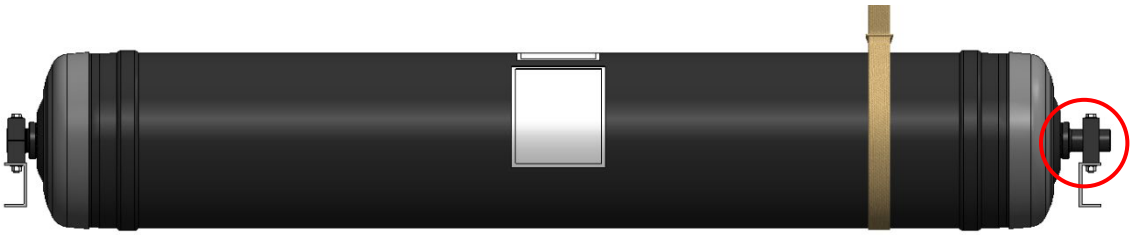


Figure 40. Delrin bushing (not visible) in sliding block cylinder valve end mount (circled) should be replaced if there is evidence of excessive movement or play.

If there are gaps greater than 1/16-in (1.6 mm) between the cylinder neck and threaded block or Delrin bushing, examine the cylinder necks for wear, and replace neck blocks and bushing.

The opposite plug end of the cylinder uses a fixed mounting block and is not normally subjected to wear.

6. CNG Fuel Cylinder Inspection and Preparation

Agility® Fuel Solutions uses Type 3 or Type 4 cylinders supplied by several manufacturers. This section is for reference only and does not replace training needed to become a qualified or certified CNG fuel system and cylinder inspector.

Cylinders manufactured by Agility® (including TUFFSHELL™ hybrid composite Type 4 and Agility® all carbon fiber Type 4 cylinders) have additional inspection details. *Refer to the Agility® publication "CNG Fuel Cylinder Inspection Manual," ENP-558.*

NOTICE

Refer to "CNG Fuel Cylinder Inspection Manual," ENP-558 for descriptions and guidelines for inspecting Agility® cylinders.

⚠CAUTION

Cylinder inspections must be performed by a certified or qualified CNG cylinder inspector.

Cylinder surfaces should be clean and free of dirt or other debris which impede inspection. Remove shields or covers as needed to ensure access to the cylinder surface. It is not necessary to remove the cylinder from the vehicle if the vehicle protects visually inaccessible surfaces and there is little potential for damage.

The inspector will examine, document and measure cylinder damage as defined by the cylinder manufacturer.

7. Fuel System Maintenance and Intervals

Performing regular maintenance will help ensure the vehicle fuel system delivers safe and reliable performance and minimize down time.

To determine the correct maintenance intervals for the vehicle, first determine vehicle service type and/or operating conditions.

NOTICE

Always select the interval that occurs first.

Severe Duty

- Operation on extremely poor roads or off-roads/highways
- Frequent short-distance or stop and go travel, such as refuse or transit bus
- Construction site operation

Normal Duty

- Long haul
- Over the road
- Infrequent stops

NOTICE

Agility® recommends oil analysis of high-pressure (HP) fuel filter residue to assess station fuel quality and to determine whether fuel filter maintenance intervals can deviate (be extended) from these guidelines.

Severe Duty

Item / action	1st 1000 mi. / 1600km / 6 months	Daily Visual Check	Every 15000 mi. / 24140km / 1000 hours
Fuel and coolant leaks	x		x
Frame/system fastener torque	x		x
Cylinder strap fastener torque (side mount)	x		x
PRD vent caps	x	x	
Fuel gauge operation	x		x
Manual cylinder valves operation	x		x
Shutoff valve operation	x		x
Fill receptacle inlet O-rings	x		x
Rubber isolators condition/displacement	x		x
System and vehicle decals		x	
Fuel and coolant leaks		x	
Cylinder mounts		x	
Cylinder strap fastener torque (side mount)		x	
PRD vent caps		x	
Manual cylinder valves operation		x	
Emergency/Manual Shutoff valve		x	
Fill receptacle inlet O-rings		x	
Replace high-pressure filter element*			x
Replace solenoid valve coil**			
High-pressure gauge		x	
Low-pressure gauge		x	
Dashboard fuel gauge		x	
PRD and components for corrosion		x	
Drive-away prevention caps		x	
Frame/system fastener torque			x
Pressure test/coolant leak			x
Rubber isolators condition/displacement			x
Cylinder inspection			x
Fuel hoses*** and tubes			x
Coolant hoses			
Cylinder shields and covers for damage			x
Cylinder bracket mounts			x
Cylinder isolator displacement			x
Cylinder valves and PRDs			x
BTC isolator mounts			x
System leak check			x

**Replace filter element every 30000 miles (48280km) / 1000 hours or at 9 months, whichever occurs first. Interval will vary depending on fuel quality. Draining HP filter is not required unless excessive oil is found at element change interval.*

***Solenoid coil replacement depends on solenoid valve type.*

****Fuel hoses must be inspected monthly or every 200 hours. Refer to Section 5.6.2.*

Normal Duty

Item / action	1st 8000 mi. / 12875km / 6 months	Daily Visual Check	Every 75000 mi. 120700km / 3000 hours
Fuel and coolant leaks	x		x
Frame/system fastener torque	x		x
Cylinder strap fastener torque (side mount)	x		x
PRD vent caps	x	x	
Fuel gauge operation	x		x
Manual cylinder valves operation	x		x
Shutoff valve operation	x		x
Fill receptacle inlet O-rings check	x		x
Rubber isolators condition/displacement	x		x
System and vehicle decals		x	
Fuel and coolant leaks		x	
Cylinder mounts		x	
Cylinder strap fastener torque (side mount)		x	
PRD vent caps		x	
Manual cylinder valves operation		x	
Emergency/Manual Shutoff valve		x	
Fill receptacle inlet O-rings		x	
Replace high-pressure filter element*			*
Replace solenoid valve coil**			
High-pressure gauge		x	
Low-pressure filter - drain		x	
Low-pressure gauge		x	
Dashboard fuel gauge		x	
PRD and components for corrosion		x	
Drive-away prevention caps		x	
Frame/system fastener torque			x
Pressure test/coolant leak check			x
Rubber isolators condition/displacement			x
Cylinder inspection			x
Fuel hoses*** and tubes			x
Coolant hoses			
Cylinder shields and covers			x
Cylinder bracket mounts			x
Cylinder isolator displacement			x
Cylinder valves and PRDs			x
BTC isolator mounts			x
System leak check			x

**Replace filter element every 30000 miles (48280km) / 1000 hours or at 9 months, whichever occurs first. Interval will vary depending on fuel quality. Draining HP filter is not required unless excessive oil is found at element change interval.*

***Solenoid coil replacement depends on solenoid valve type.*

****Fuel hoses must be inspected monthly or every 200 hours. Refer to Section 5.6.2.*

8. CNG Fuel System Maintenance

The portion of the system where work is to be performed determines whether the fuel system must be either depressurized or defueled:

1. For system components downstream of manual cylinder valves, fuel pressure can be isolated by closing manual cylinder valves and depressurizing the system.
2. For fuel cylinders, cylinder valves, pressure relief devices (PRDs) and lines, the fuel system must be defueled because there is no way to isolate the high pressure contained in these components.

Generally, low-pressure parts of the fuel system may be maintained and repaired without defueling the entire system. *Figure 49*

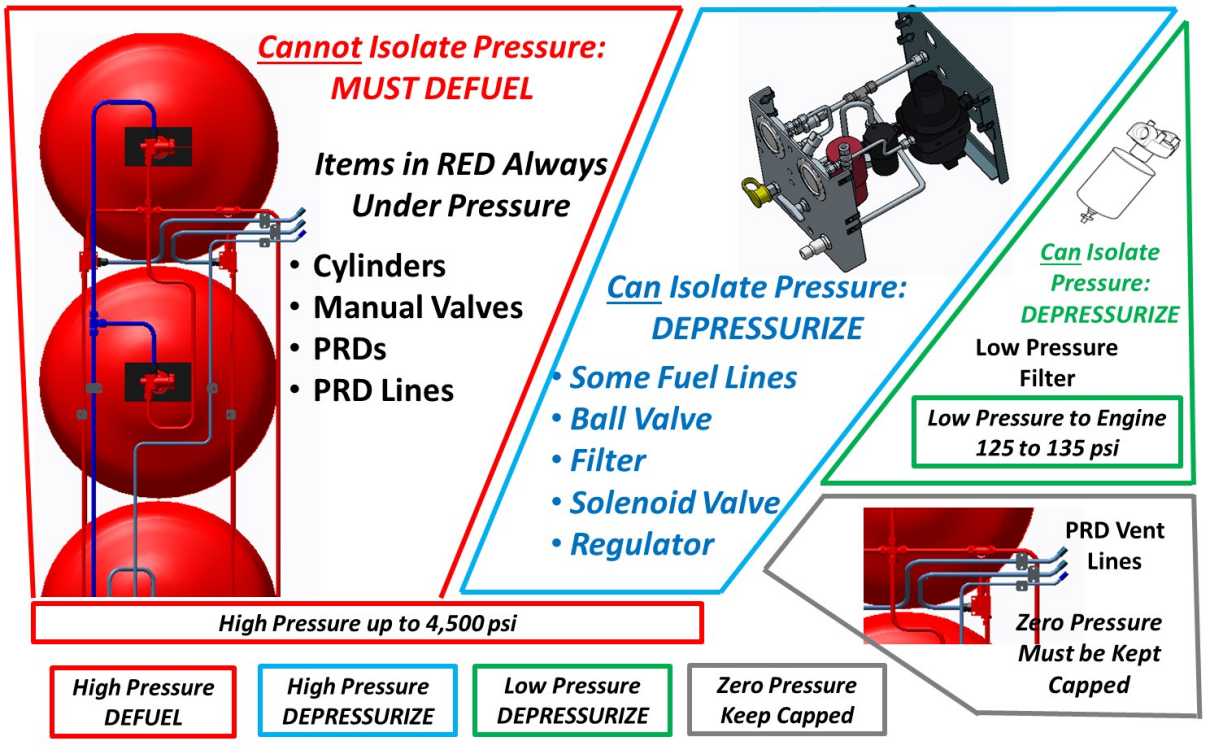


Figure 41. General guidelines to determine whether to depressurize or to defuel.

8.1. Depressurizing CNG Systems

⚠CAUTION **⚠WARNING**

Always close each cylinder valve to isolate and contain the gas inside the cylinder when depressurizing the system.

1. Turn vehicle off.
2. Close all cylinder valves.
3. Verify 1/4-turn manual shutoff valve on the FMM is in the “ON/OPEN” position.
4. Start vehicle and run engine until it stops.
5. Verify vehicle is off and the proper vehicle lock-out procedures are followed. Remove ignition key.
6. Check FMM gauges to ensure all pressure is relieved. (Gauges must read zero.)
7. Remove access cover on rear or bottom of fuel fill panel to access the defuel valve and open defuel valve to DEFUEL or OPEN.
8. Relieve remaining system pressure by slowly opening bleed valve. Regardless of vehicle or fuel system configuration, the bleed valve is installed inside the FMM. *Figure 1*
   A. The bleed valve may be mounted in the manifold or the HP filter in a box type FMM. *Figure 43.*

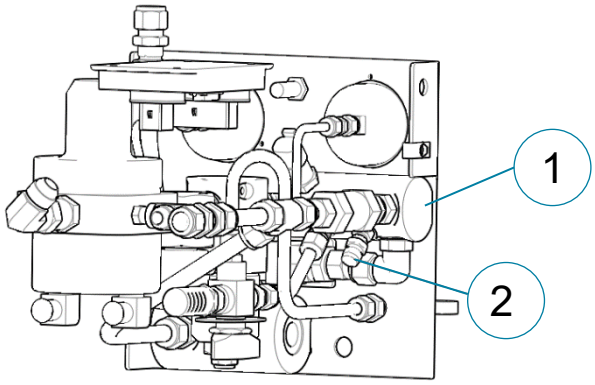


Figure 42. Rear of box style FMM. Bleed valve (2) is typically located in a manifold (1).

