Agility®
fuel solutions

Introduction to UPS Ford F59 CNG

2019 P80, P100, P120

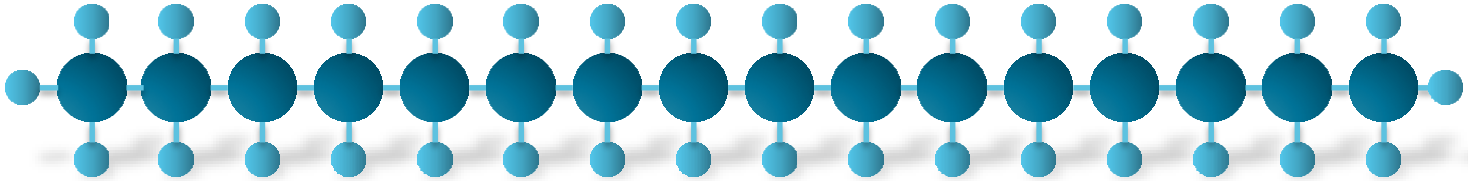
Index

Compressed Natural Gas (CNG)

What is CNG?

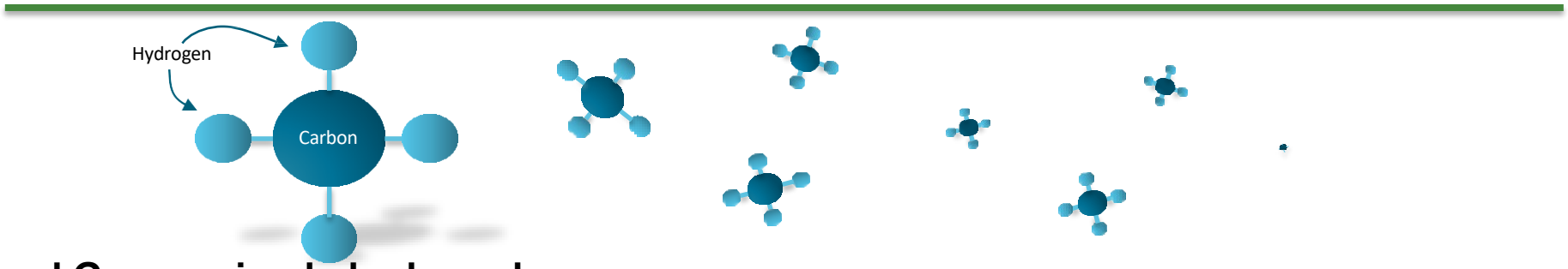
- CNG is an acronym for:
  - Compressed Natural Gas
- Same gas that is used for heat in millions of households nationwide but is compressed for storage.
- The energy density is less than diesel so volume will be about 4x
- Also can be refrigerated to -260° F (-162° C) to be stored as a liquid (LNG).
- Natural Gas has been used commercially as a fuel for cars, trucks, and buses since the 1970's.

Diesel vs Natural Gas



Diesel Chemical Composition

- There are 16 carbon molecules and 34 hydrogen.
- The ratio of carbon to hydrogen is nearly ***double*** to the ratio of carbon to hydrogen found in methane (CNG).
- Because of its complex structure, diesel fuel does not completely combust in an engine.
- Major issues NOx and particulates (soot)



Natural Gas - a simple hydrocarbon

- Has a ratio of 4 hydrogen atoms to 1 carbon atom. This makes CNG the lowest carbon fuel available.
- Major issues pressure and energy density

Characteristics of Natural Gas

- Natural gas is lighter than air and it will rise quickly and diffuse into the atmosphere when released.
- Natural gas is odorless, tasteless, non-toxic.
- Natural gas is flammable and explosive.
- Burns only when mixed with air in a 5 - 15% ratio. Cannot burn inside the cylinder or tank no oxygen.
- MERCAPTAN is injected into pipeline gas for easy detection. But LNG has no odor.
- Natural gas has a 120+ octane rating.
- CNG has 6.38 pounds per DGE
- 1000° Fahrenheit, automatic ignition temperature
- Typically measure in gasoline gallon equivalent (GGE), which is the same energy content as a gallon of gasoline

CNG Safety

CNG has an excellent safety record. The primary danger when working on a CNG system isn't fire or explosion, it's pressure. At 250 Bar or 3,600 psi, a loose fitting can cause damage or serious injury.

Qualified Personnel

- CNG systems should be maintained and inspected exclusively by trained and properly qualified personnel.

Safety Equipment

- Proper lightning and ventilation
- Protective eyewear and footwear
- Certified leak detection equipment

Procedures

- Never use an open flame or smoke near a CNG system.
- Use special procedures for hot work (e.g. welding or grinding) near CNG system.
- Electrically ground the system and use hearing protection when de-fueling.

Vehicle Safety

- Fire extinguisher must be installed on the vehicle and easily accessible.
- Ground the vehicle when fueling and defueling.
- A CNG vehicle must be identified with a blue reflective "CNG" diamond (circled) on the rear of the vehicle, but not on the bumper. Additional CNG diamonds may be placed on the front and sides of the vehicle.

Blue CNG diamond decal

Safety First Response

If a vehicle has sustained damage, or a leak is detected:

- Do not approach vehicle if sources of ignition are present.
- No smoking, no road flares.
- Do not cut any fuel lines.
- Turn the ignition switch off, set the parking brake, and turn off the battery at the main disconnect.
- If it is safe to do so, close the main shutoff valve and the cylinder valves. Check the fuel system near the damaged area for leaks by smell, sight, and sound. CNG is odorized.
- Make sure that traffic and pedestrians steer well clear.
- Keep the vehicle doors open for air circulation.
- If the vehicle is indoors, open windows and doors to allow ventilation. Avoid turning on any lights or electronics which may spark. Pay special attention to overhead sources of ignition; natural gas is lighter than air.
- Beware that gas may continue to leak once ignition is turned off and the manual shutoff valves are closed.

In Case of Fire

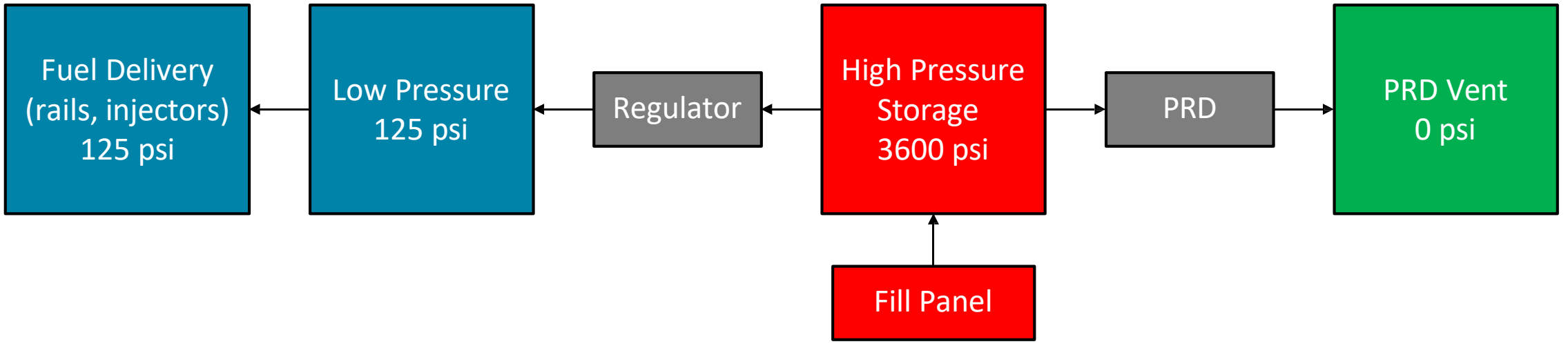
- Call 911
- Evacuate the area.
- Get passengers out of the vehicle as quickly as possible.
- Extinguish the fire using an appropriately rated fire extinguisher. Note, a CNG fire is similar to a gasoline fire. However, if the fire is not extinguished quickly the CNG cylinder pressure relief devices (PRDs) may activate to relieve excess pressure from the cylinders.

Return to Service

- If the vehicle has been subjected to a fire or collision, the fuel storage system must be inspected by a qualified inspector before it can be returned to service.
- CNG system must be leak checked before returning to service.

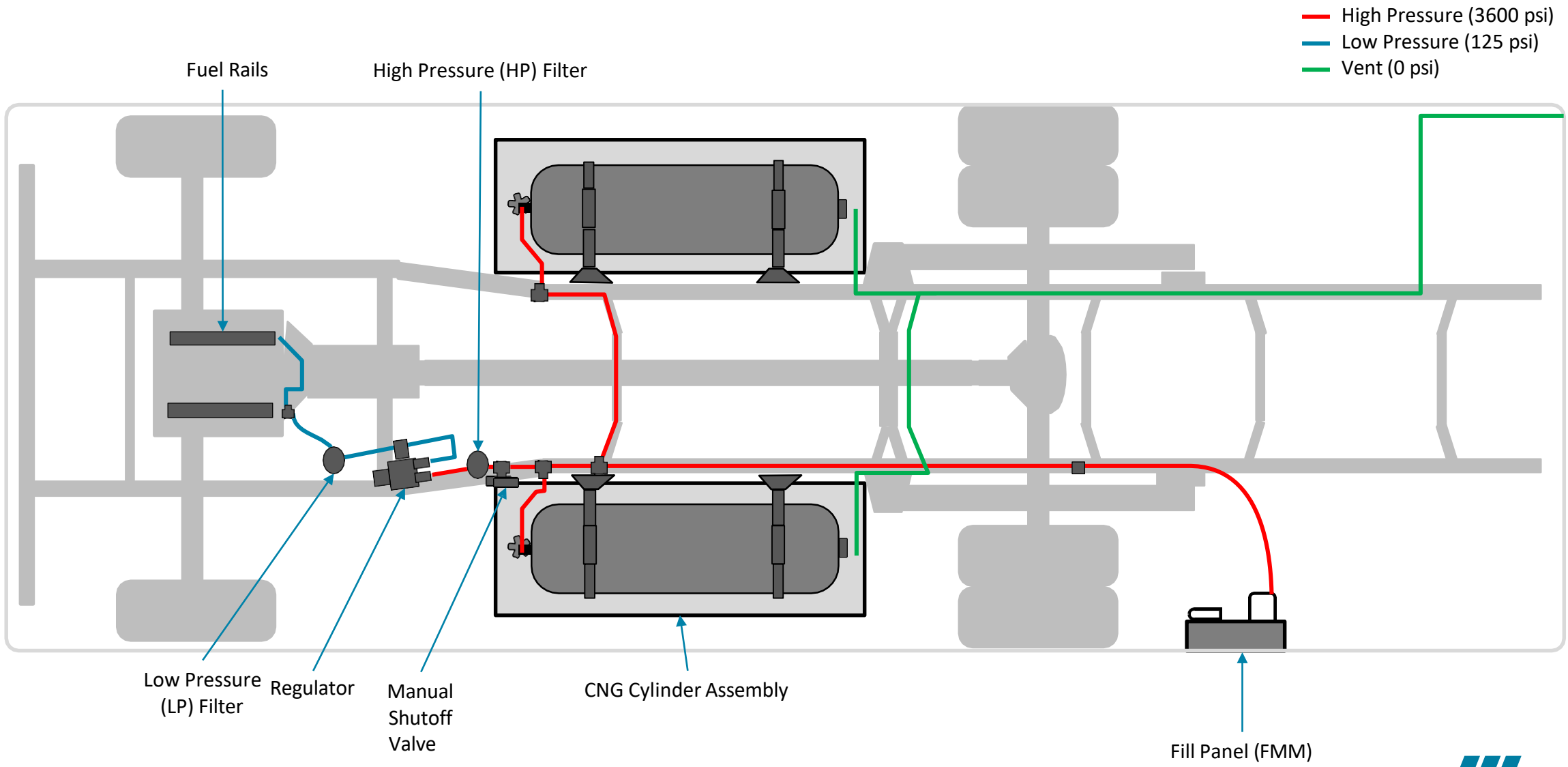
Driver Information

CNG Fuel System Operation



- Cylinders store CNG at high pressure – 3600 psi
- CNG is filtered and passes through regulator, dropping to low pressure – 125 psi
- Low pressure CNG is filtered again and delivered to the engine via fuel rails and injectors
- In case of a thermal event, PRD will open and evacuate cylinder, normally no pressure in PRD system

CNG Fuel System Layout



CNG Storage Cylinders

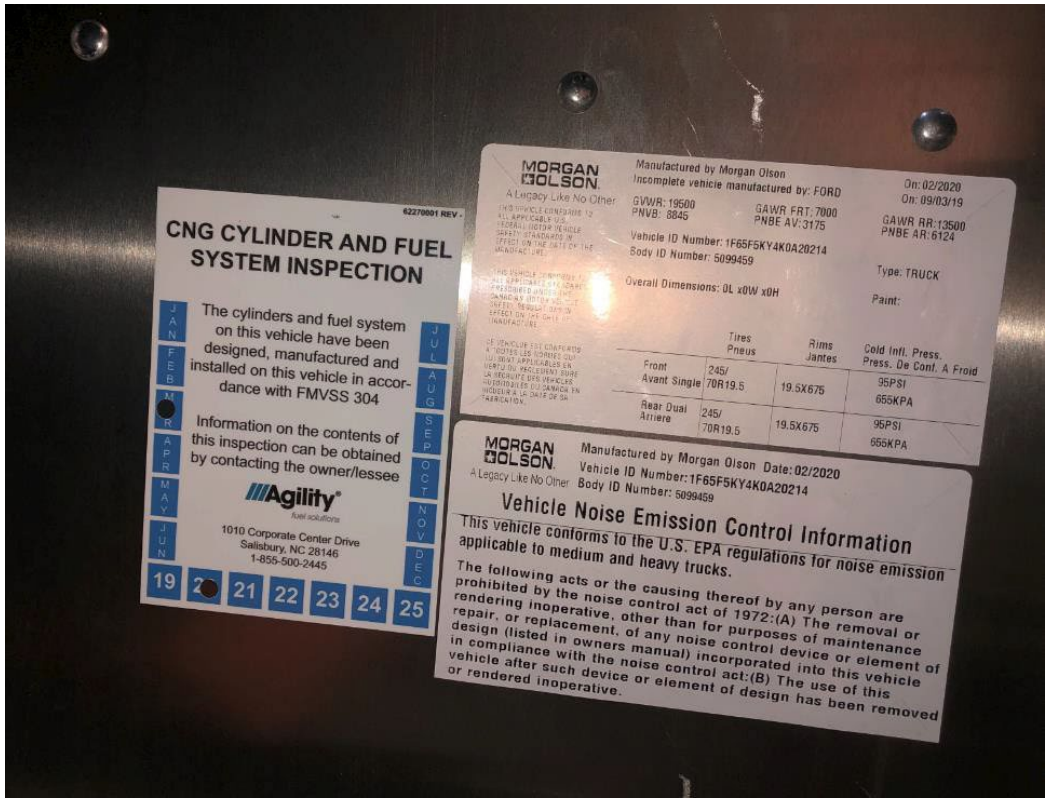
- Type 4 CNG cylinders
- Plastic inner liner, carbon fiber wrapped
- 2019 P100 and P120
  - 16”x71” cylinders
  - 15 GGE each
- 2019 P80
  - 18”x60” cylinders
  - 15.7 GGE
- 20-year cylinder life
- Type 4 cylinders have the lightest weight per volume of the cylinder types.
- Industry Pressure Standards:
  - 3600 PSI (250 Bar) nominal fill pressure 70ºF (21ºC)
  - 4500 PSI (310 Bar) maximum fill pressure
  - 8100 PSI (558 Bar) minimum burst pressure rating (2.25 times the service pressure)

Cylinder & System Inspection Stickers

- CNG cylinder inspection stickers installed on each cylinder at on/off valve end
- CNG system inspection sticker installed on bulkhead behind driver's seat

Cylinder inspection sticker

CNG system inspection sticker



Fill Panel

Defuel components (only needed for service)