   B. The bleed valve may be mounted in the manifold or the HP filter in an FMM integral with a behind the cab (BTC) system. *Figure 44.*

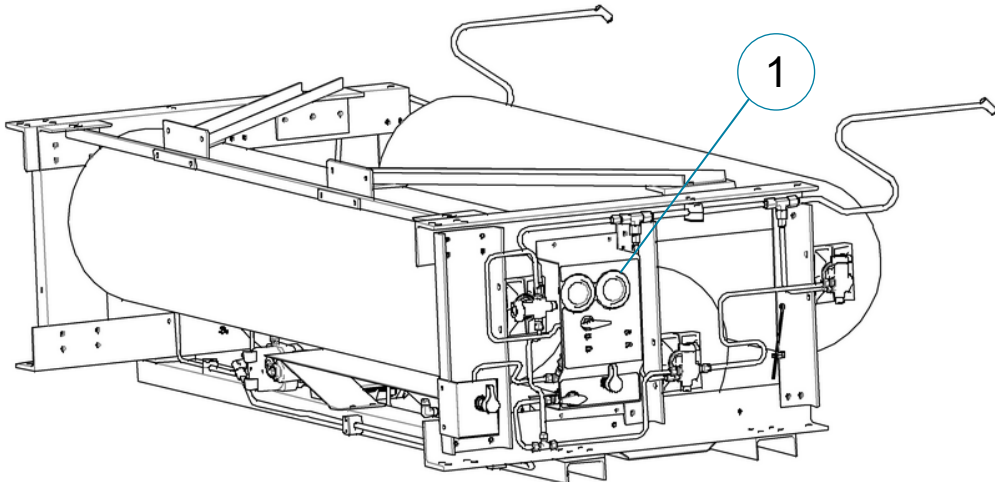


Figure 43. BTC system with integral FMM. Bleed valve (not visible) is installed in a manifold behind the control panel (1).

C. The bleed valve may be mounted in the manifold or the HP filter in an FMM integral with a side mount system. *Figure 44.*

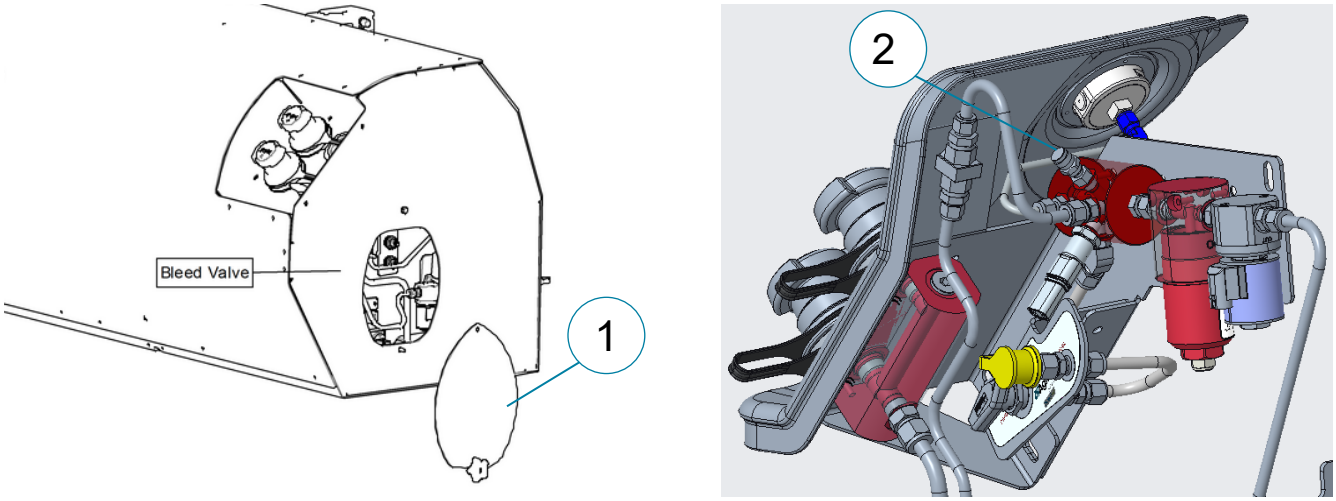


Figure 44. LEFT: Gen 4 side mount systems with integral FMMs may be equipped with a D- or oval-shape cover plate (1) to access the bleed valve (not visible). RIGHT: Gen 5 bleed valve (2) location.

9. Close red 1/4-turn manual shutoff valve handle as a secondary precaution.
10. Fuel system is now depressurized up to the primary solenoid lock-off valve.

⚠CAUTION

Residual system pressure may remain downstream of the solenoid valve; carefully loosen fittings when removing after depressurization.

8.2. Defueling CNG Systems

NOTICE

Drive vehicle to near empty or plan to defuel system at the end of a service day to minimize the amount of fuel to be returned to a fuel dispenser, or—on vent stack systems—released into the atmosphere.

Defueling requires access to the appropriate valves and receptacles on or near the FMM. Given a variety of FMM configurations, valve and receptacle locations may vary. However, valve names and functions are the same.

Two defueling procedures are provided dependent upon FMM control valves and not system configuration:

1. 1/4-turn manual shutoff valve and 3-way defuel valve. *Figures 46a, 46b and 46c*
2. Two 1/4-turn valves (manual shutoff and defuel) and Mani-Filter™. *Figures 47a and 47b*

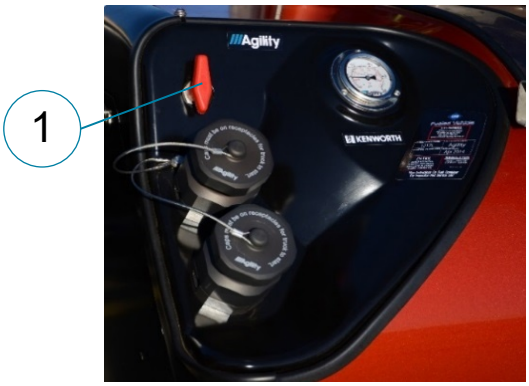


Figure 45a. Side mount system FMM with 1/4-turn manual shutoff valve (1). The 3-way defuel valve (not visible) is inside the housing, near the low-pressure gauge.
Refer also to Figure 5.

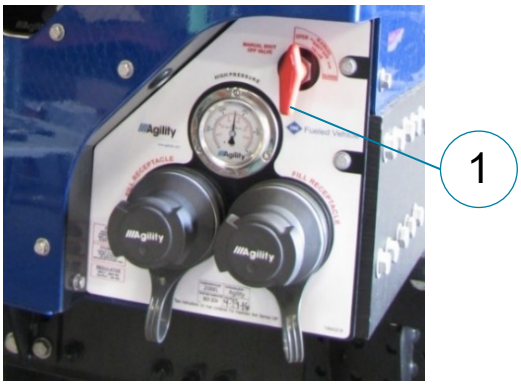


Figure 46b. Box style FMM with red 1/4-turn manual shutoff valve (1). The 3-way defuel valve (not visible) is accessed from the bottom of the FMM chassis box.
Refer also to Figure 6.

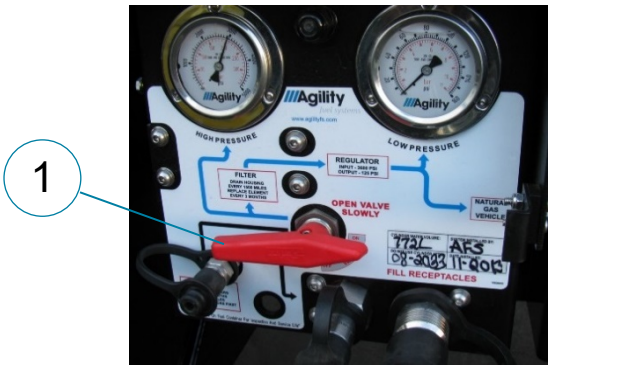


Figure 47c. Behind the cab FMM with red 1/4 turn manual shutoff valve (1). The 3-way defuel valve (not visible) is inside the cabinet.

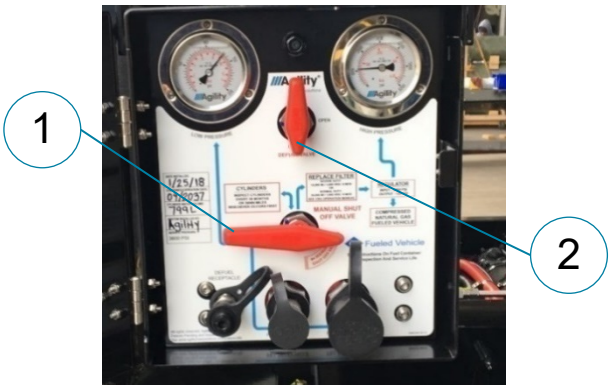


Figure 48a. Box style FMM with red 1/4-turn manual shutoff valve (1) and defuel valve (2) on FMM front panel.

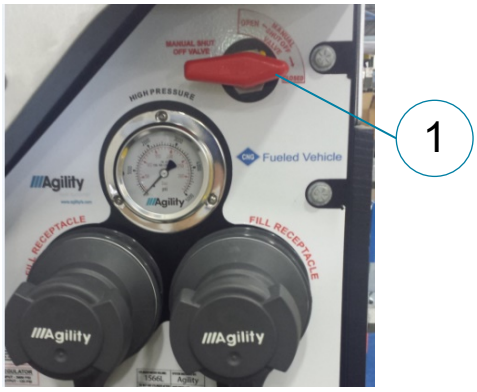


Figure 49b. Back of cab FMM panel with red 1/4 turn manual shutoff valve (1) on FMM front panel; NOTE: 1/4-turn defuel valve (not visible) is inside fuel system cabinet.

8.2.1. Defueling Preparation and Procedures

The best and safest way to defuel a CNG system is to transfer fuel back to a dispensing station, if so equipped.

NOTICE

Always check with CNG filling station personnel and/or posted instructions for specific procedures.

General rules for safe defueling:

- Only qualified personnel should perform defueling.
- Consume as much fuel as possible prior to defueling (drive vehicle or run engine).
- Never defuel indoors.
- Notify nearby personnel prior to defueling.
- Always wear personal protective equipment (PPE).
- Be familiar with evacuation routes.
- Disconnect vehicle battery to prevent a possible ignition source.
- Always ground vehicle and fuel system.
- Use a slow, steady flow when transferring fuel to reduce static electricity/electrostatic discharge and prevent freezing.
- Store fuel removed from vehicle in approved place. If permissible (check with AHJ), fuel may be vented to atmosphere.

8.2.2. Defueling Options

⚠WARNING

Both vehicle and fueling system must be grounded to prevent static electricity build-up.

Three common defueling options are as follows:

1. **Vent to Atmosphere**

   NOTICE

   Only use this method after confirming with AHJ it is legal. Local air quality regulations may restrict release of methane into the atmosphere. If atmospheric venting is acceptable, a compliant venting facility must be used. *Refer to Section 8.2.3.*

2. **Compressor Transfer**

   This defueling method uses a compressor at the fueling station to extract CNG from vehicle.

3. **Return to Supply**

   This method returns fuel to a CNG distribution system. This defueling method is also known as a passive transfer.

   NOTICE

   When using this process, pressure in the vehicle cylinder and the supply system pressure will equalize, so some pressure may remain in the vehicle fuel system which must be vented.

Driving Before Defueling is Complete

If defueling is initiated but cannot be completed, follow the following procedure:

1. Use Table 2 below to determine approximately how much fuel remains in the system. For example: defueling a 60 DGE (800L) system to 500 psi (3.44 MPa) leaves about 4.2 DGE (56L) in the cylinder.

   NOTICE

   Move vehicle only very short distances, e.g., parking lot to service bay.

2. Monitor fuel system high-pressure gauge carefully and stay within the “OK to Drive” zone shown in green.

Table 2: CNG volume remaining in 60 DGE to 175 DGE (800L to 2316L) cylinders at observed fuel pressures

		Cylinder capacity DGE (L)					
		60 (800)	75 (1000)	106 (1423)	120 (1566)	160 (2088)	175 (2316)
		Approximate remaining fuel volume DGE					
Fuel storage pressure psi (MPa)	1000 (6.89)	12.5	15.6	20.8	25.0	33.3	36.5
	900 (6.20)	10.8	13.5	18.1	21.7	28.9	31.6
	800 (5.51)	9.2	11.5	15.3	18.3	24.4	26.7
	700 (4.82)	7.5	9.4	12.5	15.0	20.0	21.9
	600 (4.13)	5.8	7.3	9.7	11.7	15.6	17.0
	500 (3.44)	4.2	5.2	6.9	8.3	11.1	12.2
	400 (2.75)	2.5	3.1	4.2	5.0	6.7	7.3
	300 (2.06)	0.8	1.0	1.4	1.7	2.2	2.4
	200 (1.37)	0.0	0.0	0.0	0.0	0.0	0.0

NOTICE

Any remaining fuel should be removed following the defueling procedures below.

8.2.3. Defueling (Venting) Facilities and Equipment

The following information is provided in the absence of formalized procedures from local authorities and governing bodies. *Figure 50* represents a typical venting facility.

⚠WARNING
Venting CNG to atmosphere to requires care. Improper equipment or procedures raise the risk of fire.

⚠WARNING
Before depressurizing, ground venting orifice to an approved electrical ground system.

⚠WARNING
Always vent CNG in an open area with air circulation and no nearby sources of open flame, ignition, or heat.

⚠WARNING
Do not vent system in an area where flammable gas is permitted to accumulate and potentially ignite.

NOTICE
Other state or local regulations may apply; check with AHJ.

Defueling stations (*Figure 50)* must include the following features.

1. **Steel vent pipe** typically 2-in (50 mm) diameter attached to a support structure. The pipe must extend a minimum of 2 ft (0.6 m) higher than the support structure and stand at least 10 ft (3 m) above ground. There should be no ignition sources near the pipe.

   ⚠WARNING
   Verify no ignition sources are closer than 15 ft (9 m) to the pipe.

2. **Electrical ground connection** with a minimum 3 AWG (5.8 mm diameter) stranded copper wire attached to a ground rod, or an equally suitable electrical ground. The other ends of the ground wire should be securely fastened to both the venting pipe and the vehicle FMM.
3. **High-pressure electrically conductive flexible hose approved for CNG**.
4. **Manual valve** to control gas flow.

Additionally, it is good practice to include the following items:

1. **Portable fire extinguisher** in an easily accessible location at the defueling facility. The extinguisher should have a rating no less than 20-B:C.
2. **Large warning signage** indicating “NO SMOKING” and “FLAMMABLE GAS.”
3. **Flame arrestor** downstream of the hand valve.

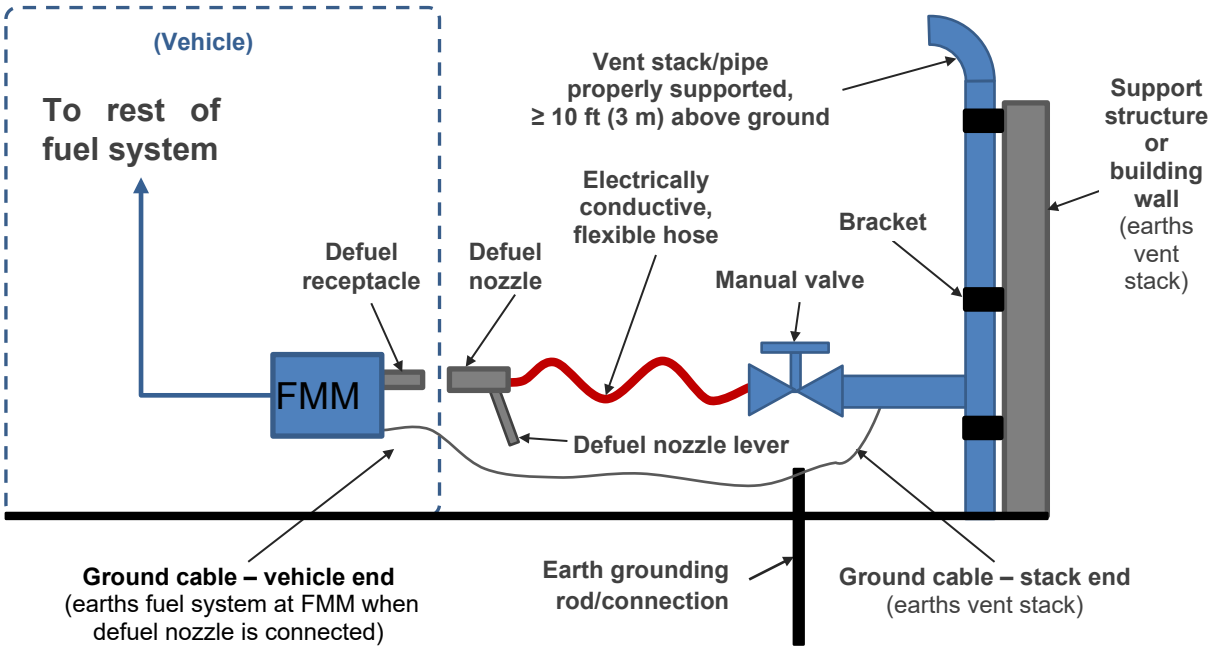


Figure 50. Required defueling connections and typical atmospheric venting facility equipment diagram.

⚠CAUTION

Freestanding cylinders must be restrained prior to venting. Cylinders will contract and move if gas is released at a rapid rate.

NOTICE

Some Type 4 cylinders used in Agility® fuel systems may be sensitive to rapid defueling and require a specific procedure be followed to avoid damage to the plastic liner. Cylinders manufactured by Agility® have no such restriction.

8.2.4. General Defueling Procedures

8.2.4.1. Defueling / Fuel Transfer Hoses

Hoses for handling CNG must made with approved, CNG-compatible conductive hose and couplings. A 35 ft fuel transfer hose is available from Agility®. *Figure 56*

Figure 51. Agility® 35 ft. CNG transfer hose, part number 20100021, may be used to transfer CNG from one vehicle to another.

⚠WARNING

The passive fuel transfer process described cannot completely remove fuel because pressures merely equalize between storage vessels. Because fuel always remains in the system, residual fuel pressure must be vented to atmosphere.

8.2.4.2. Vehicle Systems Equipped with an NGV1-style defuel receptacle, 1/4-turn valve and 3-way defuel valve. *Figure 53*

1. Manual valves on **all** fuel cylinders must be open.
2. Connect a ground wire from vehicle to vent stack system.
3. Attach the defuel hose to the vent stack system.
4. Turn 3-way defueling valve handle to VENT position. This relieves pressure to allow hose connection.
5. Attach defuel nozzle to defuel receptacle on the FMM.
6. Verify 1/4-turn manual shutoff valve is OPEN.
7. Slowly open defuel nozzle fill valve (turn to DEFUEL position) and adjust for a slow and steady flow to avoid freezing and static build-up.
   a) NOTE: If the system is equipped with a bleed valve, leave it closed.
   b) Monitor high-pressure gauge during the defuel process.
   c) When gas stops flowing, the high-pressure gauges of both vehicles should be nearly equal.
   d) Turn 3-way valve from DEFUEL position to VENT position and disconnect transfer hose from defuel receptacle.
   e) Turn 3-way valve from VENT position to OFF position.
8. Close cylinder valve.

NOTICE

A small amount of fuel pressure will remain in the system.

8.2.4.3. Vehicle systems equipped with 1/4-turn manual shutoff valve, 1/4-turn defuel valve and Mani-Filter™ high-pressure filter. *Figure 54*

1. Manual valves on **all** fuel cylinders must be open.
2. Connect a ground wire from vehicle to compressor vent stack system.
3. Close 1/4-turn manual shutoff valve.

⚠WARNING

Monitor high-pressure gauge during defueling.

4. Open defuel valve.
5. Low-pressure gauge should read a nominal pressure of approximately 125 psi (862 kPa).

   NOTE: Low pressure for Westport-Cummins Near Zero and other engines is 87 psi (600 kPa).
6. Open Mani-Filter bleed valve to relieve pressure in manifold.
7. Close Mani-Filter bleed valve when pressure is relieved.
8. Connect an approved, electrically-conductive defuel hose to the defuel receptacle.
9. Open 1/4-turn defuel shutoff valve and commence defueling.

   ⚠WARNING

   High-pressure gauge should indicate pressure is decreasing.

   NOTICE

   Adjust dispenser fill valve for a slow, steady flow to avoid freezing and static build-up.

   NOTICE

   If dispenser fill valve freezes, stop defueling and wait until valve thaws. Water from a hose may be used to thaw the defueling valve.

   ⚠CAUTION

   Never chip away ice with tools or any other object.
10. Once defueling is complete, close 1/4-turn manual shutoff valve.
11. Next, open Mani-Filter bleed valve to relieve manifold pressure to allow safe removal of defueling hose.
12. Close Mani-Filter bleed valve.
13. Disconnect defuel hose.
14. Close defuel valve.
15. Open 1/4-turn manual shutoff valve.
16. System is ready for refueling.

8.2.5. Venting Procedure

1. There are no flow restrictions upon an Agility cylinder during venting (defueling) that affects its performance or suitability for service.
2. Rapid venting of natural gas normally causes a significant temperature reduction inside CNG fuel cylinders. Internal temperatures lower than -100°F (-73°C) have been measured.
3. CNG should be vented slowly to avoid freezing plumbing components which decreases flow.
4. Residual gas in the container after initial venting expands as the cylinder warms to its surrounding temperature. This causes a buildup of pressure if the cylinder is not allowed to vent throughout the defuel process.

   NOTICE

   Keep manual cylinder valve open during this warming stage to ensure cylinder is defueled as completely as possible.

   ⚠CAUTION

   Agility® Type 4 cylinder liner can become very cold during defueling; always wait four hours after venting before re-pressurizing cylinder to prevent liner damage.
5. Do not allow a vacuum to form in the cylinder at any time. If a vacuum occurs, the cylinder should be opened to atmosphere and conditioned at a temperature above 60°F (16°C) for 8 hours before being pressurized.

8.2.6. Refueling Defueled or New Cylinders

There are no fill flow restrictions for Agility® cylinders under the following conditions:

1. Ambient temperature is greater than 10°F (-12°C), OR
2. Cylinder is in CNG vehicle service with a residual pressure greater than 100 psi (689 kPa),

   OR
3. Cylinder has been conditioned. *Refer to Section 8.2.7.*

8.2.7. Conditioning Cold Cylinders: A Special Condition

1. Agility® fuel cylinders at less than 100 psi (649 kPa) **and** at an ambient temperature of 10°F (-12°C) or less are termed “cold cylinders.”
2. The cold cylinder condition could occur after fuel system maintenance work or during installation of new cylinders in cold climates.
3. There are no restrictions when time (slow) filling a cold cylinder.
4. After a cylinder is in service and a minimum pressure of 100 psi (689 kPa) is maintained, the liner is seated and there is no restriction regardless of fill rate or temperature.
5. These procedures can be applied to any Type 4 cylinder, regardless of manufacturer.

⚠CAUTION

No Type 4 CNG fuel cylinder (regardless of manufacturer) is compatible with liquid methane (LNG).

⚠WARNING

Liquid methane can form at the filling station from an extremely cold, high-pressure cascade.

NOTICE

Procedures for filling a cold cylinder must prevent damage to the plastic liner by filling at a slow rate to a pressure that seats the liner.

If a cold cylinder is to be fast-filled, perform the following steps:

1. Partially fill cylinder, wait for five minutes, and then re-fuel as follows:
2. Fill to 450 psi ± 50 psi (3.1 MPa ± 345 kPa) directly from a compressor (not from a cascade or compressor-less transfer station).
3. Wait one hour.
4. Re-fuel normally.