Fill Nozzle with Grounding Cap

Package car will not start with grounding cap removed

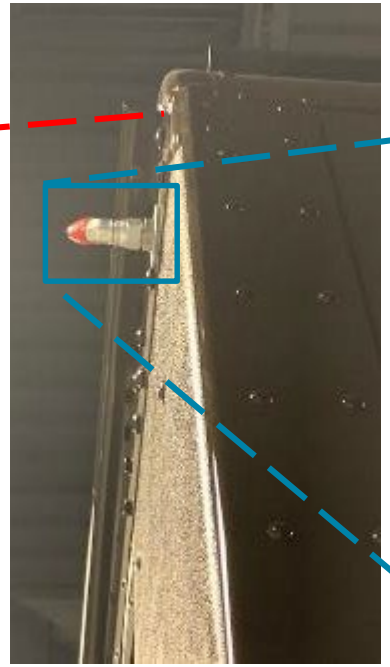
High Pressure Gauge

- Displays cylinder pressure

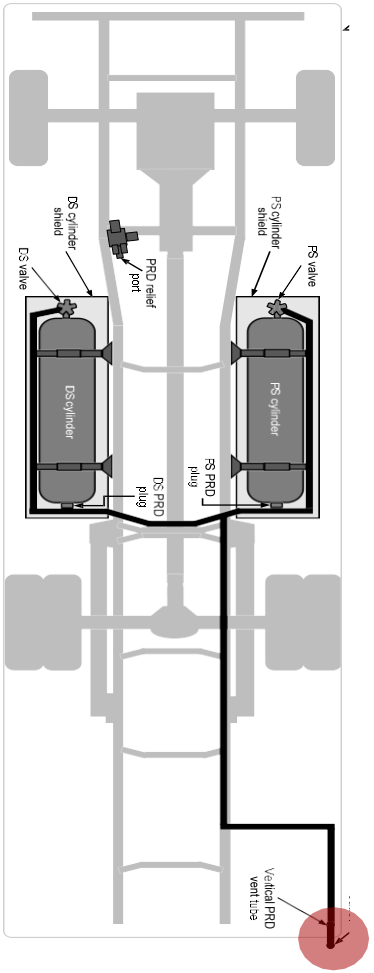
Pressure Relief Device (PRD) Vent Lines

- CNG cylinders are equipped with two PRDs each, one on each end
- PRDs are connected to a PRD vent line, which routes to the rear passenger side corner and up near the top of the rear panel, to a PRD outlet with a protective red cap
- PRDs are thermally activated at temperatures **above 230°F** and are not activated by pressure
- In a thermal event (e.g. fire) the PRDs will trip and vacate all CNG in the cylinders
- Before each trip, driver should check that the PRD cap is present. If missing, driver can still use the package car, but need to note the missing cap in the DVIR as a non-safety related issue

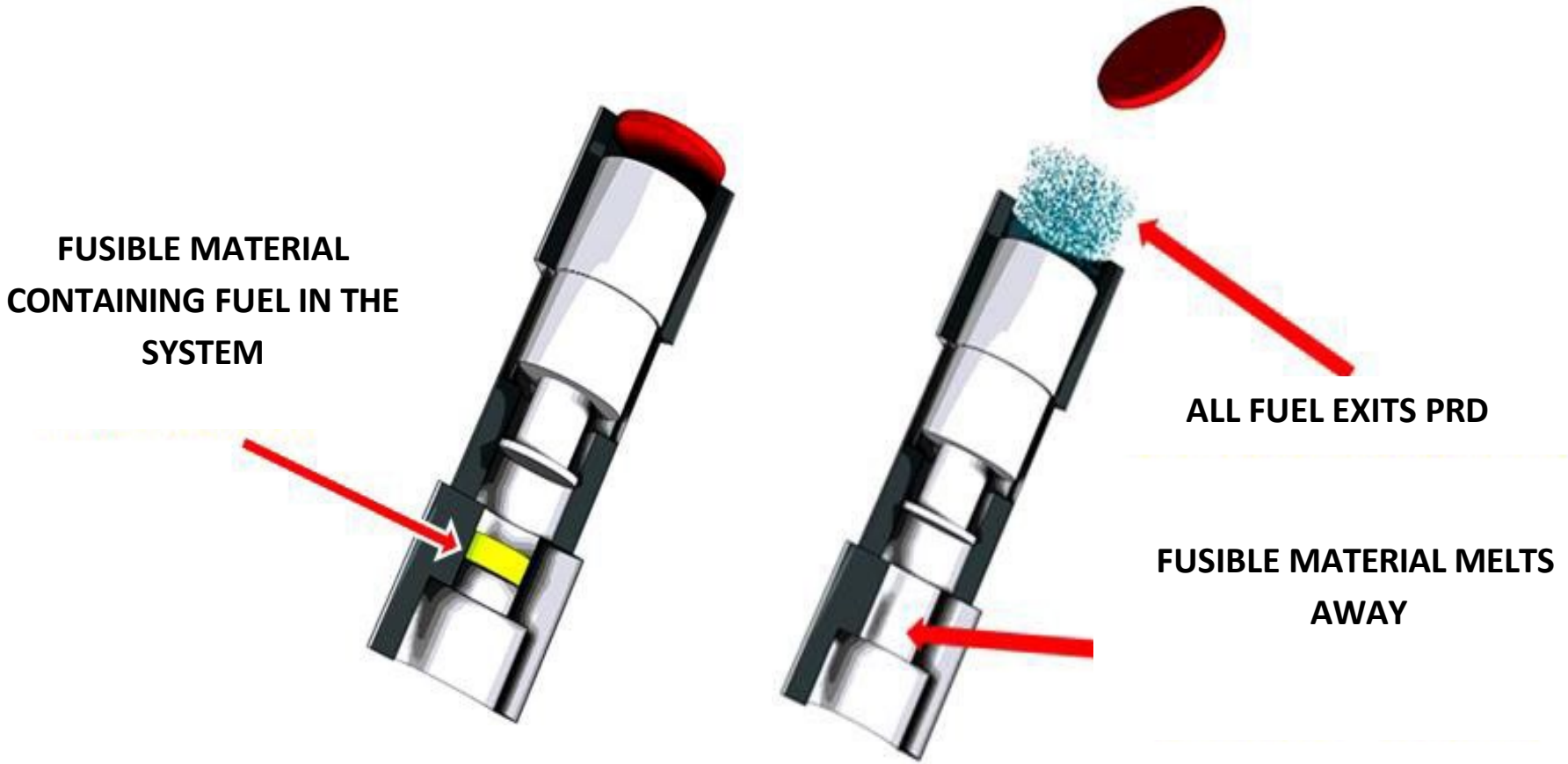
PRD Vent Warning decal is a reminder that CNG flares from the upper rear outlet during a thermal event.



PRD vent outlet with PRD cap



Standard PRD Operation



Range and Fuel Gauge

Expected Range

- Agility performed loaded range tests, based on typical UPS driving pattern
- Typical MPG: 7.5 miles/GGE
- Capacity: 30 GGE
- Range: 180 miles (full to empty reading on dash)
- Distance To Empty (DTE) will show an indicative range

Fuel Gauge

- Agility controller translates CNG cylinder pressure to fuel gauge reading in the dash
- Pressure changes with temperature, so fuel level can change in different temperatures
- Low level indicator will illuminate at the same fuel level as gasoline Fords (approx. 1/8 tank)

Pressure (psi)	Fuel Level
3107	Full
2302	¾
1754	½
1109	¼
1022	1/8 (Low Fuel Warning)
580	E

How to Fuel a CNG System

Follow all procedures below to fuel a CNG system.

1) Remove cap from fueling nozzle.
2) Connect fueling nozzle from fueling station to fuel panel receptacle.
3) Continue to fuel until the stations pressure has equalized with the on-board CNG cylinder system.
4) Remove fueling nozzle by turning valve to vent position, release from receptacle.
5) Once fueling is complete, replace cap.

Agility Segment 4 Fueling the Vehicle

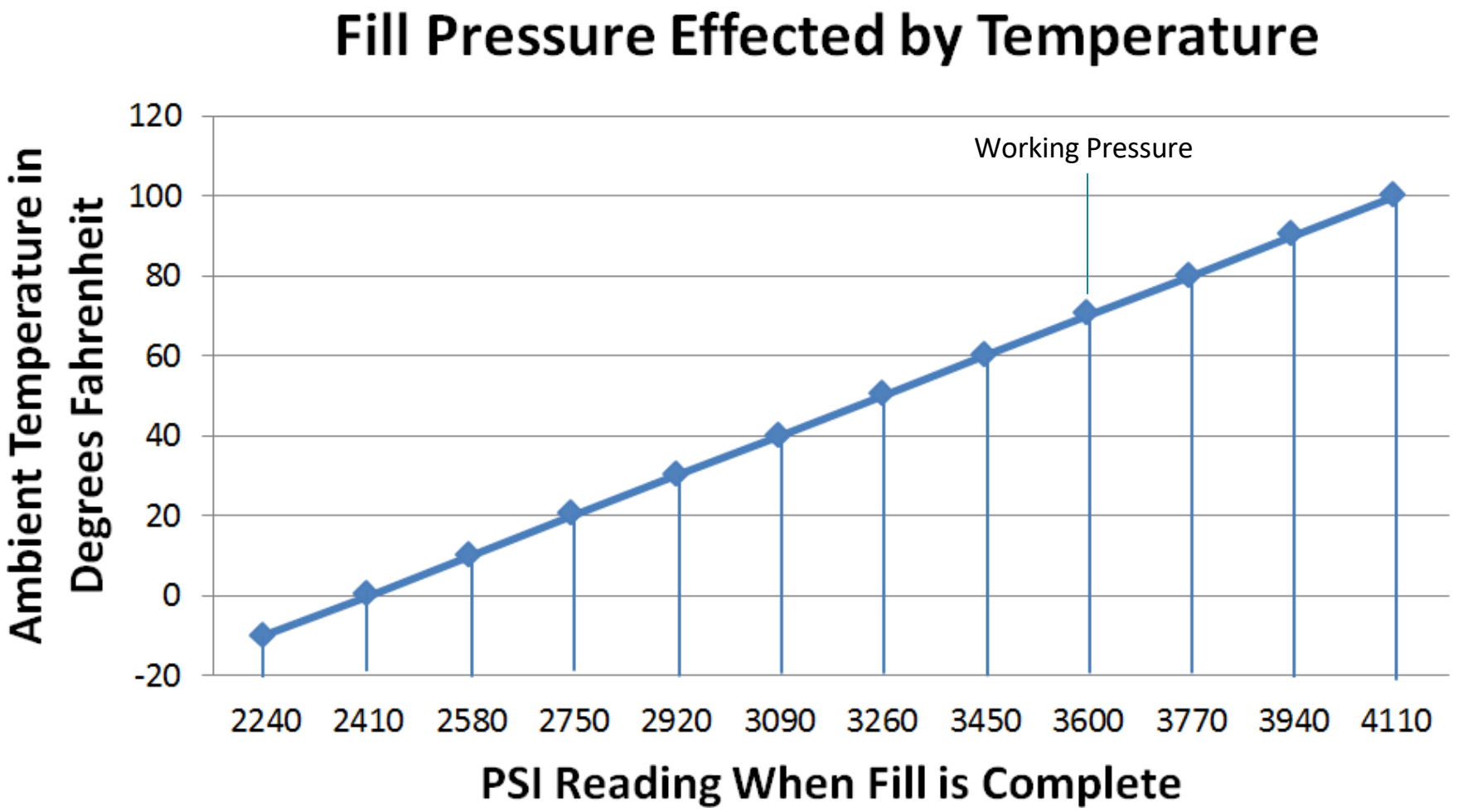
*Alt How to fuel CNG and Trillium

Facts About CNG Fueling

- During fueling, gas heats up as it compresses in the cylinders, this is normal.
- Typically, stations only fill to service pressure of 3,600 psi.
- It is possible to end a fill with pressure above 3,600 psi at an elevated temperature
- As gas cools to ambient (~70F) pressure of gas decreases to 3,600
- In cold environments (30F), may only be 2,800 psi after a fill, but this is still a complete fill
- Fill is complete when the station shuts off

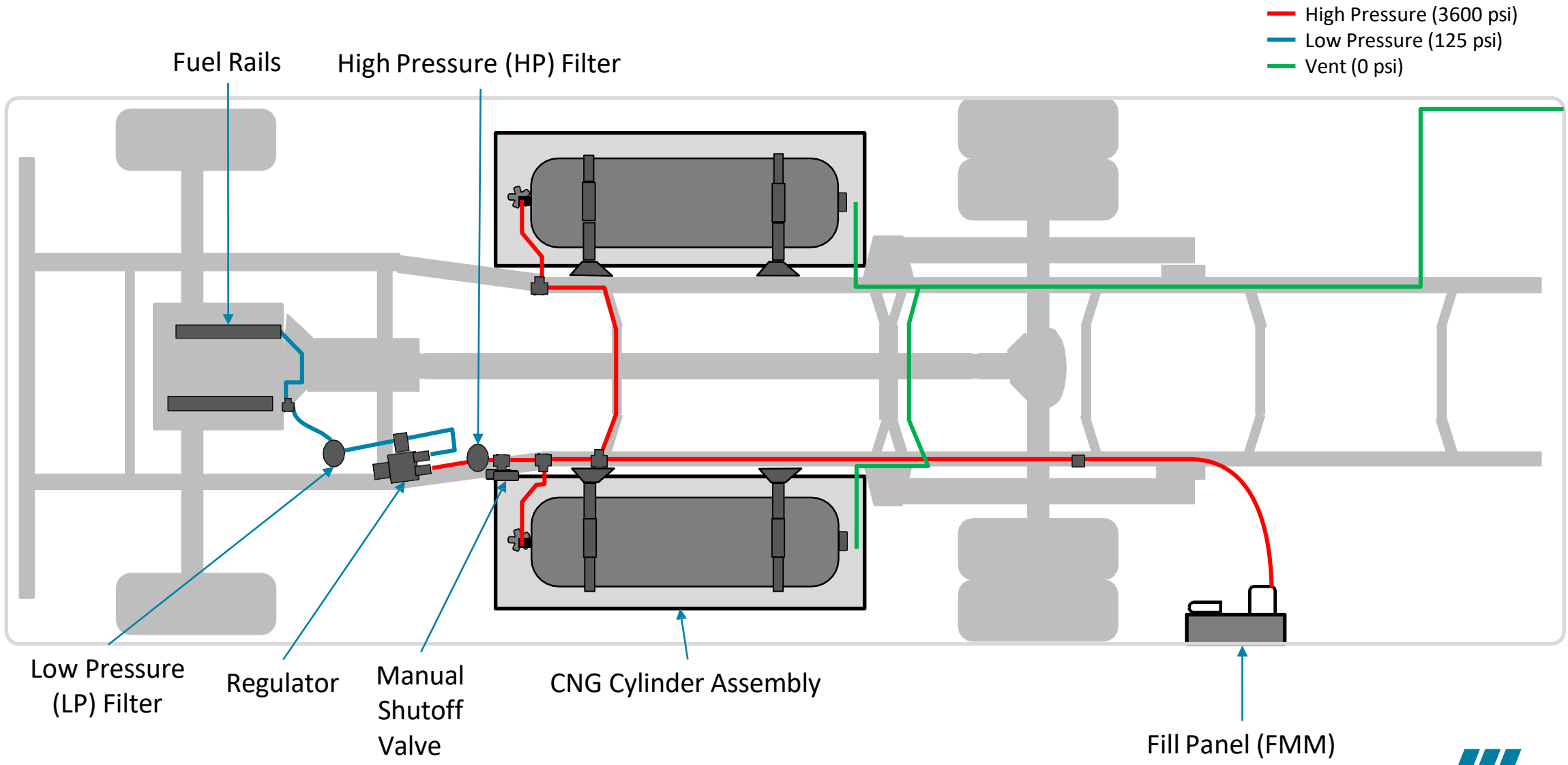
http://www.afdc.energy.gov/vehicles/cng_tank_animation.html

Pressure at temperature

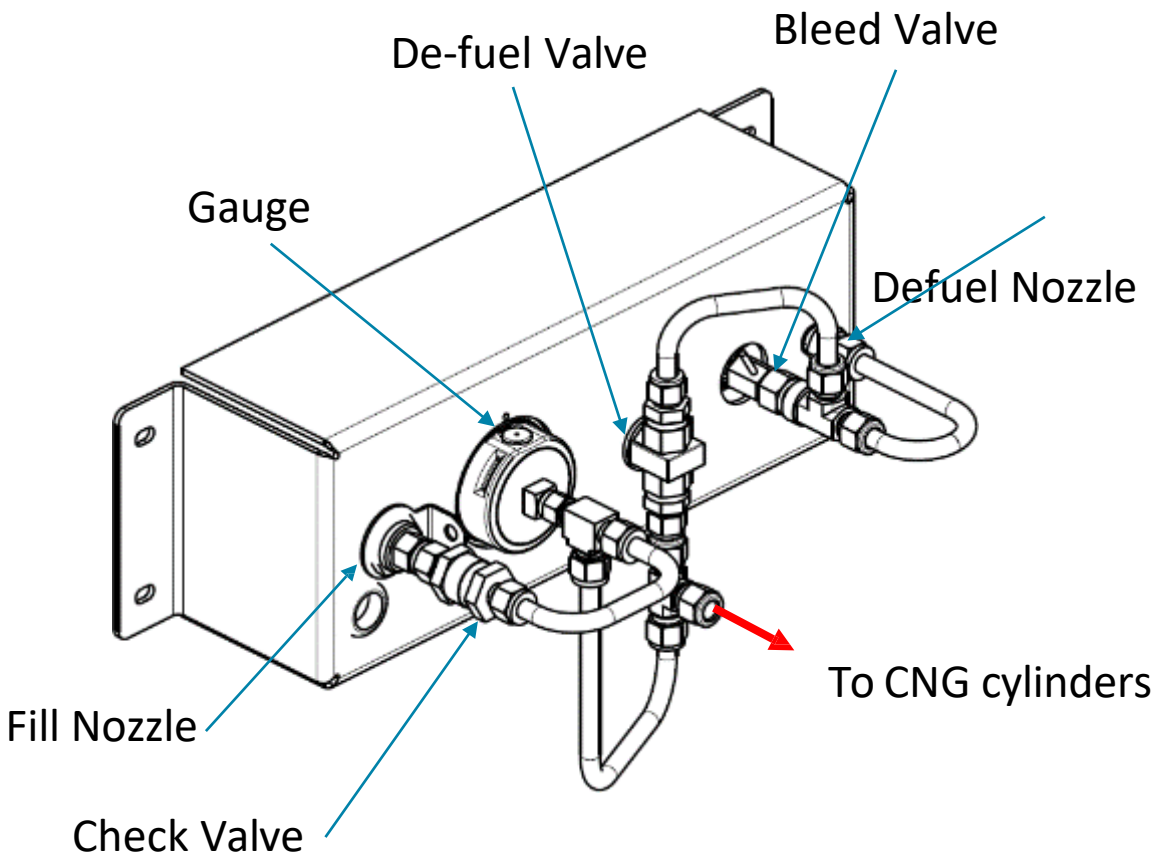


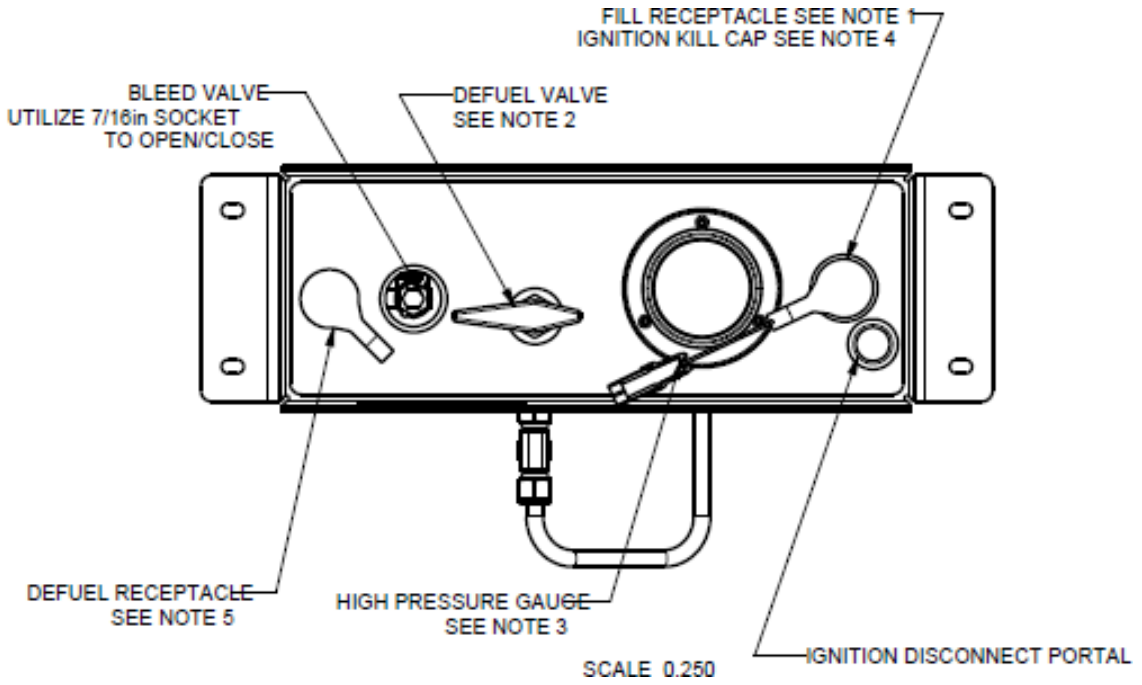
Agility CNG System - Components

CNG Fuel System Layout



Fill Panel


De-fuel Valve
Bleed Valve
Gauge
Defuel Nozzle
To CNG cylinders
Fill Nozzle
Check Valve


FILL RECEPTACLE SEE NOTE 1
IGNITION KILL CAP SEE NOTE 4
BLEED VALVE
UTILIZE 7/16in SOCKET
TO OPEN/CLOSE
DEFUEL VALVE
SEE NOTE 2
DEFUEL RECEPTACLE
SEE NOTE 5
HIGH PRESSURE GAUGE
SEE NOTE 3
SCALE 0.250
IGNITION DISCONNECT PORTAL