Remember, after a cold cylinder is in service and a minimum pressure of 100 psi (689 kPa) is maintained, the liner is seated and there is no restriction regardless of fill rate or temperature.

8.3. Repressurizing the Fuel System

1. Verify vehicle is off and remove key from the ignition.
2. *If opened for depressurizing:* Close bleed valve.

   C **Torque bleed valve to between 4 ft-lbs (5.42 Nm) and 5 ft-lbs (6.78 Nm).**
3. Ensure the high-pressure fuel filter bowl and drain plug are installed and tightened.
4. *If removed or opened:* Re-install or close fuel fill panel cover
5. Verify all manual cylinder valves are fully open.
6. Verify 1/4-turn manual shutoff valve on the FMM is in the “on/open” position.
7. Fill CNG system normally at a fuel station or use a pony tank as a temporary fuel supply.

   ⚠WARNING

   Pony tanks are not approved for use on public roads.

   NOTICE

   Refer to “Service Facility Fuel Handling Equipment,” ENP-380 for pony tank information and the pony tank operation manual.

8.4. Additional Defueling Resources

More information on the defueling process and related subjects can be found in the following Agility® publications:

- “Safely Working on CNG Fuel Systems,” ENP-391
- “Venting (Defueling) and Re-Filling Agility Fuel Solutions Cylinders,” ENP-649

- “Pony Tank Operation Manual,” ENP-005
- “Type 2 Pony Tank Operation Manual,” ENP-249
- “Service Facility Fuel Handling Equipment,” ENP-380

8.5. Pressure Relief Devices (PRDs)

PRDs do not have consumable parts and require no additional maintenance other than visual inspections and leak testing. *Figures 51 and 52. Refer also to Section 5.5.*

⚠CAUTION

Leaking, corroded or otherwise damaged PRDs must be replaced by a qualified CNG service technician.

⚠WARNING

PRDs and PRD lines are always under full cylinder pressure and cannot be isolated using fuel system valves.

PRD vent tubes must be kept free from debris and moisture. There are two maintenance and inspection points for PRD vent lines:

1. **Weep hole** at the lowest portion of the vent tube must be kept clear and open to drain moisture from the vent tube.
2. **UV-protected vent tube caps** must be in place. If caps are missing, the vent lines and PRDs must be inspected for moisture and corrosion and the caps replaced. Agility® p/n 10712383 fits both 3/8-in and 1/2-in PRD vent tubes. The caps are heat-shrinkable and must be installed using a hot air gun. *Figures 50 and 51*

   ⚠WARNING

   If a PRD vent cap is missing or damaged, the PRD vent lines and PRDs must be inspected for blockage, water intrusion, corrosion, or other damage. DO NOT simply replace the PRD vent cap.

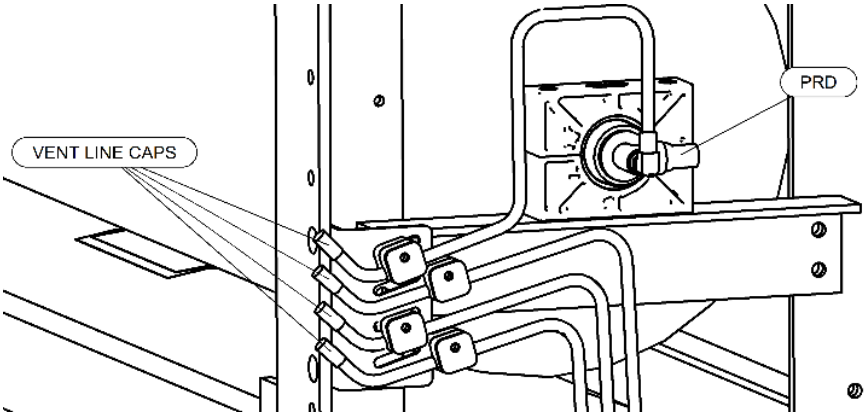


Figure 52. PRD vent line caps in place on cylinder plug end in a BTC system.

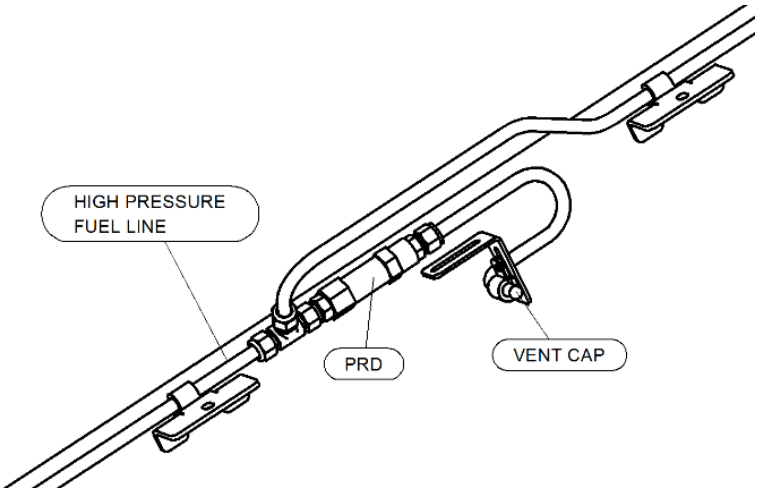


Figure 53. Typical roof mount system remote PRD and PRD vent line cap.

8.6. High-Pressure (HP) Filter Maintenance

⚠WARNING

HP filter must not be under pressure when servicing or personal injury may result.

NOTICE

Draining the HP filter is no longer necessary.

High-pressure filter element replacement intervals:

a) **Severe Duty:** 15000 miles (24140 km), 1000 hours or 9 months, whichever occurs first

b) **Normal Duty:** 35000 miles (56327 km), 1000 hours or 9 months, whichever occurs first

⚠WARNING

Depressurize fuel system.

1. Use a wrench to unscrew HP filter bowl from filter housing.
2. Remove filter bowl O-ring and clean filter bowl inside and out with a clean, dry cloth.
3. Remove filter element by pulling it off and inspect element for oil contamination.
4. Remove small O-ring from filter element housing.
5. Unscrew filter element base and remove filter element.
6. Lubricate small O-ring and install it on filter element housing.

   ⚠CAUTION

   Use only non-petroleum-based lubricant such as Parker Super-O-Lube. Do not allow lubricants to contaminate filter or filter element.
7. Install new filter element onto filter housing and screw element base in place.
8. Install filter element onto element port inside filter housing. Make sure it seats properly by twisting the element assembly.
9. Lubricate and install new filter bowl O-ring.
10. Carefully apply a silicone-based spray lubricant (e.g., 3-IN-ONE Professional or other name brand) to filter bowl threads and re-assemble filter.

    C Torque filter bowl to 50 ft-lbs ±1 ft-lbs (67.8 Nm ±1.4 Nm).

    ⚠CAUTION

    Always tighten to torque specifications printed on high-pressure cylinder decal.
11. Mark filter bowl with a torque seal marker.
12. *If a bleed valve was opened:* Close bleed valve.
13. *If closed:* Slowly open all cylinder valves.
14. Slowly open 1/4-turn manual shutoff valve.
15. Turn vehicle ignition key on to allow fuel to flow throughout the system.
16. Check HP filter and connections for leaks; repair as needed.

High-pressure filter assembly, p/n 20100008

Element replacement interval:

Severe Duty: 15000 miles (24000 km), 1000 hours, or 9 months, whichever occurs first.

Normal Duty: 35000 miles (56000 km), 1000 hours or 9 months, whichever occurs first.

Item	QTY	Part Number	Description
1	1	10200266	9/16-in hex plug (O-ring p/n 10500014)
2	1	20100107	Filter bowl
3	1	10500022	Filter bowl O-ring
4	1	20100110	Element base
5	1	20100109	Filter element*
6	1	20100108	Element housing
7	1	10500017	O-ring
8	1	20100106	Filter housing

** p/n 2010341 filter element replacement kit includes QTY: 1 each: filter bowl O-ring (3), filter element (5) and O-ring (7).*

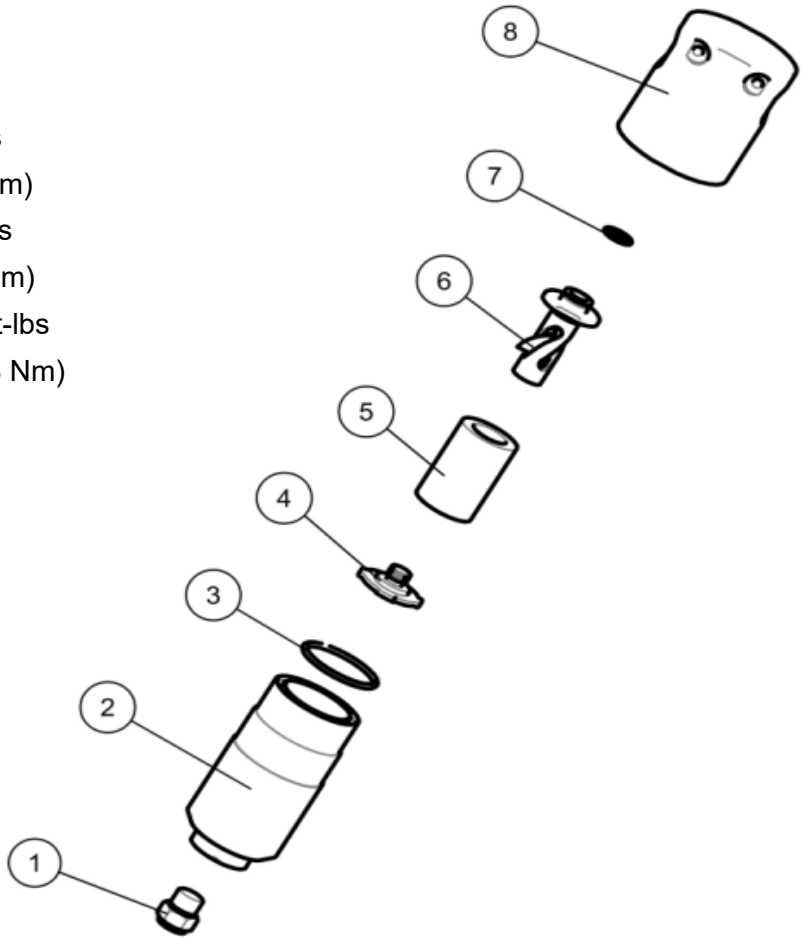
Torque specifications:

C

Filter bowl: 50 ft-lbs ±1 ft-lbs
(67.8 Nm ± 1.4 Nm)

Hex plug: 25 ft-lbs to 30 ft-lbs
(33.9 Nm to 39.3 Nm)

In/out ports: 25 ft-lbs to 30 ft-lbs
(33.9 Nm to 39.3 Nm)



High-pressure Mani-Filter™ assembly, p/n 20101001

Element replacement interval:

Severe Duty: 15000 miles (24000 km), 1000 hours or 9 months, whichever occurs first.

Normal Duty: 35000 miles (56000 km), 1000 hours or 9 months, whichever occurs first.