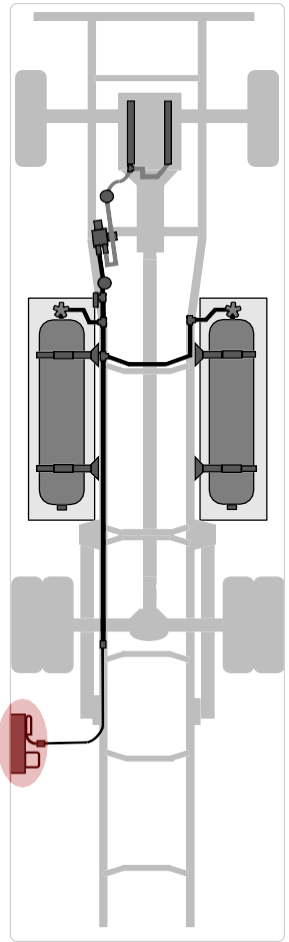
HP Fuel Line Routing

Fill Panel on exterior driver side rear body

Back of Fill Panel

HP Fuel tube

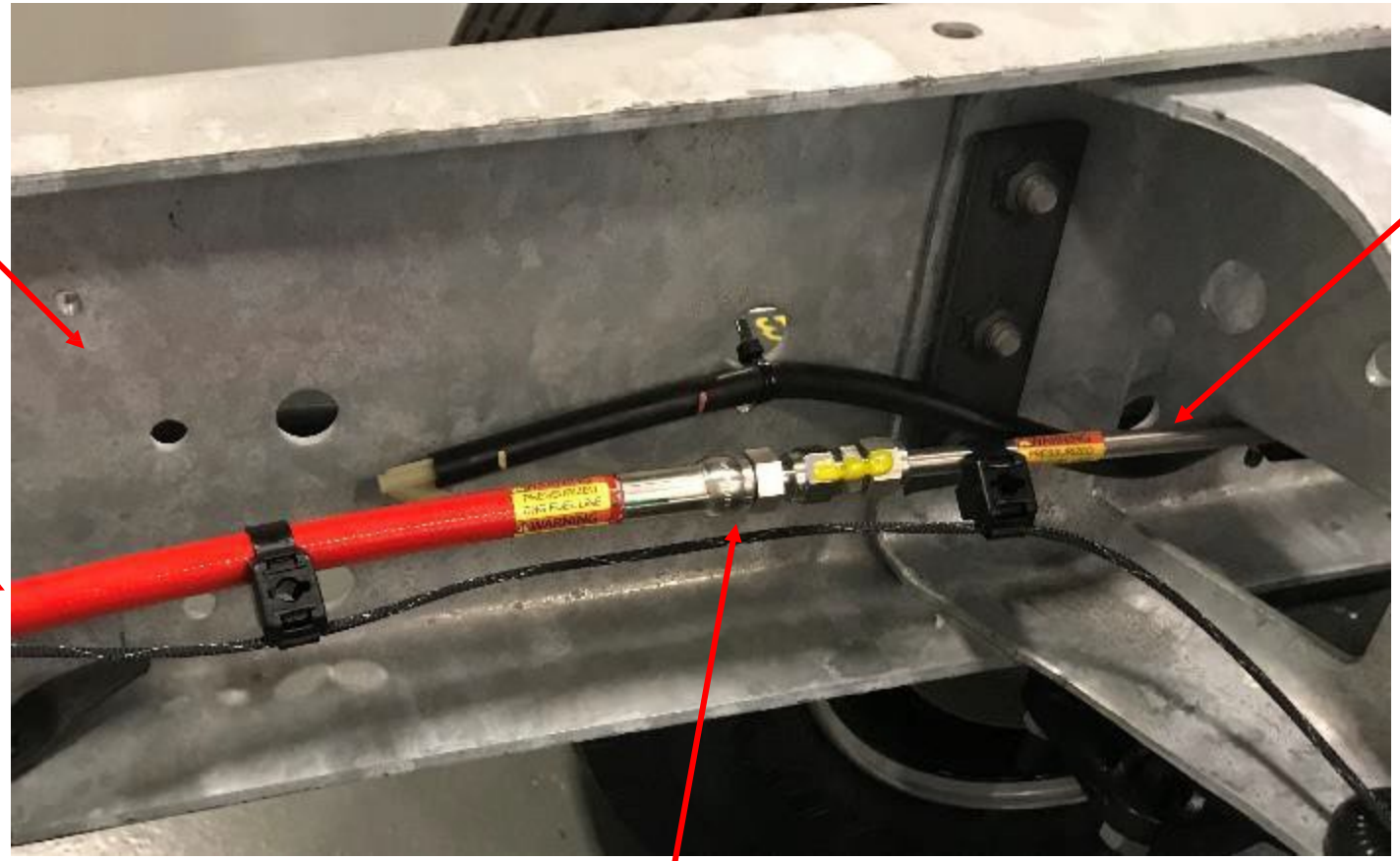
HP Fuel Flexible Hose



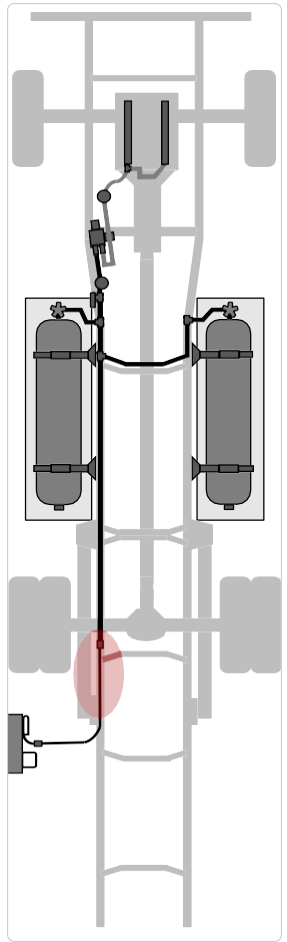
HP Fuel Line Routing

DS frame rail

To fill panel



HP Fuel Tube



HP Fuel Flexible hose

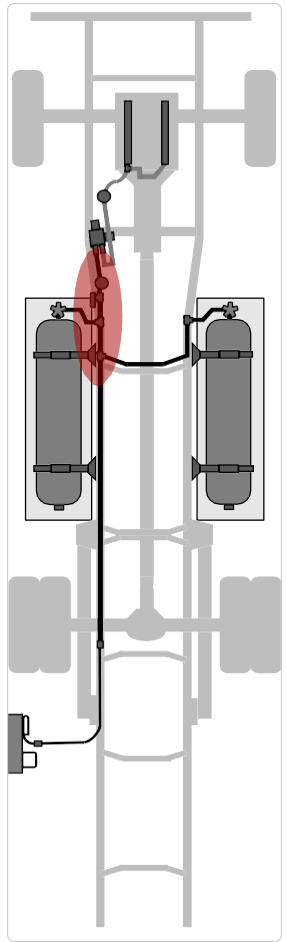
HP Fuel Line Routing

To fill panel

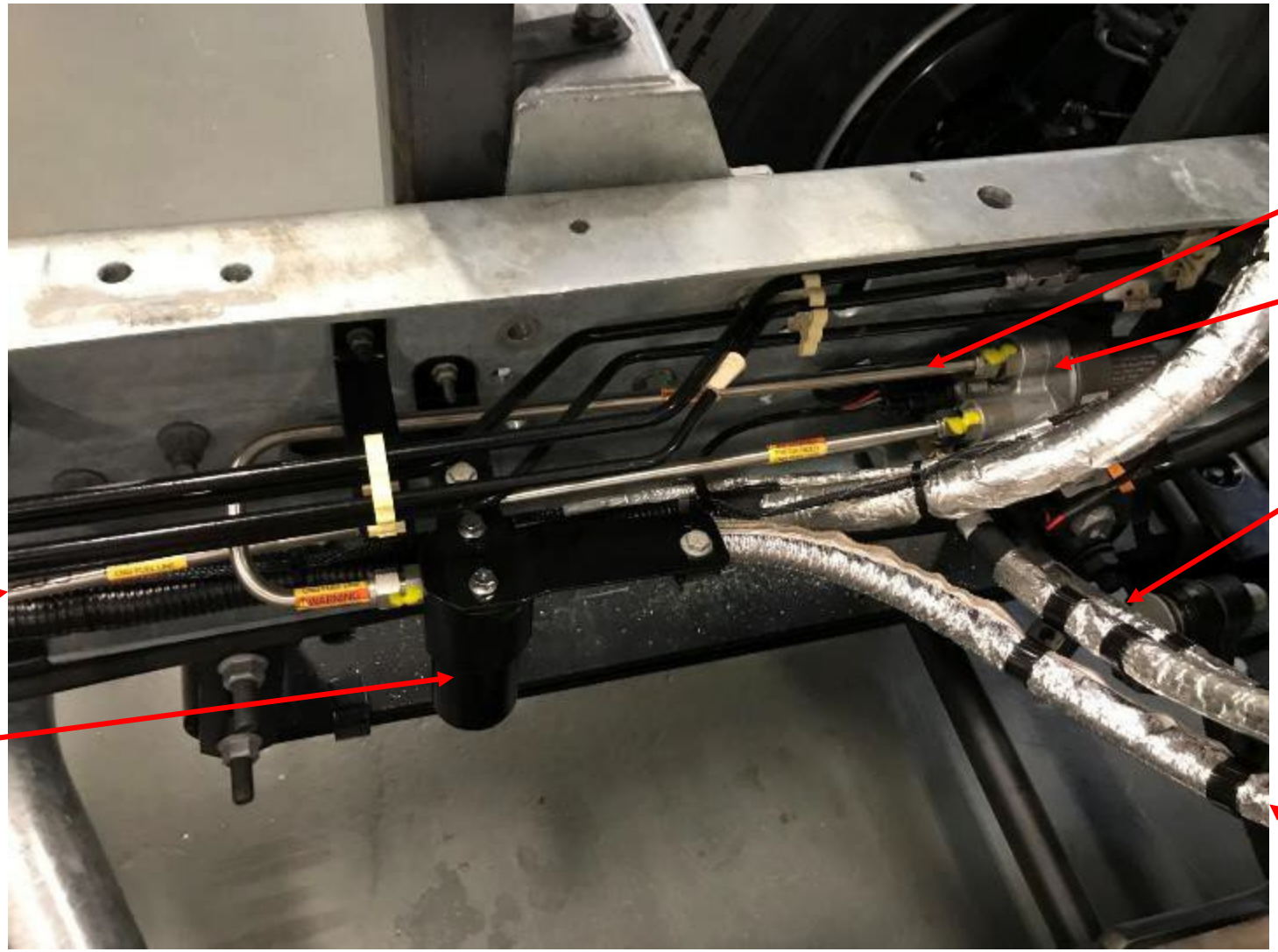
Fuel cross over to PS Cylinder

DS HP Fuel Bulkhead

HP Filter



Regulator, LP Filter



HP In

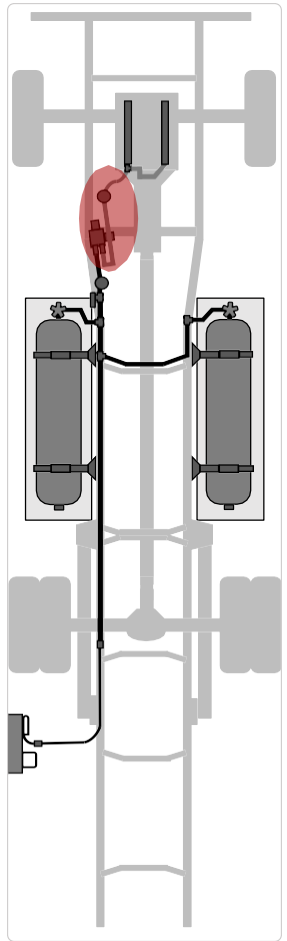
LP Filter

LP Out

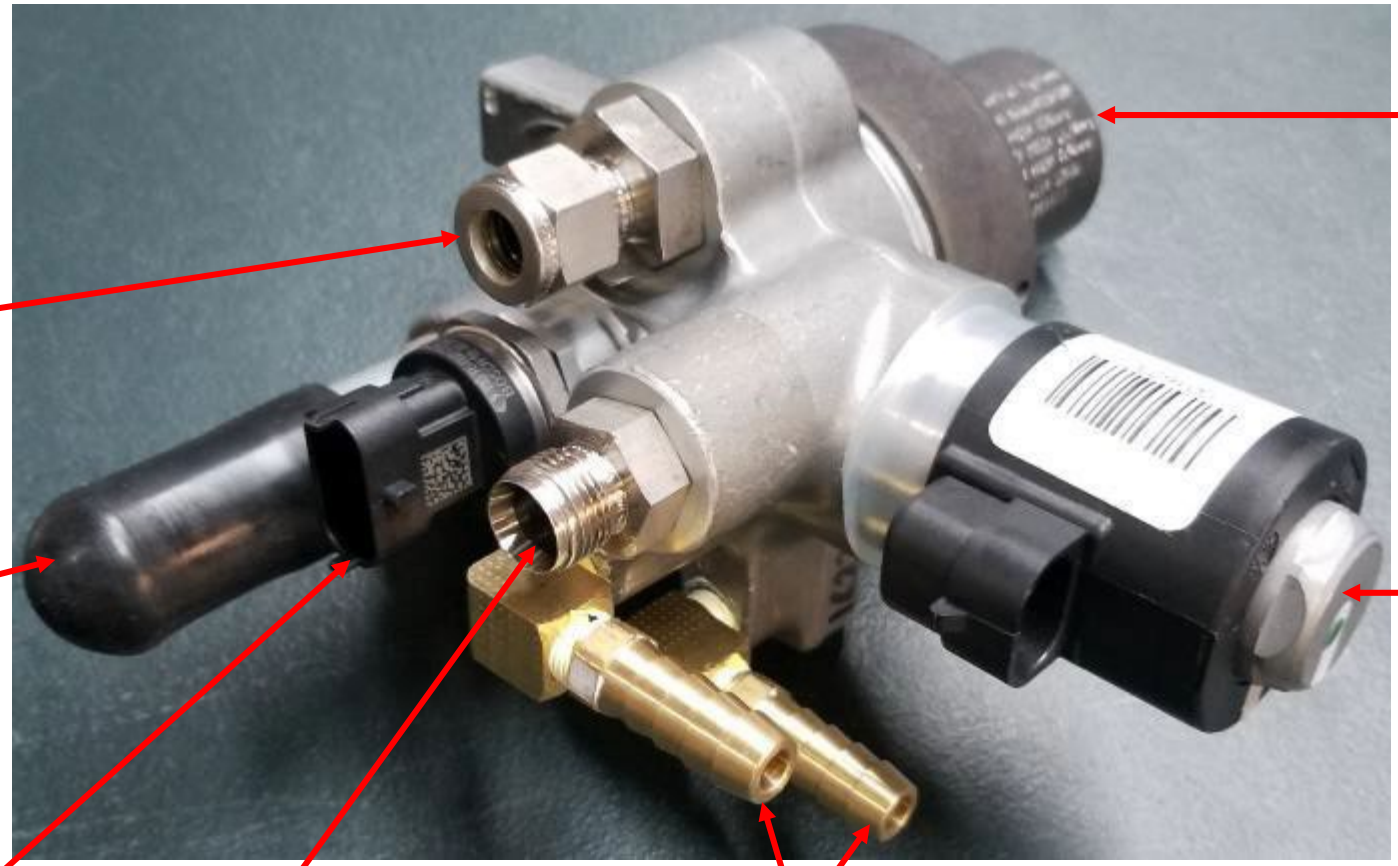
Regulator

Regulator Coolant Lines

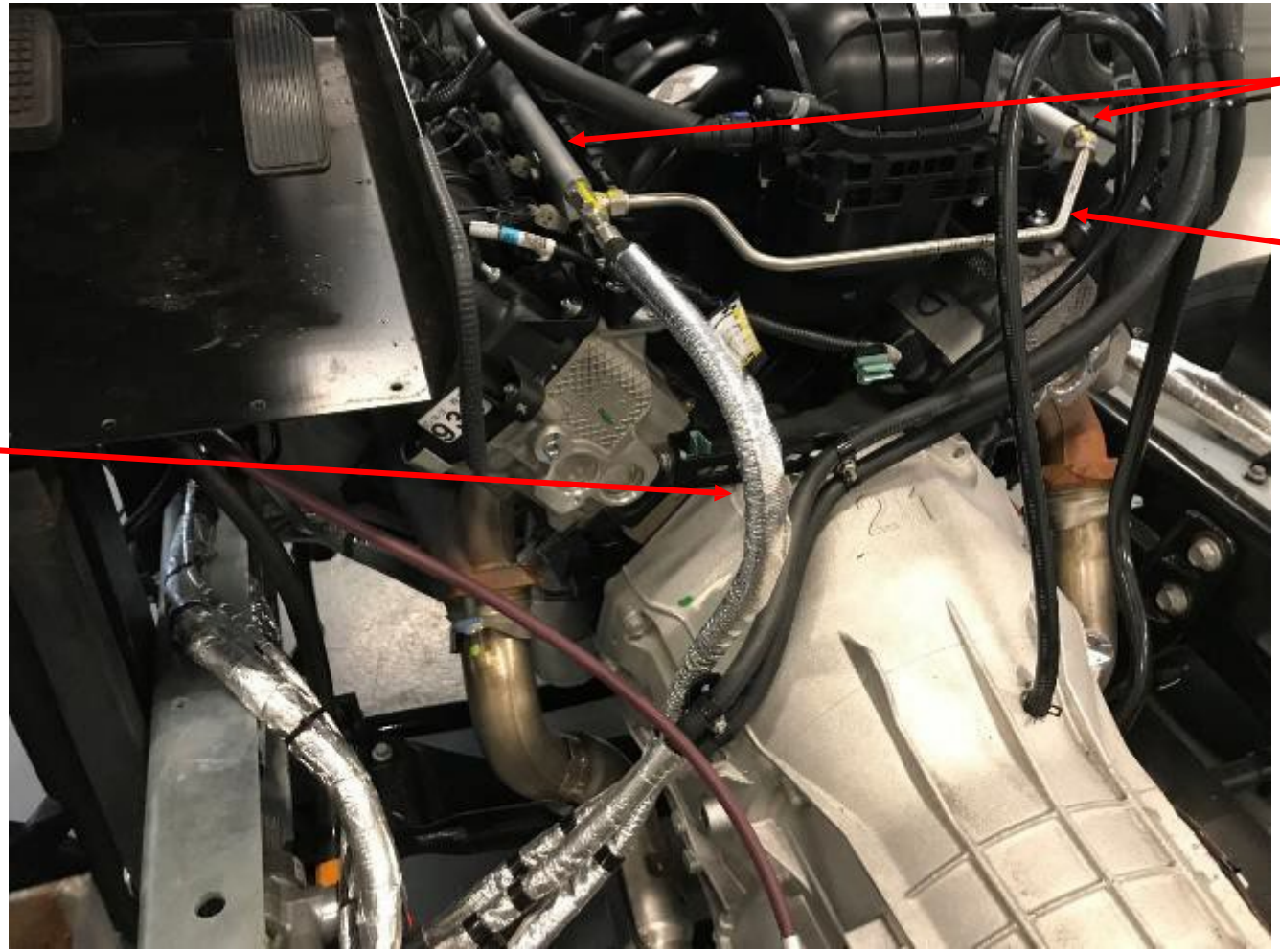
LP Flex hose to engine

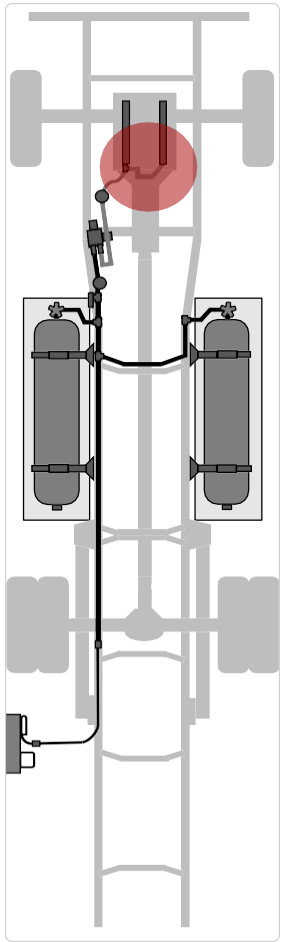


Regulator


Regulator Body
LP Out
Regulator vent cap
Solenoid
Pressure transducer
HP In
Coolant In/out