Item	QTY	Part Number	Description
1	1	10200266	9/16-in hex plug (O-ring p/n 10500014)
2	1	20100107	Filter bowl
3	1	10500022	Filter bowl O-ring
4	1	20100110	Element base
5	1	20100109	Filter element*
6	1	20100108	Element housing
7	1	10500017	O-ring
8	1	20100402	Mani-Filter, exit LHS
9	1	10500014	Hex plug O-ring

** p/n 20103412 high-pressure filter element replacement kit includes QTY:1 each: filter bowl O-ring (3), filter element (5) and O-ring (7).*

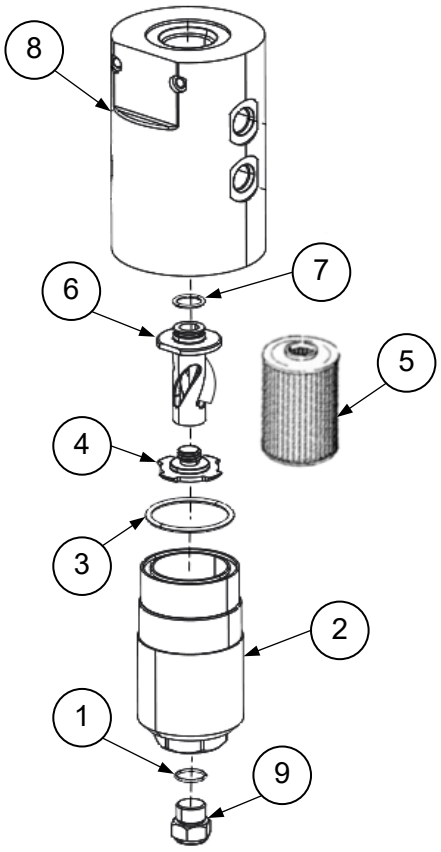
Torque specifications:

c

Filter bowl: 50 ft-lbs ±1 ft-lbs
(67.8 Nm ± 1.4 Nm)

Hex plug: 25 ft-lbs to 30 ft-lbs
(33.9 Nm to 39.3 Nm)

In/out ports: 25 ft-lbs to 30 ft-lbs
(33.9 Nm to 39.3 Nm)



8.7. Solenoid Valve Maintenance

⚠CAUTION

The solenoid valve generates heat during normal operation and may cause burns on contact.

⚠WARNING

Serious injury or death may result from improper removal of a pressurized solenoid valve. Service must be performed by a qualified CNG fuel service technician.

Principles of Operation

De-energized: The solenoid valve uses an armature and a pilot instead of a plunger. Pressure from the inlet port flows through the pilot guide surrounding the armature, and the pressure is stopped by the pilot at the orifice.

Energized: Valve operates on either 12V or 24V DC from the vehicle power supply. The armature is forced upwards and lifts the pilot from the seat of the orifice allowing pressure to flow from the inlet port to the outlet port.

Various types of solenoid valves are used in Agility® CNG systems. To ensure maximum system reliability, we recommend the following preventative measure, depending on solenoid valve type and voltage.

NOTICE

The preventative maintenance procedure described below applies only to 12V solenoid valves manufactured by AFC.

8.7.1. AFC Solenoid Valve with Molded-In Connector

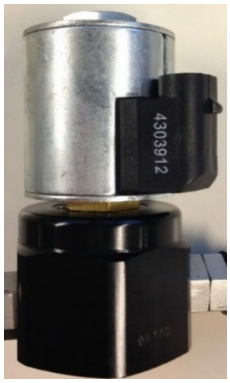


Figure 54. AFC valve with molded-in connector (with or without internal diode).

AFC solenoid valve with molded-in connector, 12V	Complete valve	Coil only repair kit
	p/n 10300441	p/n 10300463

NOTE: For Freightliner only, an additional wire harness, p/n 10400183, is required.

NOTICE

Preventative maintenance recommendation for 12V AFC solenoid valves only: remove and replace solenoid valve coil every two years, regardless of mileage.

Refer to "AFC Solenoid Coil Replacement (12V or 24V)," Field Service Bulletin ENP-068.

8.7.2. Removal Procedure for Pressure Regulator, HP Filter and Supply Solenoid Valve Subassembly

NOTICE

To remove or replace the pressure regulator, high-pressure (HP) filter or supply solenoid valve, all three components must first be removed as a subassembly. *Figure 60*

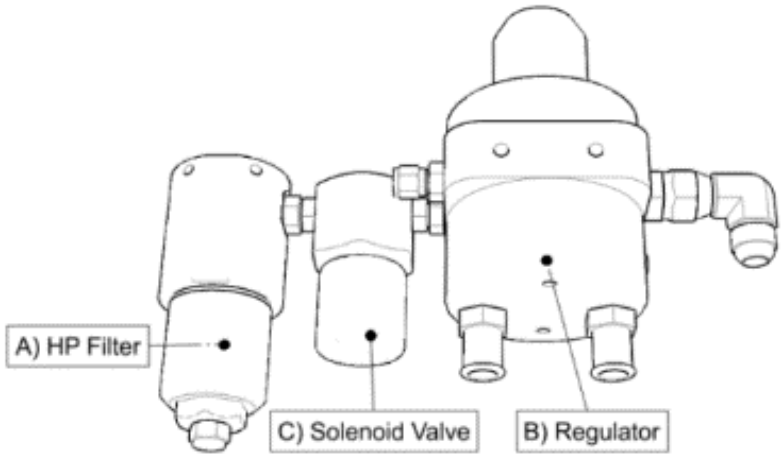


Figure 55a. Typical HP filter (A), supply solenoid valve (C), and pressure regulator (B) subassembly.

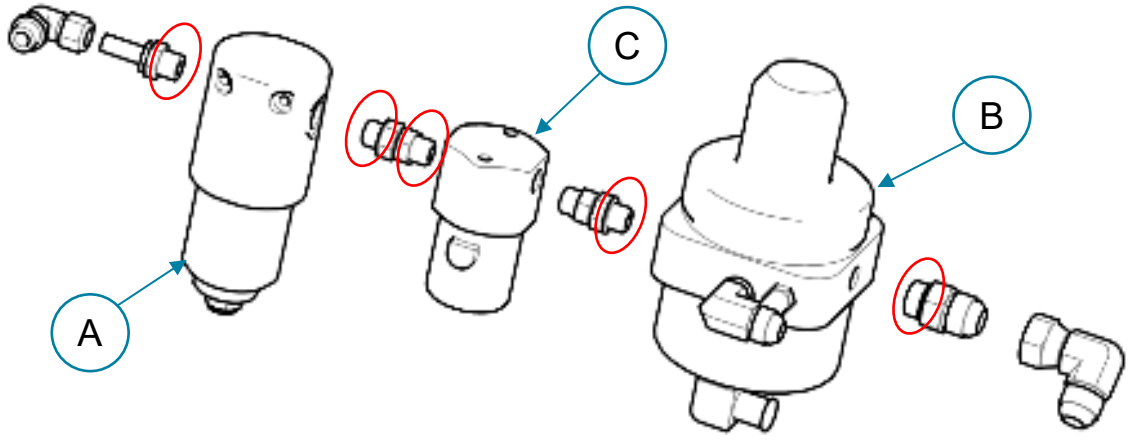


Figure 56b. Exploded HP filter (A), supply solenoid valve (C), and pressure regulator (B) subassembly.
NOTE: Inspect and lubricate O-rings on component port fittings (circled); replace if necessary.

⚠WARNING

Depressurize fuel system.

1. Disconnect external tube fittings from HP filter. *Figure 55b*

⚠CAUTION

Do not bend, kink or stress plumbing components.

2. Disconnect coolant lines from pressure regulator.

NOTICE

Clamp or pinch off hoses to prevent coolant loss. Collect residual fluid in an appropriate container and dispose of according to facility guidelines.

3. Disconnect electrical connectors from supply solenoid valve.
4. Disconnect low-pressure fuel line from pressure regulator. *Figure 55b*
5. Carefully remove any mounting hardware connecting subassembly to FMM brackets.

⚠WARNING

Solenoid valves cannot be repaired internally; if the valve does not work, replace it.

⚠CAUTION

Solenoid valve coils are designed to operate continuously for a lifecycle of 22,000 hours and generate significant heat. When a coil is energized for extended periods it will be hot. Although the coil is designed to operate under these conditions, smoke or the scent of burning insulation may be an indication of overheating and the coil should be replaced.

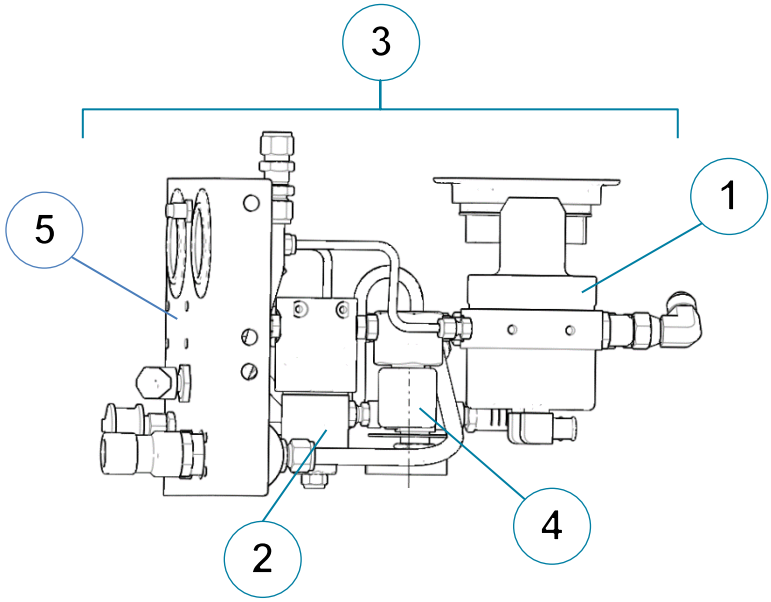


Figure 57. Typical solenoid valve (4) location inside FMM (3) between HP filter (2) and pressure regulator (1). FMM face panel (5) shown for reference.

8.7.3. Supply Solenoid Valve – Remove and Replace

The electrically operated high-pressure supply solenoid valve controls the flow of CNG to the engine. The solenoid valve is in the “OFF/CLOSED” position by default. In the event of an accident, if the battery is disconnected or if the ignition is turned off, the supply solenoid valve closes. *Figure 61*

The supply solenoid valve is located inside the FMM.

To install a new supply solenoid valve, proceed as follows:

1. Remove pressure regulator, HP filter and supply solenoid valve as a subassembly. *Refer to Section 5.7.*
2. *If necessary,* remove shipping plugs from inlet and outlet ports.
3. Verify O-rings are in good condition and free of contaminants. Inspect valve ports and remove any foreign particles and contaminants.
4. Apply O-ring lubricant to fittings, install initially by hand, then torque to 25-30 ft-lbs (33.9–40.7 Nm).
5. Connect inlet and outlet fuel lines.
6. If coil assembly is awkwardly positioned, reorient it before proceeding to the next step. Loosen coil assembly nut and reposition assembly by hand, then torque nut to 43-55 in-lbs (58.3–74.6 Nm).
7. Plug solenoid electrical connector into wiring harness.
8. Open all cylinder manual shutoff valves.
9. Start engine and idle for five minutes before shutting engine off.
10. Perform a leak inspection on any section of plumbing serviced; test at 3600 psi (28.4 MPa).

    ⚠CAUTION

    Leaks may not appear immediately; allow a minimum of 10 minutes before confirming no leaks are present.
11. Repair any leaks.
12. If no leaks are found the vehicle may be returned to duty.

Table 3. Solenoid valve diagnosis

Condition	Procedure
Valve fails to operate.	1. Check valve electrical supply with a voltmeter. Voltage must match solenoid nameplate rating. 2. Check solenoid coil with an ohmmeter for open or shorted condition. 3. Verify pressure matches solenoid nameplate rating. 4. If no apparent system problem exists, remove and replace solenoid valve.
Valve is sluggish or inoperative, but there are no power supply issues and pressure complies with the nameplate rating.	If no apparent system problem exists, remove and replace solenoid valve.

8.8. Pressure Regulator

Pressure regulator maintenance points are as follows:

1. Coolant hose connections to the regulator bowl
2. Fuel line inlet and outlet connections.

Check all connections for leaks, and repair as needed. If pressure regulator fails, replace regulator.

8.9. Valves

Valves do not require regular maintenance.

⚠WARNING

If leaks are found, depressurize fuel system and tighten or replace fittings or valve as necessary.

⚠WARNING

Always contact Agility® Customer Care for assistance if a cylinder valve is suspected to have failed.

8.10. Fill Receptacles

⚠CAUTION

Receptacles are designed to operate with AGA/CGA NGV1 certified fueling nozzles. For coupling and uncoupling procedures, consult CNG fueling dispenser instructions.