Fuel Rails





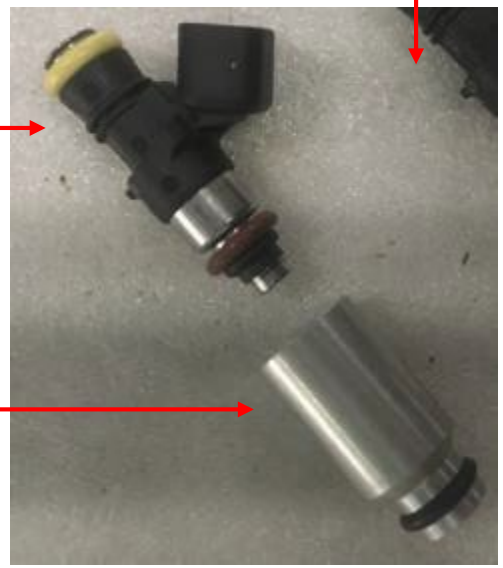
Fuel Rails

Fuel rail installed on passenger side of engine

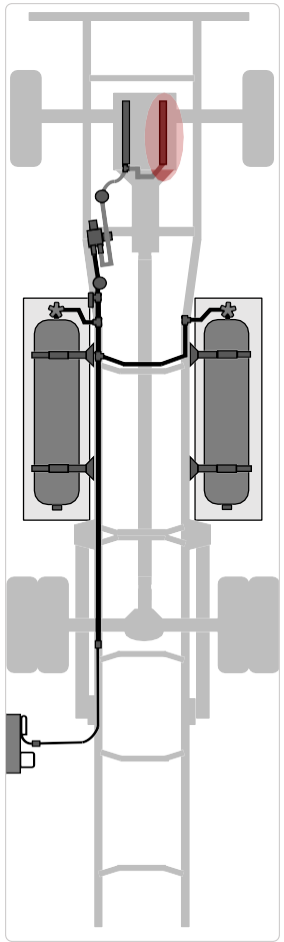
Fuel rail assembly

CNG Fuel Injector

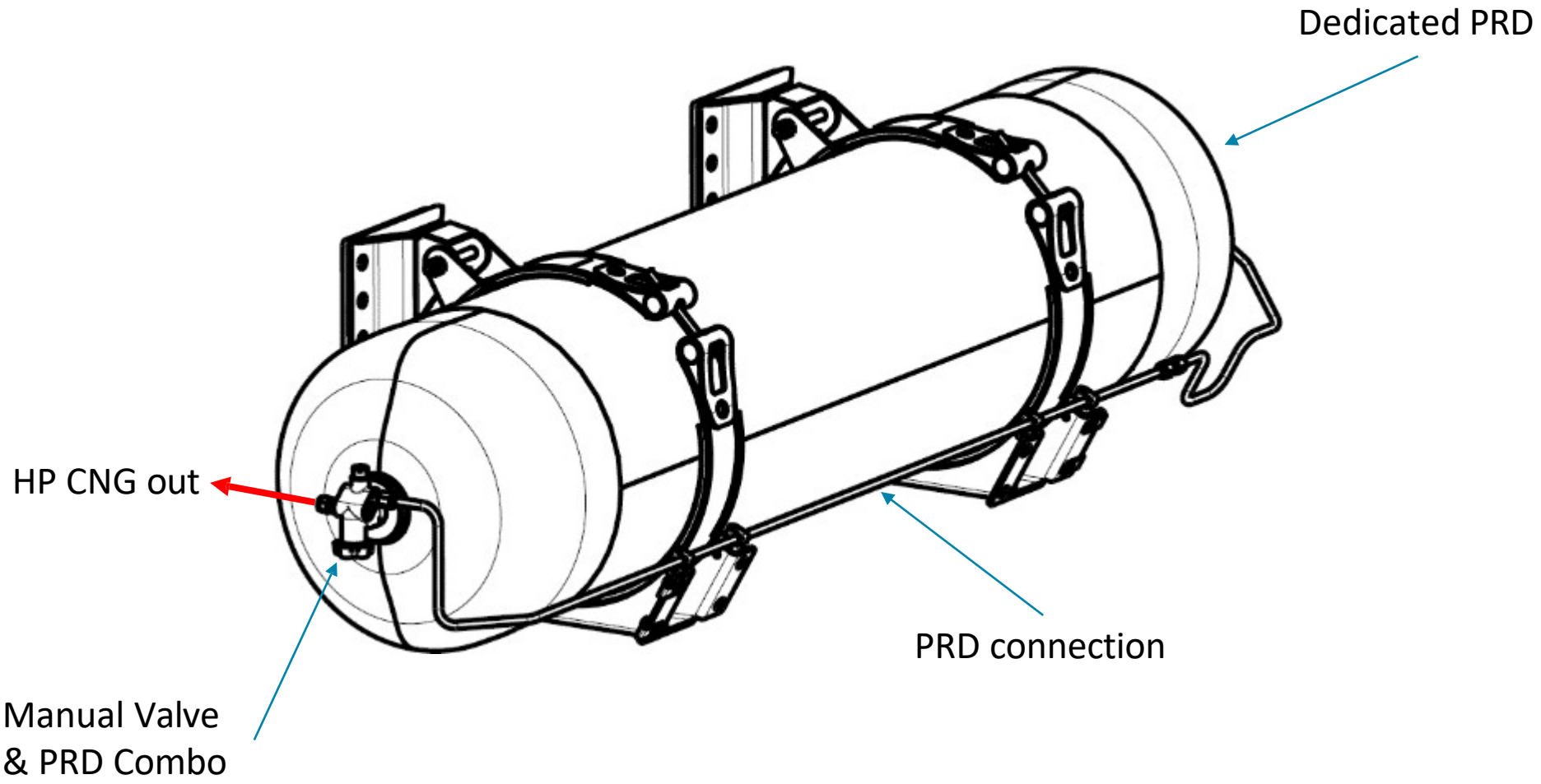
Fuel Injector Spacer



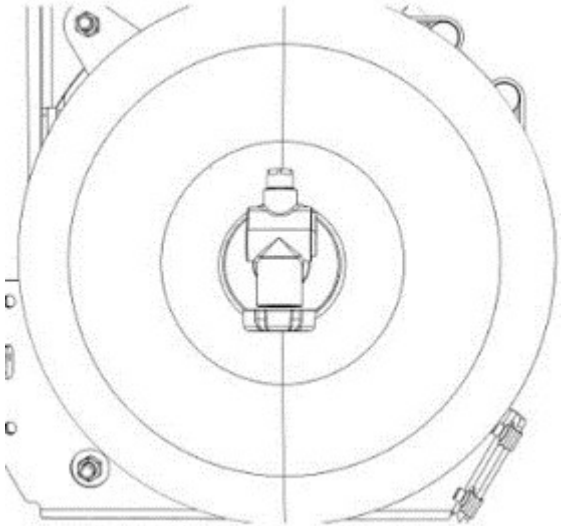
Injector Assembly



Cylinder Assemblies



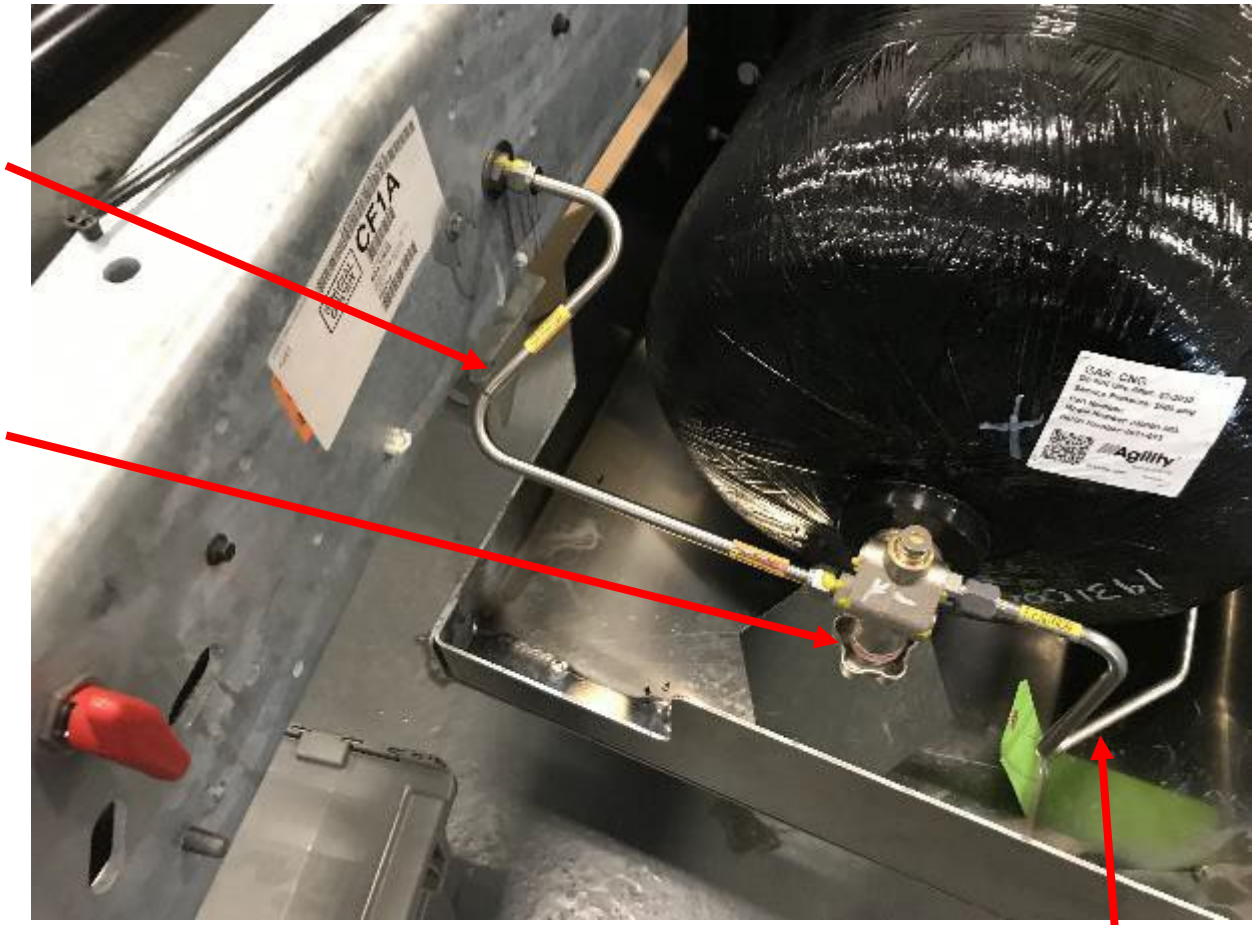
Cylinder – Forward End



Integrated Cylinder Shutoff Valve/PRD

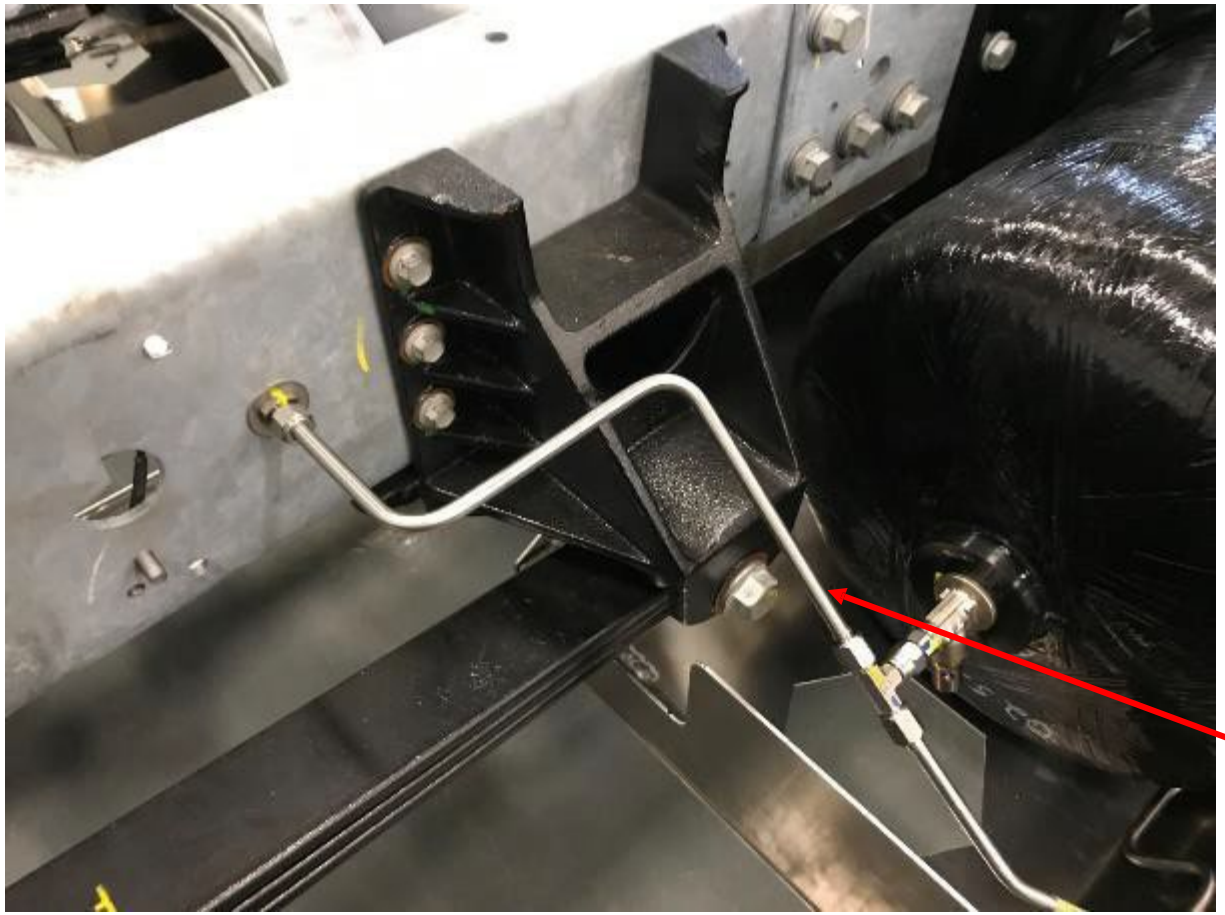
HP CNG to manual valve

Manual shutoff valve knob

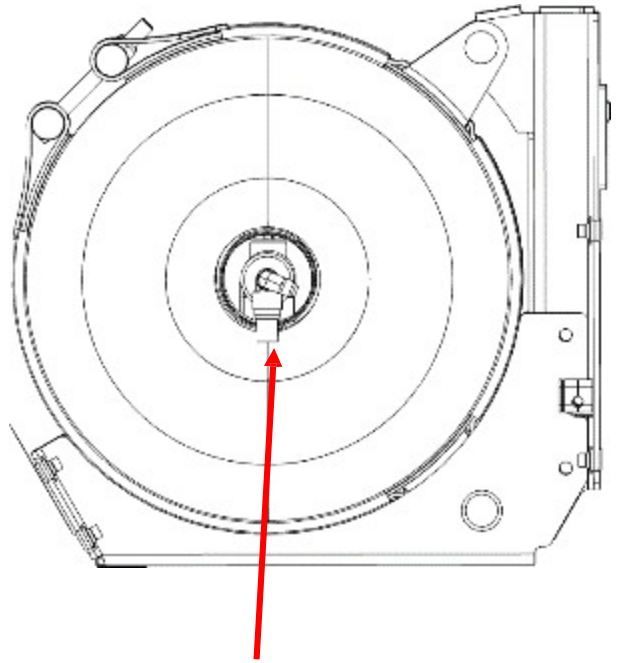


PRDs are thermally activated at 230˚F ±18˚F (110˚C ± 10˚C), **not pressure activated**.

Cylinder – Rear End



PRD vent line



Dedicated PRD

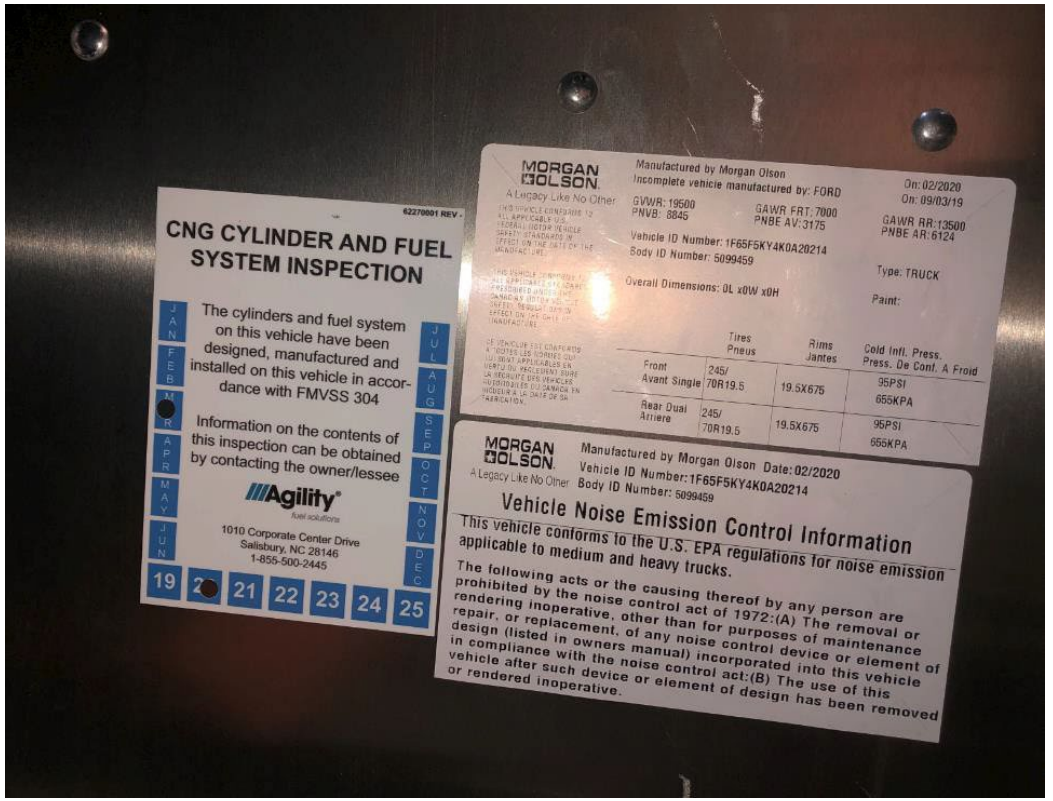
PRDs are thermally activated at 230˚F ±18˚F (110˚C ± 10˚C), **not pressure activated**.

Cylinder & System Inspection Stickers

- CNG cylinder inspection stickers installed on each cylinder at on/off valve end
- CNG system inspection sticker installed on bulkhead behind driver's seat

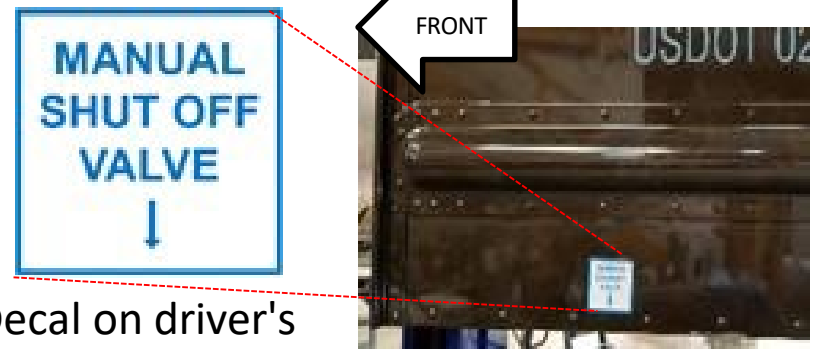
Cylinder inspection sticker

CNG system inspection sticker

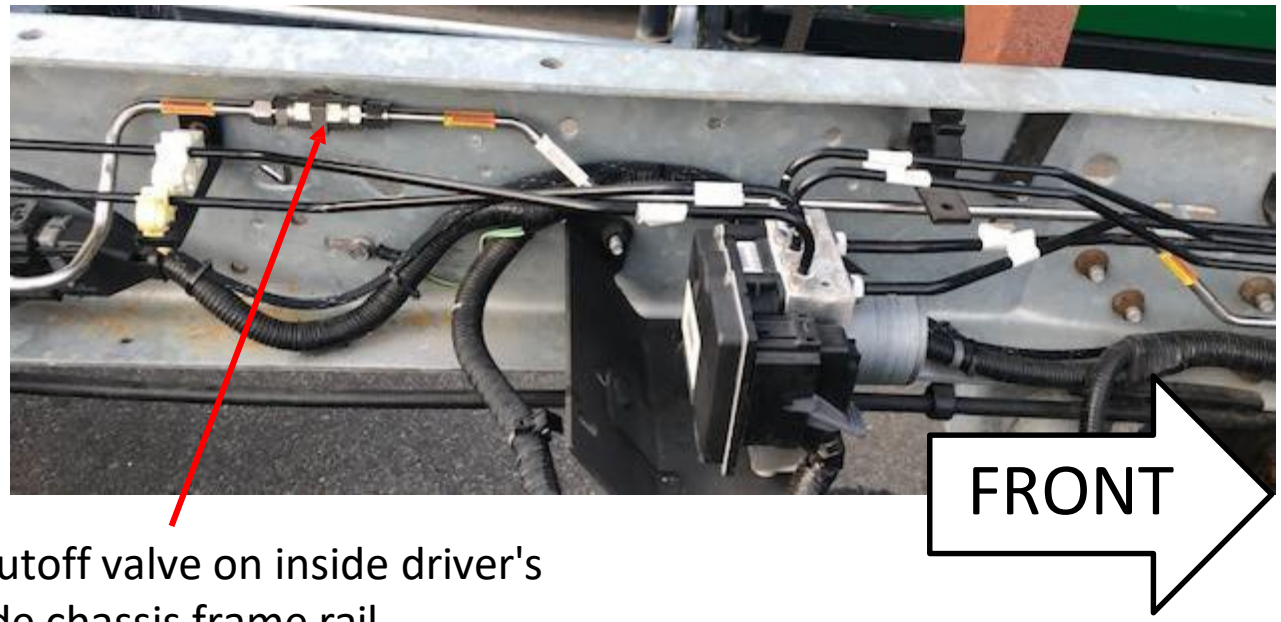


Manual Shutoff Valve

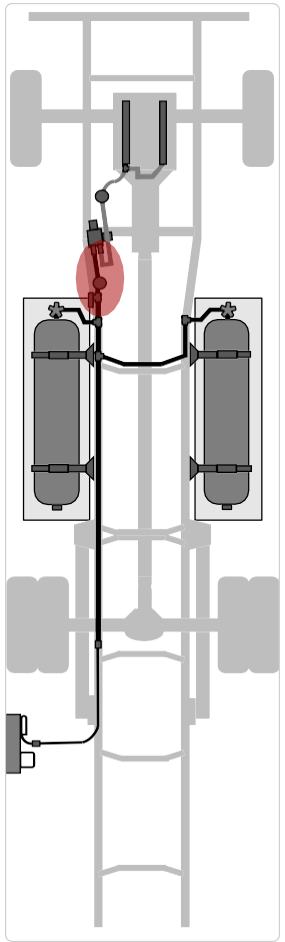
Manual shutoff valve red handle on outside driver's side chassis frame rail; AKA "¼-turn valve"