1. Always keep receptacle surfaces clear of contaminants and debris. A dust cap is provided for this purpose.
2. External mounting hardware, fill receptacle O-rings, and receptacle dust caps should be checked periodically to ensure components are functioning properly without leaks. If functionality is compromised or a leak is detected consult a qualified technician.

   ⚠WARNING

   Only qualified fuel system personnel should service or maintain a fill receptacle.
3. Do not tamper with or dissemble the receptacle, or any component connected to the receptacle.

9. Leak Testing

Figure 58. If a gas odor is present, locate leaks using leak detection solution.

Fittings and connections should be checked periodically for leaks. This task must be carried out by qualified fuel system personnel.

For monthly maintenance, the entire fuel system can be leak tested with leak detection solution (preferred method), and/or a methane detector. All tubing junctions and component connections should be tested.

Leaks usually occur at fitting connections. When checking for leaks always use certified leak detecting equipment and solutions designed for use with stainless steel and brass such as Swagelok® Snoop®.

1. Apply a certified leak detecting solution and look for bubbling or foaming. *Figure 55*
2. Examine connections for icing or signs of condensation around the tubing. *Figure 55*
3. Check for signs of damaged or perforated tubing. *Figure 55*

9.1. Leak Repair

⚠WARNING

Verify system is depressurized before repairing any leaks.

⚠WARNING

Maintenance and repair must be performed by qualified personnel.

Perform leak repairs in the order listed below.

NOTICE

Move on to the next repair only if the previous repair did not fix the leak.

⚠WARNING

If a leak is detected, always depressurize fuel system.

1. Once system is depressurized, tighten leaking fittings.
2. Repressurize system.
3. When the system is pressurized, conduct a leak test.

   ⚠WARNING

   If the leak continues, the system must be depressurized again.
4. Remove leaking fittings and verify mating surfaces are clean.
5. *If equipped:* Inspect for the presence of O-rings for signs of damage.
6. Replace leaking tubes and/or fittings.
7. Reinstall fittings according to the Swagelok® guidelines for compression fittings or SAE torque settings for O-ring boss fittings.
8. Repressurize fuel system and test for leaks.
9. Tighten fitting according to compression fitting specifications in Section 9.1.2 or SAE torque settings for O-ring boss fittings.
10. If the leak cannot be repaired, the component and stainless steel line should be replaced.
11. If replacement is necessary, obtain replacement parts, install them, perform a leak test and fix any leaks.

NOTICE

If the above procedures do not fix the problem, please contact Agility® Customer Care for assistance.

9.1.1. Tube Fitting Assembly and Adjustment

C In order to achieve a safe, leak free seal, tubing connections must be fully bottomed in the fitting.

1. De-burr tubing so it sits flush in the fitting.
2. Tubing must be round; elliptical or warped tubing must not be used.
3. Tubing must have a minimum length straight section before a bend radius per ENP-524.

⚠CAUTION

Adjusting double ferrule compression fittings requires Swagelok® or Agility® fitting assembly training.

9.1.2. Fitting Nut Tightening

9.1.2.1. Swagelok® double ferrule Compression Fittings

M For new fittings, Swagelok® recommends tightening fitting nuts as follows:

- 1-1/4 turns beyond snug for 1-in tubing and smaller.
- 1/16-in, 1/8-in, and 3/16-in tubing require 3/4 turns beyond snug.

M When re-using Swagelok® fittings, nuts should be tightened to no more than 1/2-turn from snug.

M "Snug" is defined as the point at which the tube cannot be rotated freely in the pre-set swaging tool or fitting body.

NOTICE

Swagelok® fittings employ a two-ferrule design: the front ferrule provides the seal and the rear ferrule provides a firm grip on the tubing.

⚠WARNING

Whenever fittings and components are replaced or re-installed a leak check using approved liquid leak detector is necessary.

9.1.2.2. Joint Industry Committee (JIC) Fittings

Refer to Section 11.1.5 for torque specifications.

9.1.2.3. O-ring Boss (ORB) Fittings

Refer to Section 11.1.6 for torque specifications.

10. Troubleshooting

The following section covers a variety of potential problems and solutions. The issues addressed in this section are unique to CNG storage systems; however, issues concerning other onboard systems may influence or directly cause problems with the CNG storage system.

NOTICE

For any issues not addressed in this manual, please contact Agility® Customer Care for assistance.

10.1. Using Cummins-Westport Fuel System Fault Codes

Cummins-Westport fault codes related to fuel delivery can be helpful when diagnosing and troubleshooting fuel system issues:

Fault Code / Driver Warning	Fault Description	Effects	Possible Causes
2723 Check engine lamp (amber)	1. Engine gas control valve intake pressure above/below operating range. 2. Moderately severe.	Possible reduced performance.	Pressure regulator failure.
2722 Check engine lamp (amber)	1. Engine gas control valve intake pressure above/below operating range. 2. Moderately severe.	Possible reduced performance.	Pressure regulator failure.
2991 Stop engine lamp (red)	1. Engine gas control valve intake pressure above/below operating range. 2. Most severe.	1. Progressive power de-rate increasing in severity from time of start. 2. If engine protection shutdown feature is enabled, engine shuts down after 30 seconds of red lamp flashing.	1. Pressure regulator or fuel flow restriction. 2. Plugged filter(s). 3. Damaged or kinked fuel lines. 4. Malfunctioning solenoid valve. 5. Partially closed valves.

Cummins-Westport Fuel System Fault Codes (continued)

Fault Code / Driver Warning	Fault Description	Effects	Possible Causes
2724 Check engine lamp (amber)	1. Gas supply pressure (regulated) above operating range. 2. Moderately severe.	Possible reduced performance.	Pressure regulator failure.
2568 Stop engine lamp (red)	1. Gas supply pressure (regulated) above operating range. 2. Most severe.	Engine power de-rate.	Pressure regulator failure.
2725 Check engine lamp (amber)	1. Gas supply pressure (regulated) below operating range. 2. Moderately severe.	Possible reduced performance.	1. Pressure regulator or fuel flow restriction. 2. Plugged filter(s). 3. Damaged or kinked fuel lines. 4. Malfunctioning solenoid valve. 5. Partially closed valves.

Refer to Section 9.2. "Cummins-Westport Fuel System Troubleshooting" below for corrective actions to the above symptoms.

10.2. Cummins-Westport Fuel System Troubleshooting

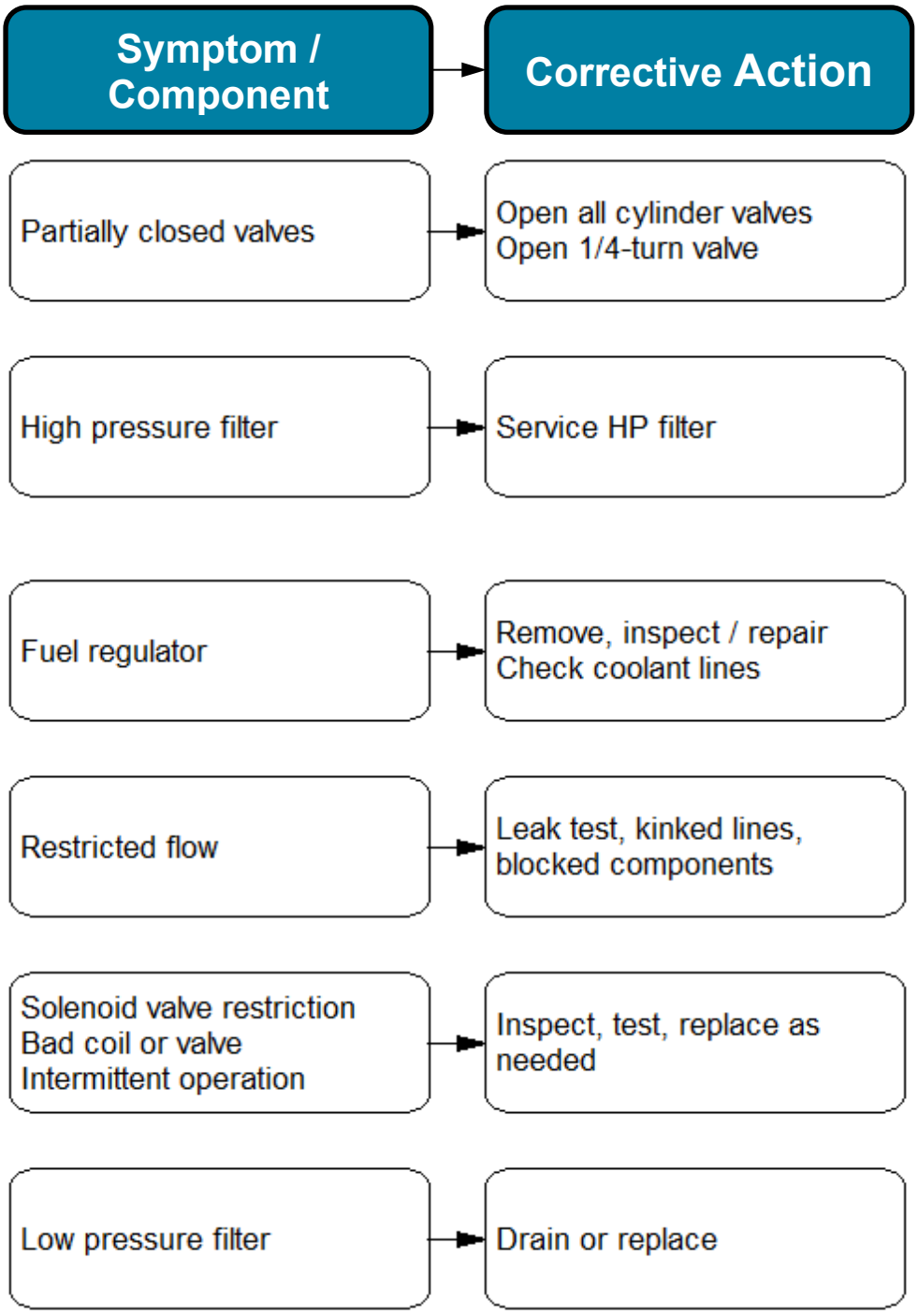


Figure 59. Systematically check the above items and conditions when fuel flow or fuel pressure related Cummins-Westport fault codes are present.

10.3. Fuel System Symptom Assessment & Repair

Qualified fuel system personnel may perform the following troubleshooting procedures based on symptoms or conditions.

Problem / Symptom	Cause(s)	Solution
After disconnecting fuel nozzle, fuel flows out of fill receptacle.	Fill receptacle O-ring frozen due to gas expansion.	Wait for fill receptacle to warm up to ambient temperature and check if leak persists.
	Debris in fill receptacle.	1. Depressurize fuel fill manifold. 2. Remove fill receptacle from manifold. 3. Inspect fill receptacle for blockage or damage. 4. Reinstall or replace fill receptacle as needed. 5. Test for leaks.
	Damaged check valve.	1. Depressurize fuel fill manifold. 2. Remove check valve from manifold. 3. Inspect check valve for blockage or damage. 4. Reinstall or replace check valve as needed. 5. Test for leaks.
Main shutoff valve does not isolate fuel – engine continues to run even when valves have been turned to the OFF position.	Worn valve seats or Debris will not allow valve to fully close.	1. Depressurize system. 2. Remove main shutoff valve. 3. Replace valve seats per valve manufacturer instructions or replace valve. 4. Test for leaks.
Too much pressure from regulator; > 125 psi (861 kPa)*	Regulator not working properly.	1. Depressurize system. 2. Remove and replace the regulator.
Not enough pressure from regulator; < 125 psi (861 kPa)*	Clogged high- or low-pressure filter element.	Replace appropriate filter element.

**Low-pressure reading should be approximately 87 psi (600 kPa) for Cummins 6.7L, 9L, 12L and Near Zero 12L CNG engines.*

10.4. Engine – No Crank

Test 1: Does crank signal pass through Agility® Electronic Control Unit (ECU) inside the FMM?

- Bypass the Agility® ECU (jump blue and purple wires on the chassis side).

  NOTE: Some systems have reed switches wired directly through the OEM chassis wiring along with a fuse and/or a relay which must be jumped or checked.

If no crank – OEM chassis issue, not fuel system - check key switch wiring.

If engine cranks – Agility® issue, proceed to Test 2:

Test 2: Check reed switch, kill cap and/or proximity switch at each filler panel door and fuel filler dust cap, including auxiliary fill receptacles.

1. Check two single wires (yellow-black and brown-black) at ignition switch for power.
2. Check kill cap (single black wire). Unplug cap connector and attach to new ground.
3. If more than one reed switch: Jump one switch at a time to chassis ground to determine which reed switch is not working.
4. Possible cause: Missing magnet or improper alignment of reed switch to magnet.
5. Touch reed switch inside the fill receptacle or door directly with test magnet and engine should crank.

10.5. Engine - No Run

Test 1: Determine whether Agility® fuel system provides proper fuel pressure to the engine:

1. The high-pressure gauge must read more than 500 psi (3.4 MPa) and the low-pressure gauge must read about 125 psi ± 10 psi (861 kPa ± 68.9 kPa).

   NOTE: *Low pressure should be approximately 87 psi (600 kPa) for Cummins 6.7L, 9L, 12L and Near Zero 12L natural gas engines.*
2. Verify all valves are open (1/4 turn manual shutoff valve and all cylinder valves).
3. With ignition key ON, **open low-pressure fuel filter petcock to allow gas to flow**. Pressure should be maintained.

NOTICE

If fuel pressure is present, the no-run condition is an engine or chassis issue (not the fuel system).

If symptom checks fail, proceed to Test 2 as follows:

Test 2: Chassis wiring power input to Agility® ECU:

1. Use a digital multimeter to check for power to FMM (black and red wires).
2. Check chassis wiring harness fuse: **If fuse is blown**, test solenoid coil before replacing fuse (Test 3).

Test 3: Check Agility® ECU.

1. Use a digital multimeter to check for power at solenoid valve inside FMM.
2. Check solenoid mechanically by plugging the solenoid in and unplugging it several times with the ignition key in the ON position while listening for the solenoid valve clicking.
   - **If solenoid has power** and **clicks when plugged in,** there is a fuel regulator issue; **proceed to Test 4.**
   - **If solenoid is not powered**, check for a blown chassis fuse and for possible shorted solenoid coil. Coil resistance check (7.1 ohms ± 0.5 ohms).
3. **Replace solenoid coil**.

Test 4: Test pressure regulator.

1. De-fueling is **not necessary** for this operation.
2. It is **not necessary** to depressurize the system.
3. It is **not necessary** to remove the pressure regulator from the vehicle for this test.
4. Cylinder pressure must be between 1500 psi (10.3 MPa) and 3600 psi (24.8 MPa) before starting the test.
5. Build test jig using a 15 psi (103.4 kPa) gauge. *Figure 64.* Refer to *ENP-088, "CNG Fuel Pressure Regulator Troubleshooting."*
6. Remove maintenance cover from FMM.
7. Clamp or pinch off the coolant hoses near the regulator and remove the connections going to the regulator.
8. Install pressure gauge jig between the two pressure regulator coolant ports. *Figure 64.*
9. Turn ignition switch to ON but not crank or start engine; this allows the solenoid valve to open.
10. Observe test jig gauge for 20 minutes to confirm any pressure in regulator.
11. If pressure builds, **replace pressure regulator**—unit is not serviceable.

Figure 60. Left: Shop-built pressure regulator test jig.
Right: Test jig installed on pressure regulator coolant inlet and outlet ports.

11. References

11.1. Torque Specifications

NOTICE

Aluminum-zinc, zinc coated and 18.8 stainless steel fasteners are the preferred fastener finishes for Agility® fuel systems. However, if a vehicle is equipped with yellow zinc fasteners, it is not necessary to change them.

⚠CAUTION

Do not mix aluminum-zinc or zinc coated fasteners with yellow zinc fasteners.

11.1.1. Aluminum-zinc and Zinc Coated Fasteners

Aluminum-zinc or Zinc coated Grade 8 lock nut size	Minimum torque	Desired torque	Maximum torque
1/4-20	7 ft-lbs (9.5 Nm)	8 ft-lbs (10.8 Nm)	9 ft-lbs (12.2 Nm)
5/16-18	17 ft-lbs (23 Nm)	18 ft-lbs (24.4 Nm)	20 ft-lbs (27.1 Nm)
3/8-16	26 ft-lbs (35.3 Nm)	30 ft-lbs (40.7 Nm)	34 ft-lbs (46.1 Nm)
7/16-14	38 ft-lbs (48.8 Nm)	45 ft-lbs (61 Nm)	52 ft-lbs (70.5 Nm)
1/2-13	60 ft-lbs (81.3 Nm)	69 ft-lbs (93.6 Nm)	79 ft-lbs (105.8 Nm)
9/16-12	85 ft-lbs (115.2 Nm)	95 ft-lbs (128.8 Nm)	105 ft-lbs (142.4 Nm)
5/8-11	120 ft-lbs (162.7 Nm)	135 ft-lbs (183 Nm)	150 ft-lbs (203.4 Nm)
3/4-10	210 ft-lbs (284.7 Nm)	240 ft-lbs (325.4 Nm)	270 ft-lbs (366.1 Nm)
7/8-9	350 ft-lbs (474.5 Nm)	380 ft-lbs (515.2 Nm)	410 ft-lbs (555.9 Nm)
1-8	490 ft-lbs (664.4 Nm)	550 ft-lbs (754.7 Nm)	610 ft-lbs (827.1 Nm)
1/2-13 neck bolts	60 ft-lbs (81.3 Nm)	69 ft-lbs (93.6 Nm)	79 ft-lbs (107.1 Nm)

11.1.2. 18.8 Stainless Steel Fasteners

18.8 SS lock nut size	Minimum torque	Desired torque	Maximum torque
1/4-20	75 in-lbs (8.47 Nm)	78 in-lbs (8.81 Nm)	82 in-lbs (9.26 Nm)
3/8-16	236 in-lbs (26.6 Nm)	240 in-lbs (27.1 Nm)	259 in-lbs (29.1 Nm)
Metric 8-1.25	169 in-lbs (19.1 Nm)	169 in-lbs (19.1 Nm)	196 in-lbs (22.1 Nm)
1/4-20 (through nut clip)	75 in-lbs (8.3 Nm)	87 in-lbs (9.8 N m)	100 in-lbs (11.3 Nm)
3/8-16 (through nut clip)	23 ft-lbs (31.2 Nm)	25 ft-lbs (33.9 Nm)	30 ft-lbs (39.3 Nm)
Metric 6 -1 (through nut clip)	70 in-lbs (7.9 Nm)	84 in-lbs (9.4 Nm)	92 in-lbs (10.3 Nm)
Metric 8-1.25 (through nut clip)	169 in-lbs (19.1 Nm)	202 in-lbs (22.8 Nm)	225 in-lbs (25.4 Nm)
Metric 6 -1 (Grade 8.8)	70 in-lbs (7.9 Nm)	84 in-lbs (9.4 Nm)	92 in-lbs (10.3 Nm)
Metric 8-1.25 (Grade 8.8)	169 in-lbs (19.1 Nm)	202 in-lbs (22.8 Nm)	225 in-lbs (25.4 Nm)

11.1.3. Yellow Zinc Fasteners

Information presented here is for reference only. Yellow zinc is being phased out and is no longer recommended for new installations.

Yellow zinc Grade 5 fastener size	Minimum torque	Desired torque	Maximum torque
1/2-in eye bolt	53 ft-lbs (71.9 Nm)	60 ft-lbs (81.3 Nm)	80 ft-lbs (108.5 Nm)
5/8-in eye bolt	106 ft-lbs (143.7 Nm)	125 ft-lbs (169.5 Nm)	158 ft-lbs (214.2 Nm)
3/4-in eye bolt	190 ft-lbs (257.6 Nm)	225 ft-lbs (305.1 Nm)	274 ft-lbs (371.5 Nm)
3/8-16	23 ft-lbs (31.2 Nm)	28 ft-lbs (38 Nm)	34 ft-lbs (46.1 Nm)
1/2-13	57 ft-lbs (77.3 Nm)	66 ft-lbs (89.5 Nm)	75 ft-lbs (101.7 Nm)
5/8-11	113 ft-lbs (139.6 Nm)	120 ft-lbs (162.7 Nm)	165 ft-lbs (223.7 Nm)

Yellow zinc Grade 8 lock nut size	Minimum torque	Desired torque	Maximum torque
1/4-20	12 ft-lbs (16.3 Nm)	14 ft-lbs (19 Nm)	18 ft-lbs (24.4 Nm)
5/16-18	19 ft-lbs (25.8 Nm)	20 ft-lbs (27.1 Nm)	25 ft-lbs (33.9 Nm)
3/8-16	30 ft-lbs (40.7 Nm)	35 ft-lbs (27.5 Nm)	45 ft-lbs (61 Nm)
7/16-14	52 ft-lbs (70.5 Nm)	63 ft-lbs (85.4 Nm)	70 ft-lbs (94.9 Nm)
1/2-13	77 ft-lbs (104.4 Nm)	90 ft-lbs (122 Nm)	120 ft-lbs (162.7 Nm)
9/16-12	120 ft-lbs (162.7 Nm)	145 ft-lbs (196.6 Nm)	170 ft-lbs (230.5 Nm)
5/8-11	159 ft-lbs (215.6 Nm)	190 ft-lbs (256.3 Nm)	212 ft-lbs (287.4 Nm)
3/4-10	280 ft-lbs (379.6 Nm)	339 ft-lbs (459.6 Nm)	376 ft-lbs (508.4 Nm)
7/8-9	455 ft-lbs (615.5 Nm)	505 ft-lbs (684.7 Nm)	606 ft-lbs (821.6 Nm)
1-8	681 ft-lbs (923.3 Nm)	818 ft-lbs (1109.1 Nm)	909 ft-lbs (1232.4 Nm)

Yellow zinc Grade 8 bolt size	Minimum torque	Desired torque	Maximum torque
1/2-in neck bolt	80 ft-lbs (108.5 Nm)	85 ft-lbs (90.2 Nm)	90 ft-lbs (122 Nm)

11.1.4. Valves, PRDs, and Plugs

Valve / PRD / Plug & cylinder type	Minimum torque	Desired torque	Maximum torque
Valve / PRD / end plug into Type 3 cylinder (1.125-12 thread)	110 ft-lbs (149.1 Nm)	140 ft-lbs (189.8 Nm)	160 ft-lbs (216.9 Nm)
Valve / PRD / end plug into Quantum cylinder (1.125-12 thread)	110 ft-lbs (149.1 Nm)	115 ft-lbs (155.9 Nm)	120 ft-lbs (162.7 Nm)
Valve / PRD / end plug into Lincoln cylinder (1.125-12 thread)*	See note*		

**Valve or PRD manufacturer specifies torque value.*

For OMB products, torque is 70 ft-lbs to 96 ft-lbs (94.9 Nm to 130.2 Nm).