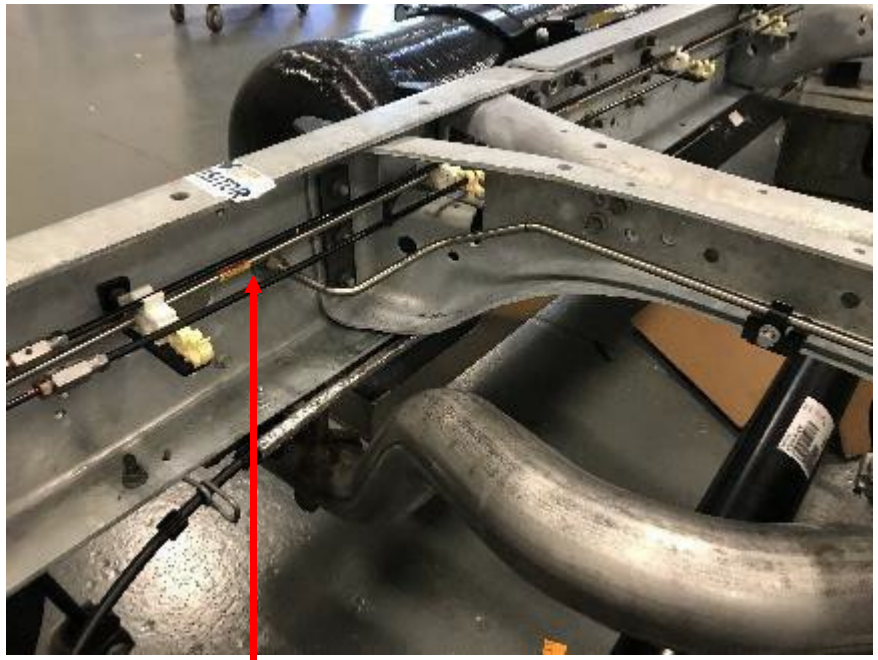
Decal on driver's side body



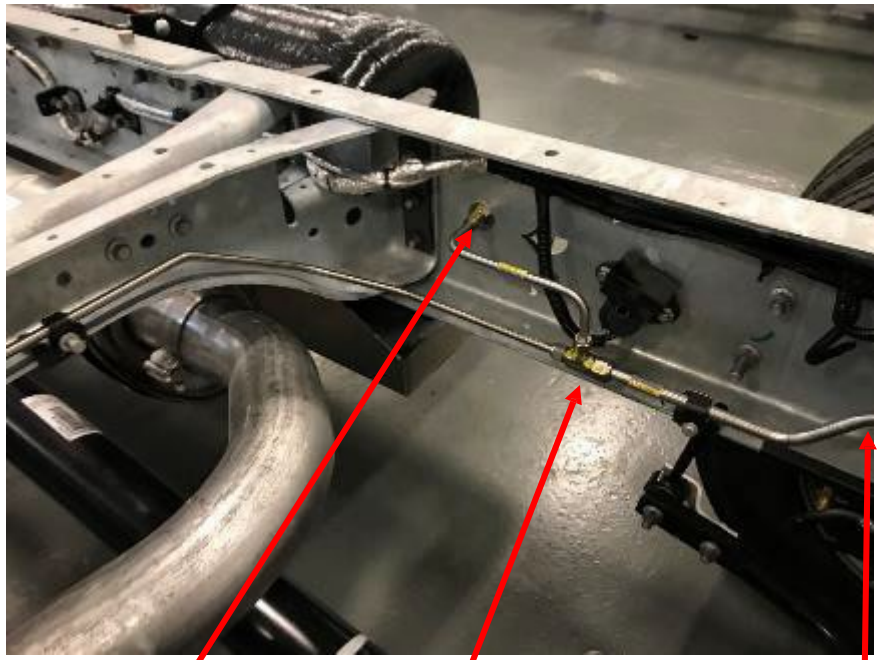
Manual shutoff valve on inside driver's side chassis frame rail



PRD Vent Line Routing



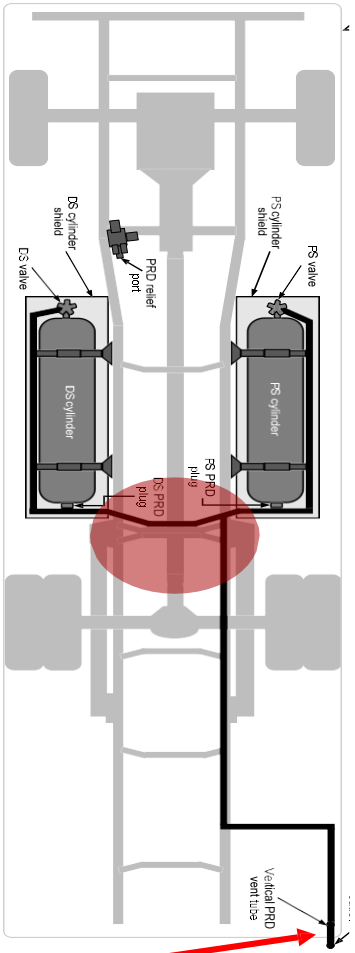
DS PRD
Bulkhead



PS PRD
Bulkhead

PRD Tee
connector

To PRD vent



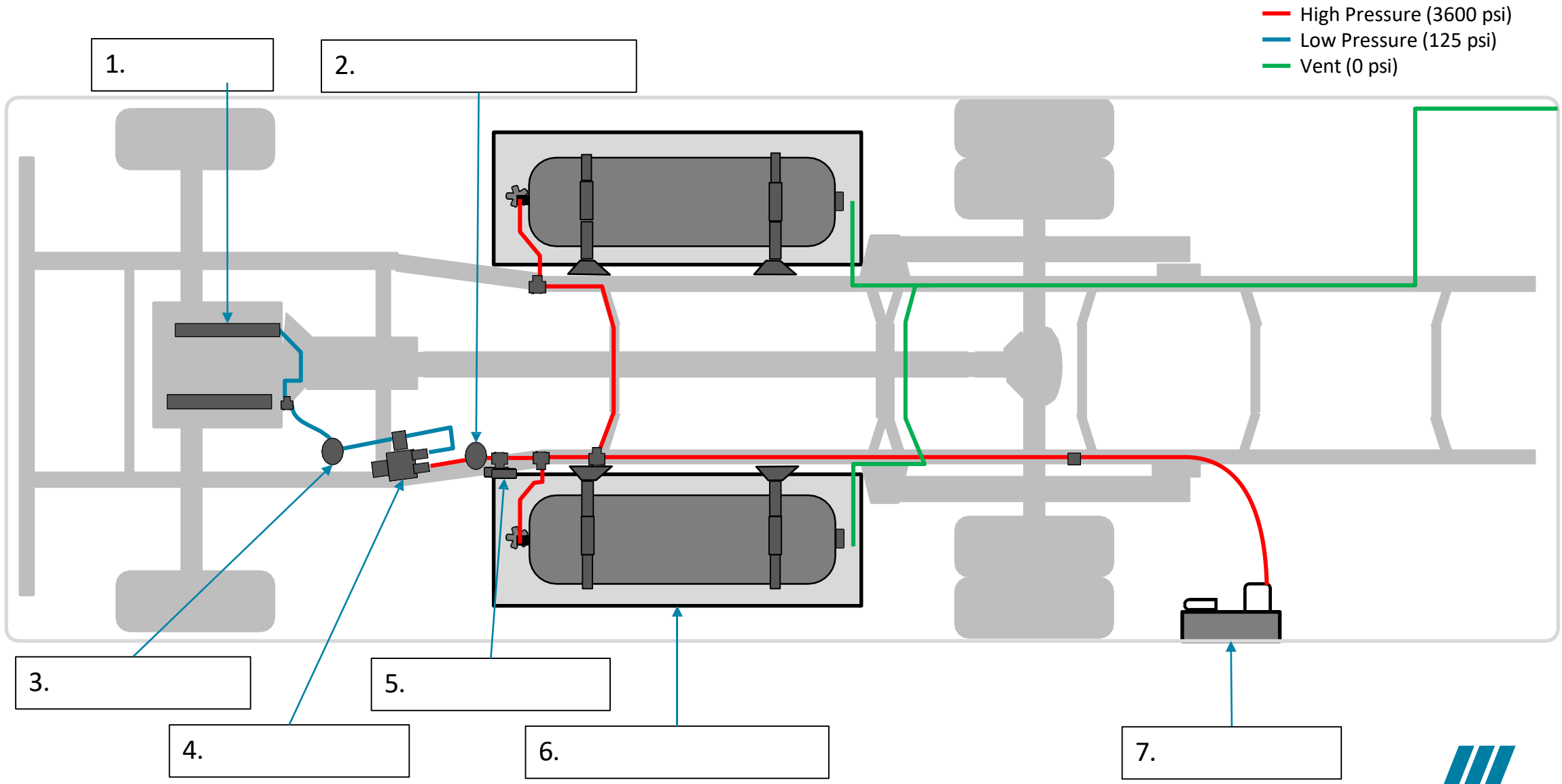
Line Labeling

Fuel lines from fill panel to pressure regulator (high pressure)

Fuel line (low pressure)

PRD vent lines (no pressure)

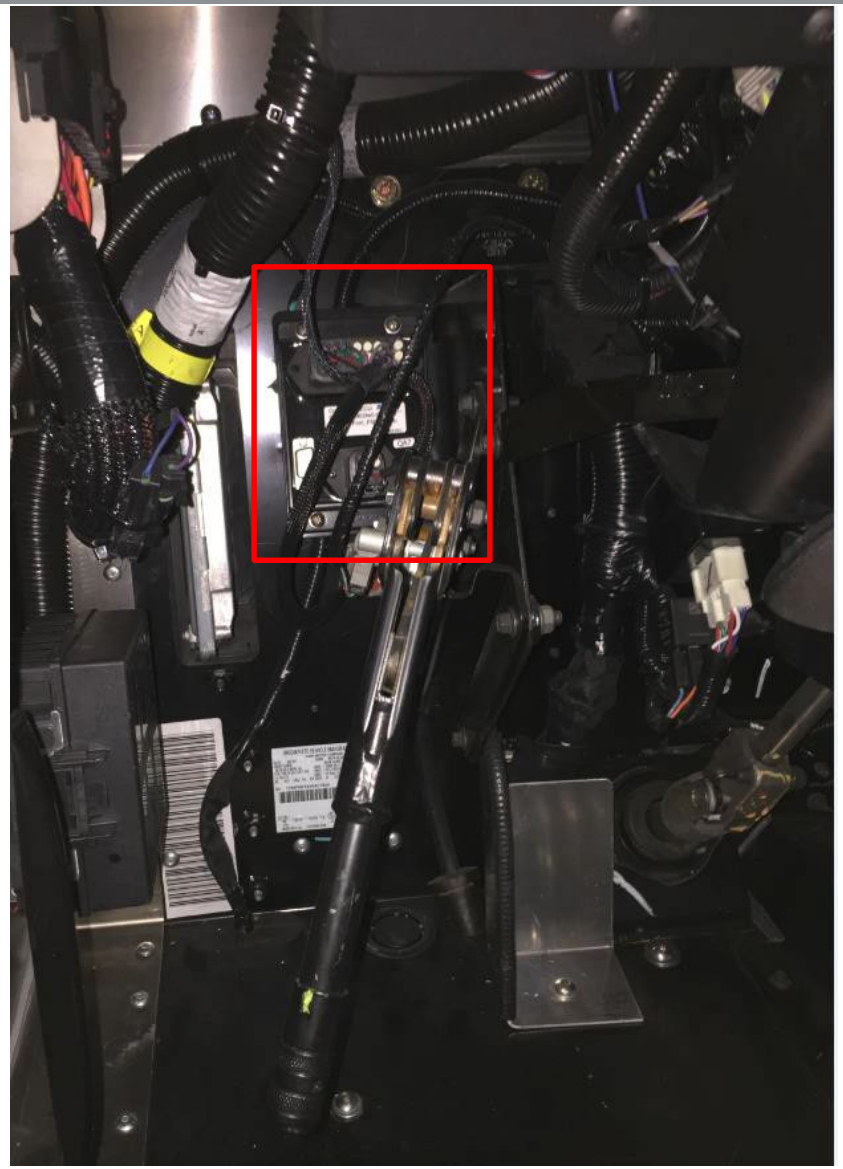
Learning Check – Fill in the Blank



Agility CNG System - Electrical

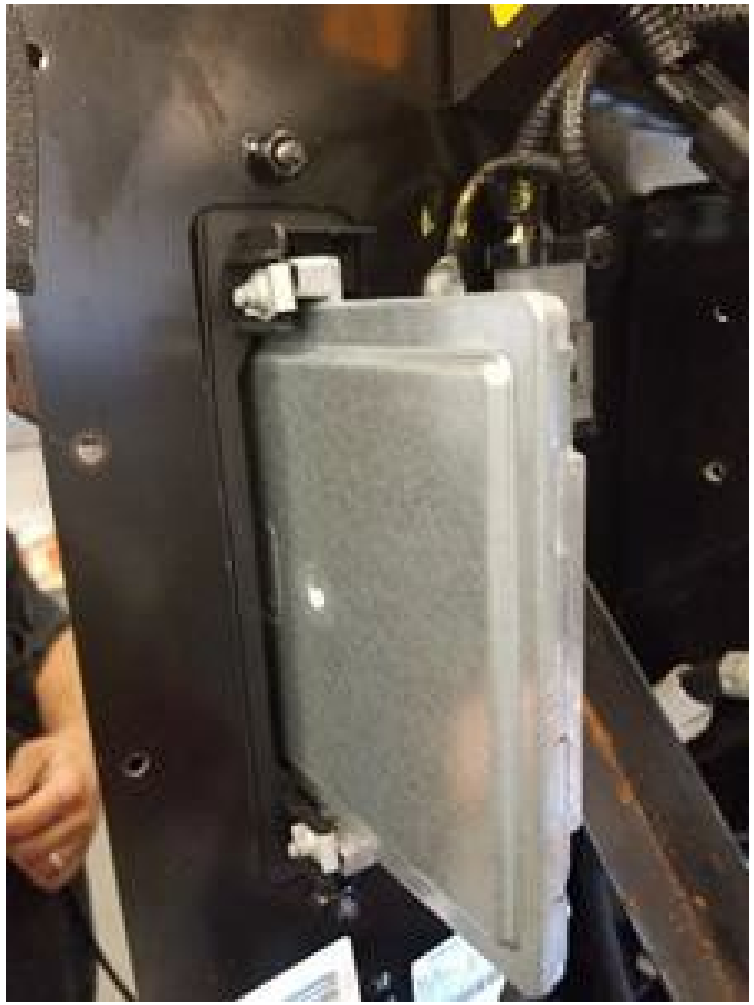
Agility Controller

- Mounted next to Ford PC, under steering wheel, to left of E-brake bracket
- Inputs
  - Pressure sensor signal
  - Start request
  - 12 V power from fuel pump connector
- Outputs
  - Fuel gauge signal
  - Crank confirm
  - Solenoid open



Ford Controller

- CNG calibration runs on existing Ford Powertrain Control Module (PCM).
- No Fuel Injector Control Module (FICM) necessary.
- Agility® re-flashed a portion of the stock calibration related to fuel injector timing and pulse width.
- No other areas of control are impacted (e.g. torque control, ABS, etc.)
- Agility will provide a loaner flash tool to program the PCM when necessary



DO NOT REPROGRAM warning label

A "Do Not Reprogram" warning decal is affixed to the engine compartment firewall to help prevent accidental PCM re-flashing.