11.1.5. Joint Industry Committee (JIC) Fittings

Fitting size	Minimum torque	Desired torque	Maximum torque
1/4-in JIC	11 ft-lbs (14.9 Nm)	15 ft-lbs (20.3 Nm)	18 ft-lbs (24.4 Nm)
3/8-in JIC	18 ft-lbs (24.4 Nm)	25 ft-lbs (33.9 Nm)	31 ft-lbs (42 Nm)
1/2-in JIC	36 ft-lbs (48.8 Nm)	45 ft-lbs (61 Nm)	59 ft-lbs (80 Nm)
5/8-in JIC	57 ft-lbs (75.9 Nm)	70 ft-lbs (94.9 Nm)	85 ft-lbs (115.2 Nm)
3/4-in JIC	79 ft-lbs (107.1 Nm)	90 ft-lbs (122 Nm)	118 ft-lbs (160 Nm)

11.1.6. SAE O-ring Boss (ORB) Fittings in Manifold/Valve Ports

Fitting size	Minimum torque	Desired torque	Maximum torque
3/8-24 SAE straight	7 ft-lbs (9.5 Nm)	7.5 ft-lbs (10.2 Nm)	9 ft-lbs (12.2 Nm)
7/16-20 SAE straight	14.5 ft-lbs (19.7 Nm)	15 ft-lbs (20.3 Nm)	17 ft-lbs (23 Nm)
1/2-20 SAE straight	18 ft-lbs (24.4 Nm)	18.5 ft-lbs (25.1 Nm)	20 ft-lbs (27.1 Nm)
9/16-18 SAE straight	25 ft-lbs (33.9 Nm)	26 ft-lbs (35.3 Nm)	30 ft-lbs (39.3 Nm)
3/4-16 SAE straight	51 ft-lbs (69.1 Nm)	52 ft-lbs (70.5 Nm)	58 ft-lbs (78.6 Nm)
7/8-14 SAE straight	73 ft-lbs (99 Nm)	74 ft-lbs (100.3 Nm)	81 ft-lbs (109.8 Nm)
1-1/16-12 SAE straight	122 ft-lbs (165.4 Nm)	125 ft-lbs (169.5 Nm)	138 ft-lbs (187.1 Nm)
1-3/16-12 SAE straight	155 ft-lbs (210.2 Nm)	158 ft-lbs (214.2 Nm)	175 ft-lbs (237.3 Nm)
1-5/16-12 SAE straight	195 ft-lbs (264.4 Nm)	199 ft-lbs (296.8 Nm)	220 ft-lbs (296.9 Nm)
1-5/8-12 SAE straight	206 ft-lbs (279.3 Nm)	210 ft-lbs (284.7 Nm)	231 ft-lbs (313.2 Nm)
1-7/8-12 SAE straight	268 ft-lbs (363.4 Nm)	273 ft-lbs (370.1 Nm)	300 ft-lbs (406.7 Nm)

11.1.7. Gear Clamps

Clamp size	Minimum torque	Desired torque	Maximum torque
Constant torque gear clamp 1 1/16-in, size 10	--	50 in-lbs (5.64 Nm)	--

11.1.8. Side Mount System Cylinder Straps

As a function of normal operation, Type 3 and Type 4 cylinders expand and contract depending on pressure. This wall movement requires cylinder mounting system fastener torque to be adjusted. For cylinders mounted with stainless steel straps and a Belleville washer stack, the following torque specs should be utilized.

Although several strap mount configurations are in use, the following torque specs and cylinder pressures should be used for all side mount Agility® fuel systems:

C **Top plate bolts:** 160 ft-lbs (216.9 Nm) to 180 ft-lbs (244.0 Nm). *Figure 65*

C **Cylinder strap Belleville washer stack bolts**. *Figure 65*

A. For cylinder pressures from 500 psi (3.45 MPa) to 1500 psi (10.34 MPa): 50 ft-lbs (36.8 Nm) to 60 ft-lbs (44.2 Nm)
B. For cylinder pressures greater than 1500 psi (10.34 MPa): 60 ft-lbs (44.2 Nm)

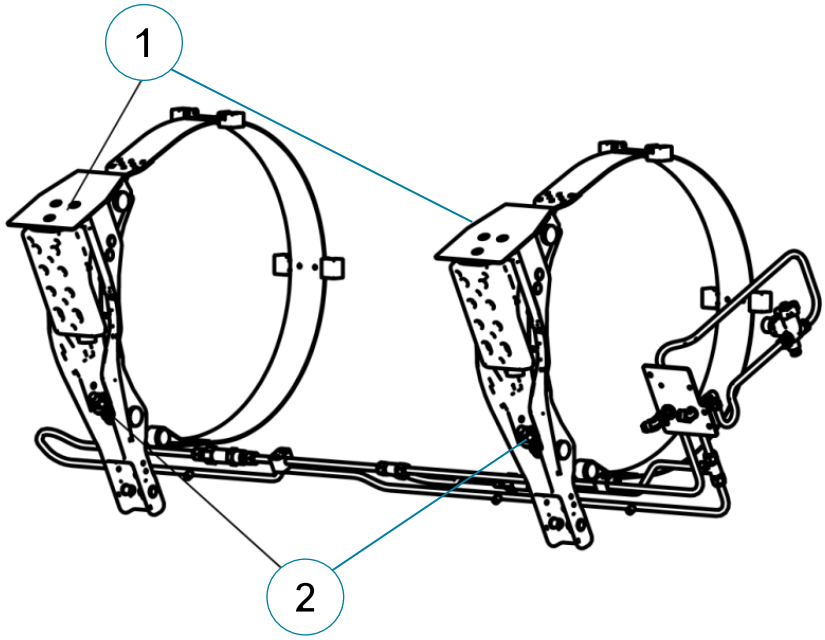


Figure 61. Side mount system cylinder bracket and strap hardware. Check top plate bolts (1) and cylinder strap Belleville washer stack bolts (2) for proper torque.

⚠CAUTION

Observe cylinder pressure and torque specifications when reassembling cylinder strap brackets.

11.1.9. Behind the Cab System Mounts

Two behind the cab (BTC) fuel system cabinet to vehicle chassis mounts are currently in use:

1. “Flat” rubber

   and

2. “Ring and bushing” isolator mounting systems. *Figure 66*

11.1.10. Flat Isolator Torque Procedure

Tighten flat isolator bolts according the sequence and torque values for the fastener types listed below. *Figure 66 & Table 3*

Figure 62. BTC systems with flat isolators require multiple torque sequences.

Table 3: Initial Torque and Settled Torque Ranges by Fastener Type

Fastener finish	Initial torque	Settled torque range
Yellow zinc	200 ft-lbs (271.2 Nm)	159 ft.-lbs to 185 ft-lbs (215.6 Nm to 250.8 Nm)
Aluminum-zinc	150 ft-lbs (203.4 Nm)	120 ft.-lbs to 135 ft.-lbs (162.7 Nm to 183 Nm)

1. Tighten fasteners to initial torque value. *Table 3*
2. Torque reading should remain the same as initial value after a minimum of 4 hours after second torque. If not, re-torque fasteners in the same sequence.

⚠CAUTION

Do not mix yellow zinc fasteners with aluminum-zinc or zinc coated fasteners.

11.2. Natural Gas Vehicle Cylinder Inspection Record

Inspector Name	
Inspection Date	
Serial No.	
Model No.	
Expiration Date	
Mounting Location	
Vehicle Identification Number (VIN)	
Vehicle Mileage	

Examination Features	**Accept**	**Reject**	**Comments** (Include damage level if applicable)
Cylinder and brackets cleaned prior to inspection			
Cylinder installation			
1/2-in (12.7 mm) clearance around cylinder when mounted			
Bracket condition			
Mounting pads/isolators in good condition			
Cylinder labels in place			
Cylinders not expired			
Cylinder service pressure meets or exceeds vehicle service pressure			
Valve condition			
PRD condition			
Plug condition			
Fuel lines secure			
Vent lines secure			
Vent lines free of debris or moisture			
Interfaces free of leaks			
Cylinder condition			
Cylinder dome with valve condition			
Cylinder dome no valve condition			

11.3. CNG Cylinder and System Inspection Regulations, Codes and Guidelines

This is not a comprehensive list. Other local, state or provincial regulations may apply. Check with AHJ, usually the fire department, for more information.

a. NGVAmerica Technology & Development Committee Fuel System Inspection Working Group, “Compressed Natural Gas Vehicle Fuel System Inspection Guidance.”
b. Federal Motor Vehicle Safety Standards (FMVSS) Standard 304, “Compressed Natural Gas Fuel Container Integrity.”
c. ANSI/IAS NGV2, “Basic Requirements for Compressed Natural Gas Vehicle Fuel Containers.”
d. ANSI NGV2-PRD-1, “Pressure Relief Devices for Natural Gas Vehicle (NGV) Fuel Containers.”
e. CSA/ANSI NGV 3.1:2020, “Fuel System Components for Compressed Natural Gas Powered Vehicles.”
f. Compressed Gas Association, CGA C-6.4, “Methods for External Visual Inspection of Natural Gas Vehicle Fuel Containers and Their Installations.”
g. National Fire Protection Association (NFPA) 52, “Vehicular Gaseous Fuel Systems Code.”
h. State of California Vehicle Code 2402.6, “Regulations and Standards: Compressed or Liquefied Gas and Liquefied Petroleum Gas” and 270909, “Transporting Liquefied Petroleum or Natural Gas.”
i. Cylinder manufacturer guidelines

11.4. Glossary

Abrasion damage: Damage to composite caused by wearing, grinding or rubbing away of material by friction.

All-composite (Type 4): Fuel cylinder made primarily from non-metallic materials such as plastic and high strength fiber reinforced composites. May incorporate metal ports for valves and other plumbing devices.

Boss (see “Ports”): Aluminum fittings at the ends of cylinders which contain ports for installation of valves, pressure relief devices and blank plugs.

Blank plug (see “Solid plug”): Threaded plug with O-ring seal.

Carbon fiber: One type of reinforcement fiber used in fuel cylinder composite overwrap.

CNG: Compressed natural gas

Condemned cylinder: Fuel container that has been damaged beyond repair and must be removed from service and rendered unusable. See “Destroyed.”

Cylinder: Fuel storage container; preferred term over “tank” in CNG applications and systems.

Drive away protection (DAP): Vehicle engine cannot be started unless all fuel caps (including fuel system doors and auxiliary fill caps) are securely in place.

Delamination: An induced separation between composite layers. This type of damage occurs from localized impact or resin burn out.

Destroyed: Alteration of a fuel cylinder to make it unusable.

Drop-N-Go™: Agility® registered trademark for side- or rail-mounted fuel systems featuring mounting brackets that simplify installation.

Factory inspection: An inspection and evaluation performed at an approved Agility® facility utilizing comprehensive testing techniques not available in field inspection.

Field inspection: Inspection performed at a location other than an Agility® facility.

Impact damage: Cylinder damage caused by dropping or by a blow from another object. Impact damage may be at the surface, internal to the structure or both.

Level 1 Damage: Minor damage that is considered inconsequential to safe cylinder operation.

Level 2 Damage: Damage which is more severe than Level 1. Additional evaluation and/or rework may allow the cylinder to be returned to service.

Level 3 Damage: Damage that is not repairable and renders a cylinder unfit for continued service. Cylinders with Level 3 damage must be condemned and destroyed.

Liner: An internal component of a Type 4 cylinder that serves as a permeation barrier, preventing gas leakage through the composite structure.

Manufacturer's Label: The label or labels containing the official markings required by the U.S. DOT, FMVSS304, ANSI/CSA NGV2, ISO 11439, CSA B51-Part 2 (Canada), and/ or other applicable standards. The label markings shall include a "CNG Only" designation, manufacturer's symbol or trademark, manufacturer's model number, type designation, serial number, month and year of manufacture, service pressure, the inspector's symbol or trademark and the date when the service life expires.

Maximum Fill Pressure: Fill pressure allowed to obtain settled service pressure at 70°F (21°C). For all cylinders, maximum fill pressure under ANSI/ CSA NGV2 is 125% of rated service pressure.

NGV: Natural gas vehicle.

Pressure relief device (PRD): Device installed in direct contact with internal pressure in the cylinder that will release the contained gas in specific emergency conditions. Excessive temperature, excessive internal pressure or both may activate the device depending on the PRD design. Thermally activated pressure relief devices are required in all CNG installations.

Resin: Epoxy material in the composite overwrap filling the space and transfers the load between individual reinforcing fibers.

Solenoid valve: A valve which is turned on or off electrically.

Tank: Usually refers to liquefied natural gas (LNG) storage vessels. For compressed natural gas (CNG), use the term "cylinder."

TUFFSHELL®: Agility® registered trademark for Type 4 cylinders. Includes protective features such as foam inserts on the ends and a glass overwrap to absorb impact and abrasion damage.

Vent line: High-pressure line used to conduct gas away from a pressure relief device to a location outside of the vehicle.

Proprietary Statement

Trademark Notice