WARNING

DO NOT REPROGRAM

REPROGRAMMING WITH THE INCORRECT CALIBRATION WILL CAUSE VEHICLE NOT TO RUN PROPERLY. CONTACT AGILITY FUEL SOLUTIONS BEFORE ATTEMPTING A RE-FLASH OF THIS VEHICLE

AGILITY FUEL SOLUTIONS
PHONE: 855-500-2445
EMAIL: PTSPARTS@AGILITYFS.COM

61210022

The factory PCM program must not be changed without contacting Agility®.

OBD-II reflash warning label

An additional reprogram warning decal is affixed adjacent to OBD-II port to the right of the steering column under the dash to help prevent accidental PCM re-flashing.

The factory PCM program must not be changed without contacting Agility®.

Agility VECI label

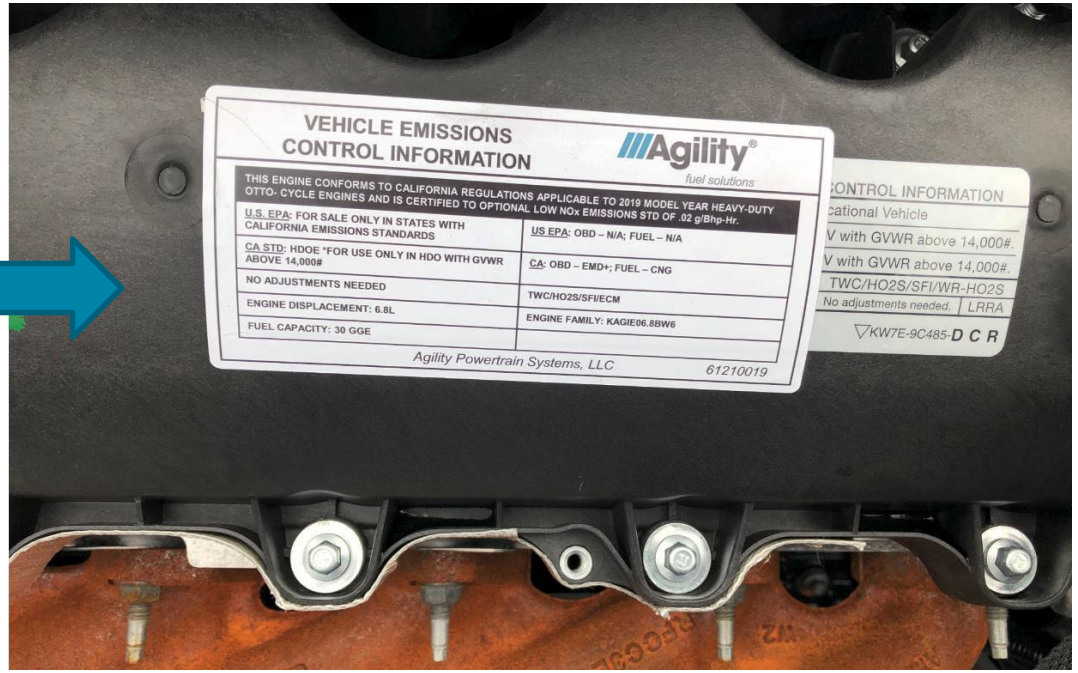
All on-highway vehicles are required to carry a Vehicle Emissions Control Information (VECI) label. An Agility® CNG fuel system VECI decal is affixed over the OEM Ford VECI label on the passenger side rocker cover.

VEHICLE EMISSIONS CONTROL INFORMATION

Agility® fuel solutions

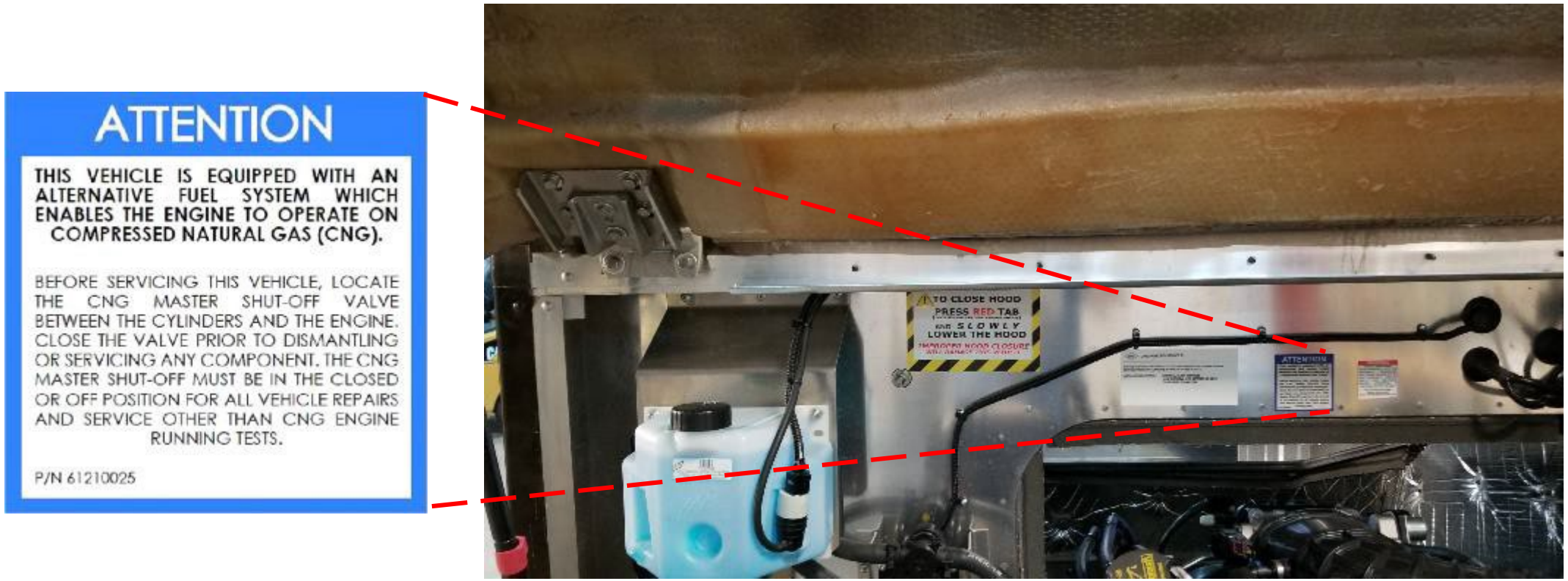
THIS ENGINE CONFORMS TO CALIFORNIA REGULATIONS APPLICABLE TO 2019 MODEL YEAR HEAVY-DUTY OTTO-CYCLE ENGINES AND IS CERTIFIED TO OPTIONAL LOW NOx EMISSIONS STD OF .02 g/Bhp-Hr.	
U.S. EPA: FOR SALE ONLY IN STATES WITH CALIFORNIA EMISSIONS STANDARDS	US EPA: OBD – N/A; FUEL – N/A
CA STD: HDOE *FOR USE ONLY IN HDO WITH GVWR ABOVE 14,000#	CA: OBD – EMD+; FUEL – CNG
NO ADJUSTMENTS NEEDED	TWC/HO2S/SFI/ECM
ENGINE DISPLACEMENT: 6.8L	ENGINE FAMILY: KAGIE06.8BW6
FUEL CAPACITY: 30 GGE	

Agility Powertrain Systems, LLC 61210019



CNG vehicle ¼-turn valve label

To alert operators and technicians to presence of the Agility® CNG fuel system and required operation of the 1/4-turn manual shutoff valve during service, the following warning label is affixed to the engine compartment firewall:



Electrical System

Agility harness is woven loom with white thread crosses

Agility Controller

Crank Confirm

Start Request

PLUG

ECU-16

ECU-4

Firewall Connector A

2 10400965

Firewall Pass Thru

Firewall Connector B

3 10401202

S1

S2

S3

Fuel Pump Interface

Supply Solenoid

Grounding Ring Terminal (Ground)

Kill Cap

Pressure Transducer

Remote Kill Cap PN: 10404006

Top view

Side view

Chassis Harness

Fuel Pump Interface

Firewall

Firewall Bulkhead

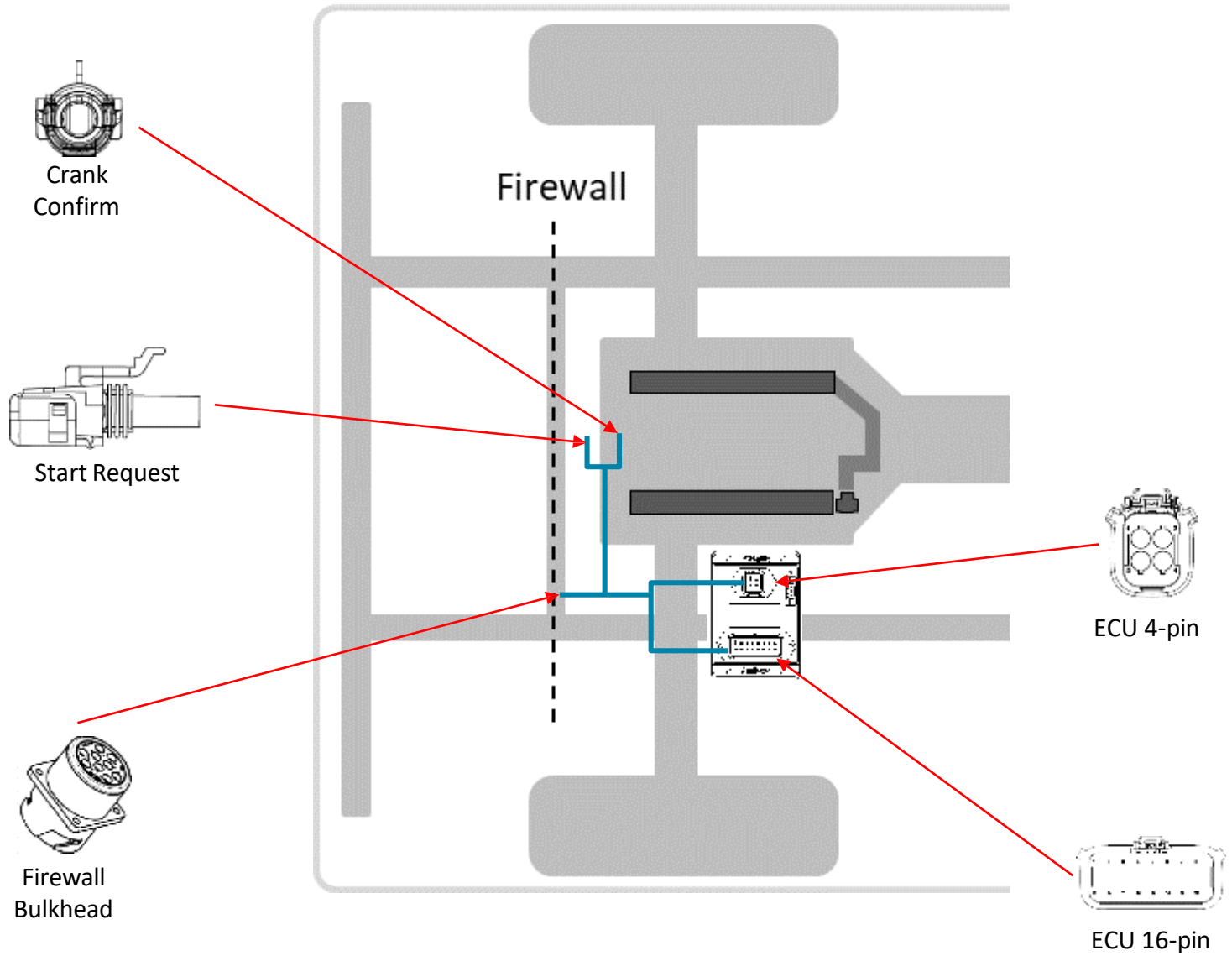
Supply Solenoid

Pressure Transducer

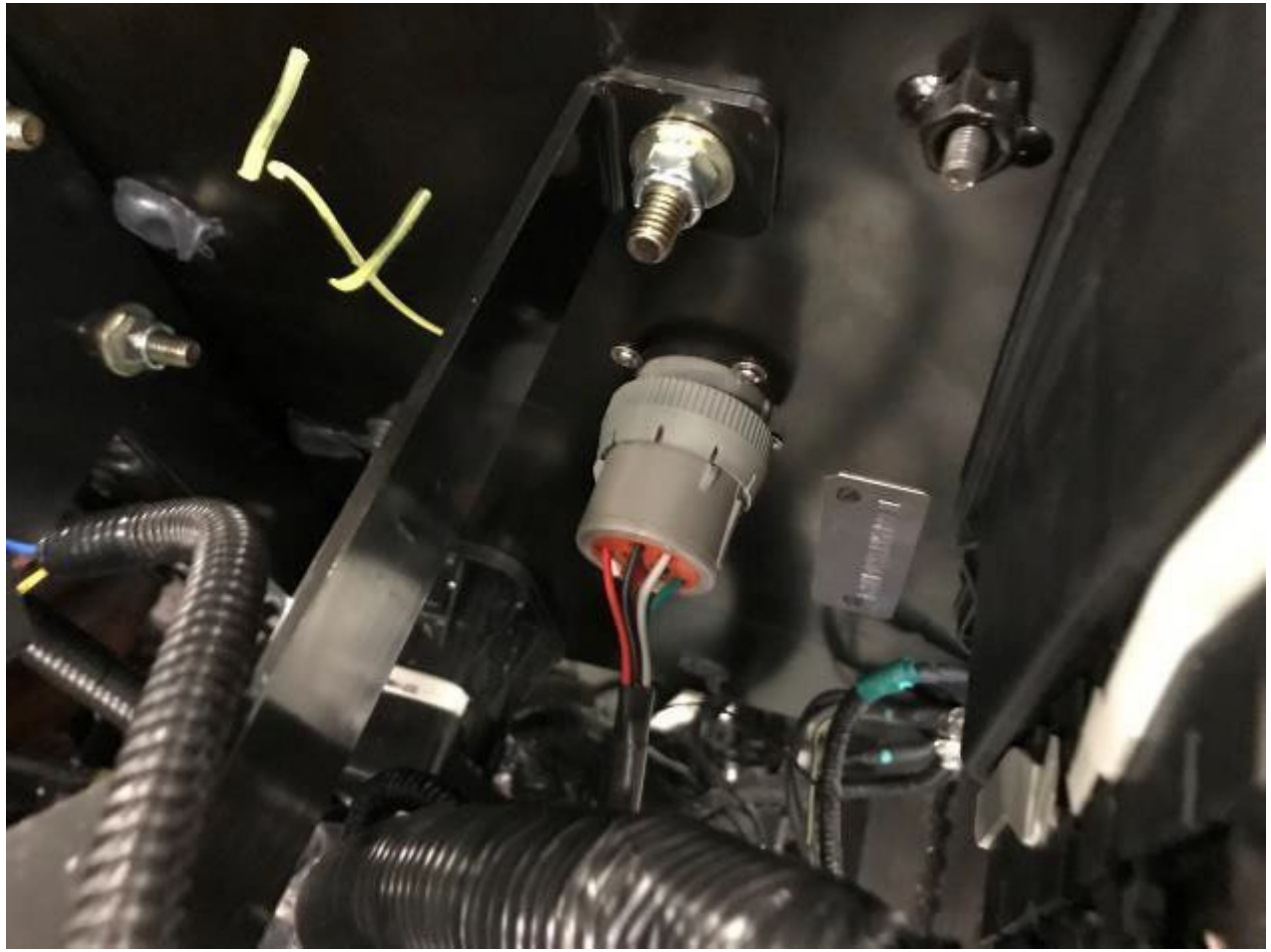
Grounding Ring

Kill Cap

Cabin Harness

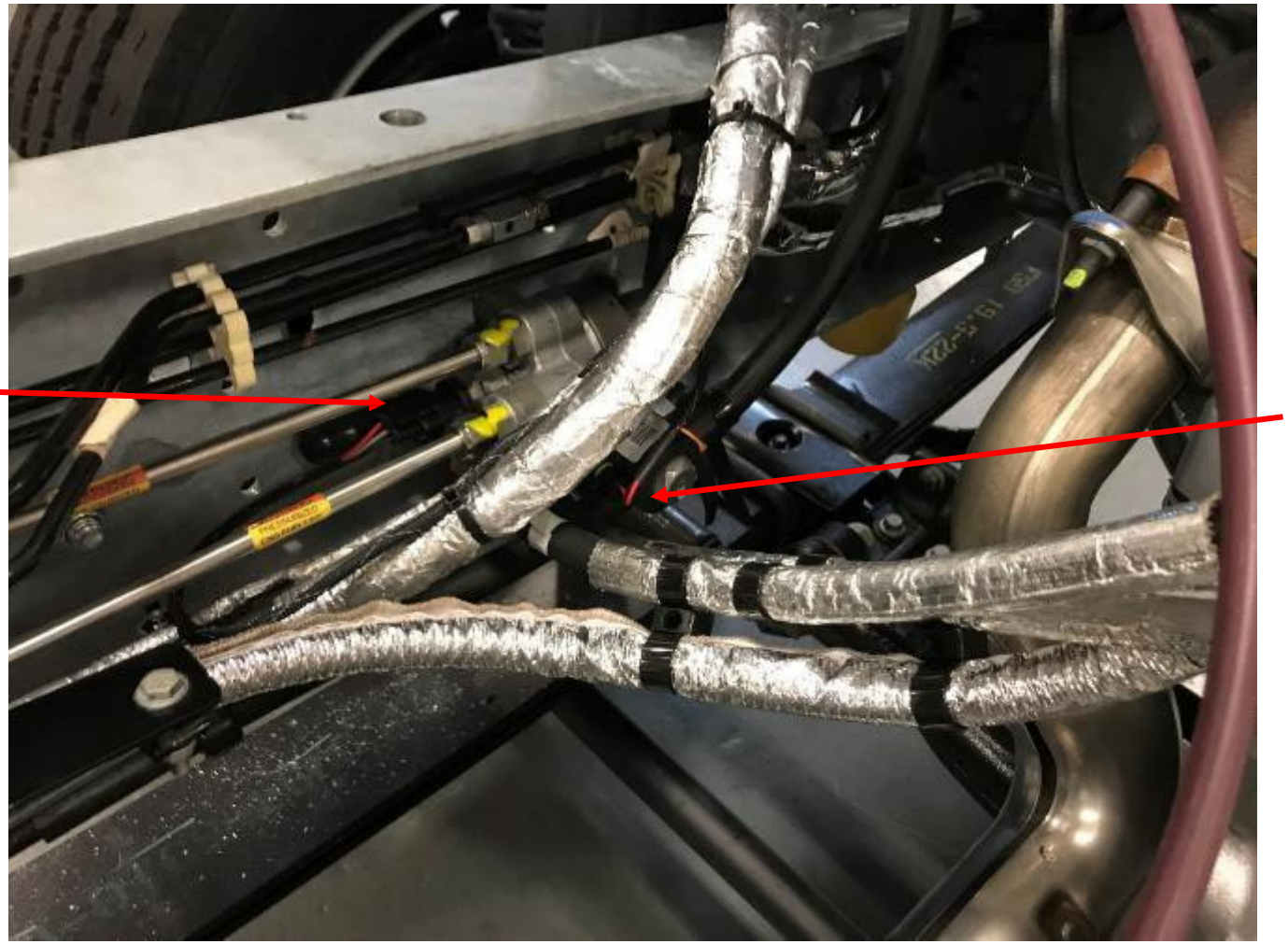


Firewall Bulkhead Connector



Pressure Regulator Connectors

Pressure Transducer Connector



Supply Solenoid Connector

OEM Fuel Harness Connector

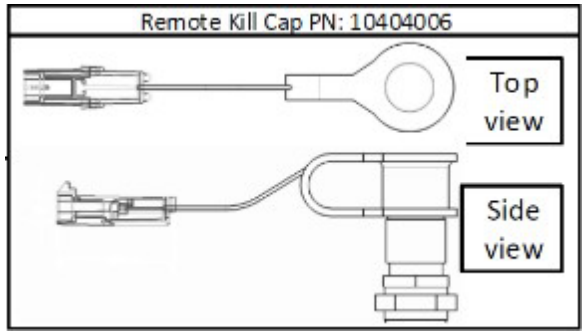
OEM Fuel Harness Connector

DAP Connector

The Drive Away Protection (DAP) feature prevents engine from cranking if the fuel receptacle dust cap is not in place

Chassis Harness DAP Connector

Fuel Receptacle Dust Cap AKA "Kill Cap"

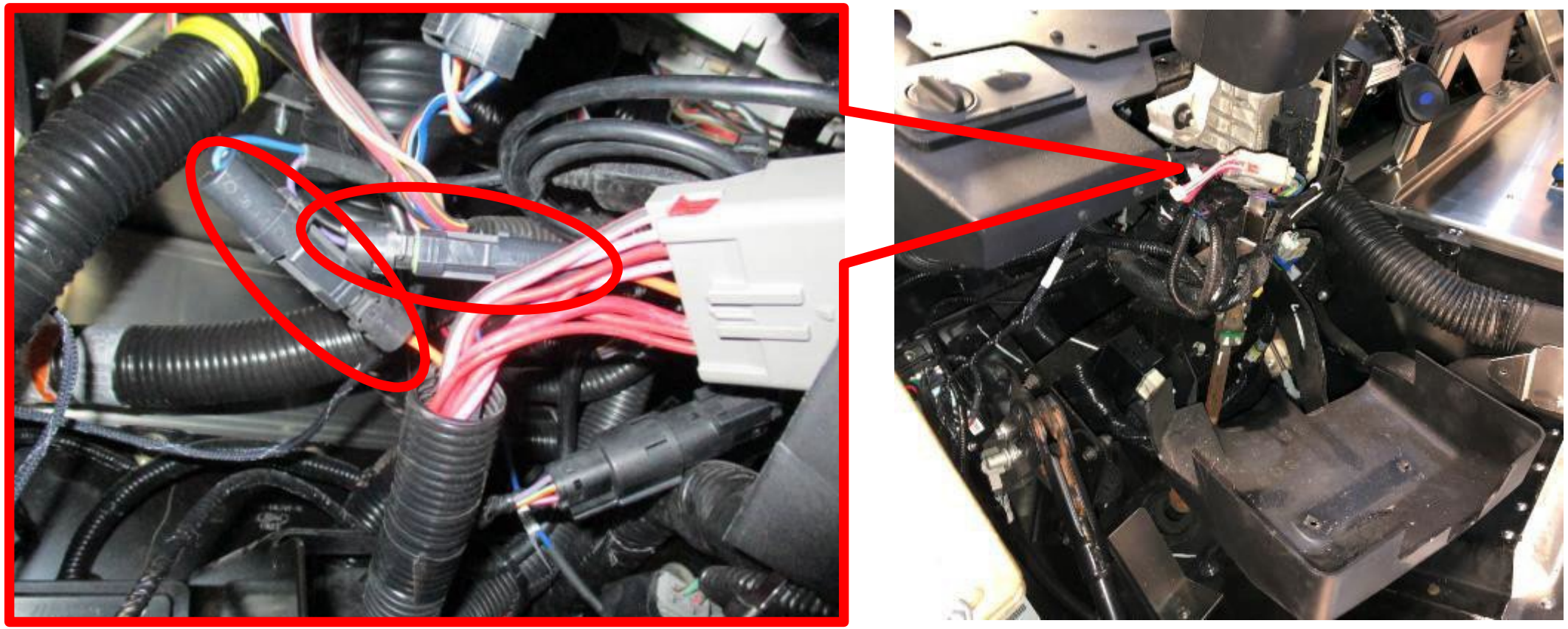


No Crank, No Start Common Failure

- Most common failure is the Drive Away Protection (DAP) system.
  - Check to make sure filling cap is completely installed on receptacle.
  - Inspect cap to make sure the spring-loaded button is installed.
  - Disconnect the 2 connectors under the dash (start request, and crank confirm), connect the orange ends together to bypass DAP. If truck starts DAP failure is cause. Reconnect as originally connected. (see next slide)
  - Check for proper ground at DAP/Kill Cap.
    - Connect ground jumper from eyelet on back of Fuel Management Module (FMM) to a good ground. If vehicle starts call Agility Technical support for further direction. (see next slide)

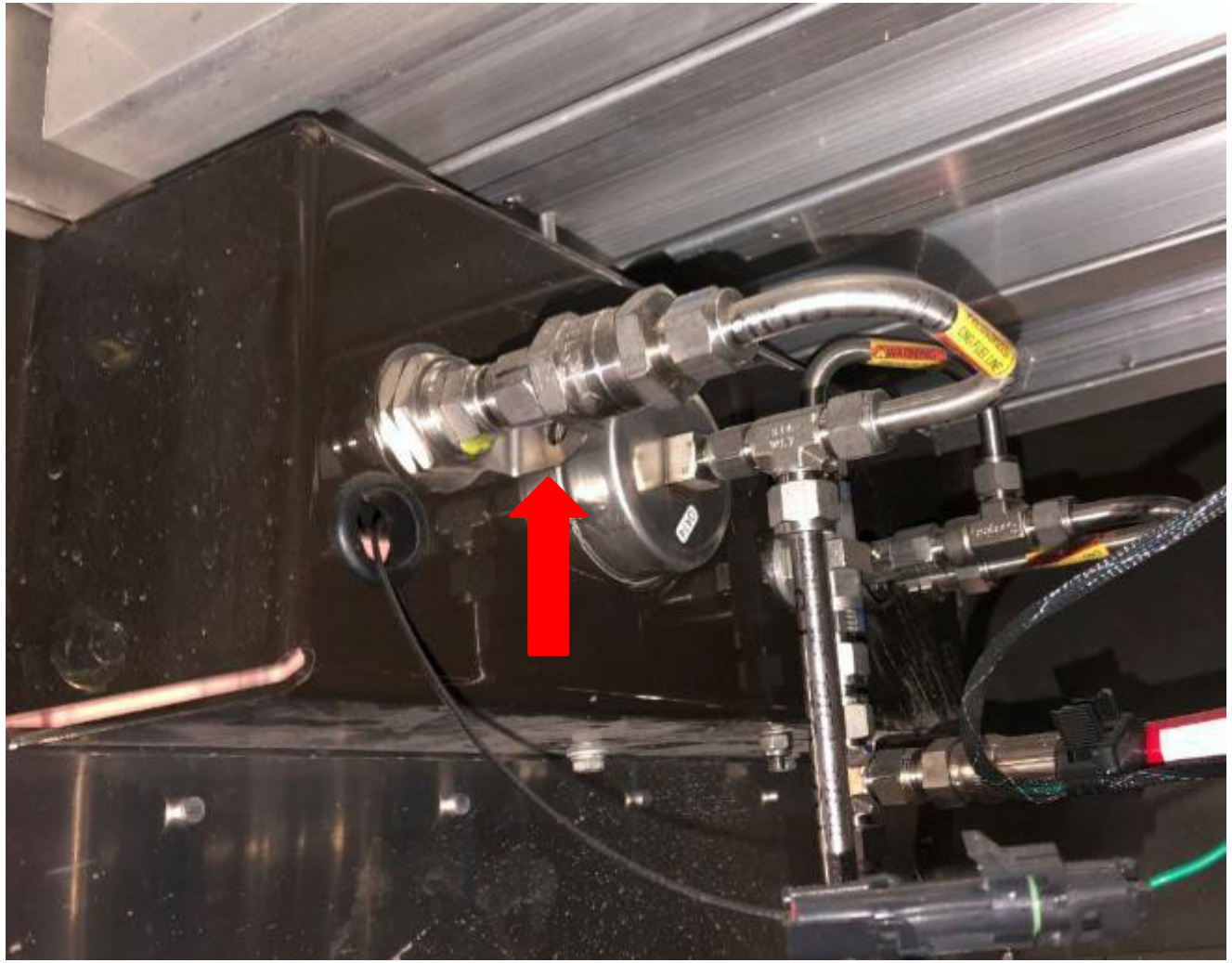
No Crank, No Start figures

Start request and Crank confirm connectors



No Crank, No Start figures

FMM Eyelet (located behind fill panel)



Fill Panel

Maintenance Intervals

Maintenance Schedule

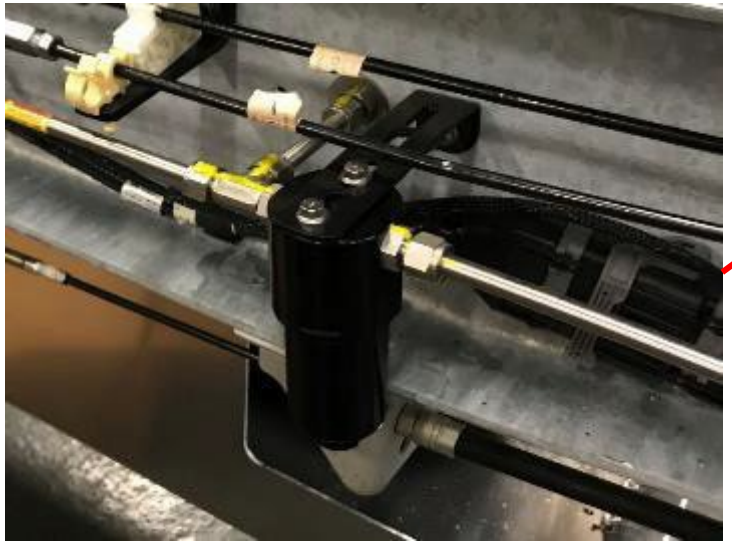
CNG System Maintenance / Inspection Item	Frequency
Replace Low and High Pressure Fuel Filters	UPS PMI for LOF (4,000-5,000 mi)
Spark plugs	50,000 mi
Leak Test	UPS PMI
Component Visual Inspection	UPS PMI
CNG System Inspections*	Every 3 years or 36,000 miles

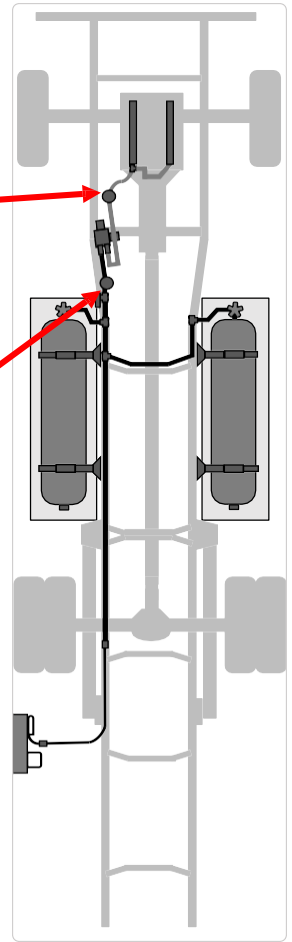
* Also after any accident or thermal event

Filters

LP Filter
LOF

HP Filter
LOF





CNG Leak Detection

- Check fittings and connections for leaks.
- Most leaks will be found at a connection.
- When checking for leaks use certified leak detection equipment. Either 365 or Snoop or FBI.

What to look for:

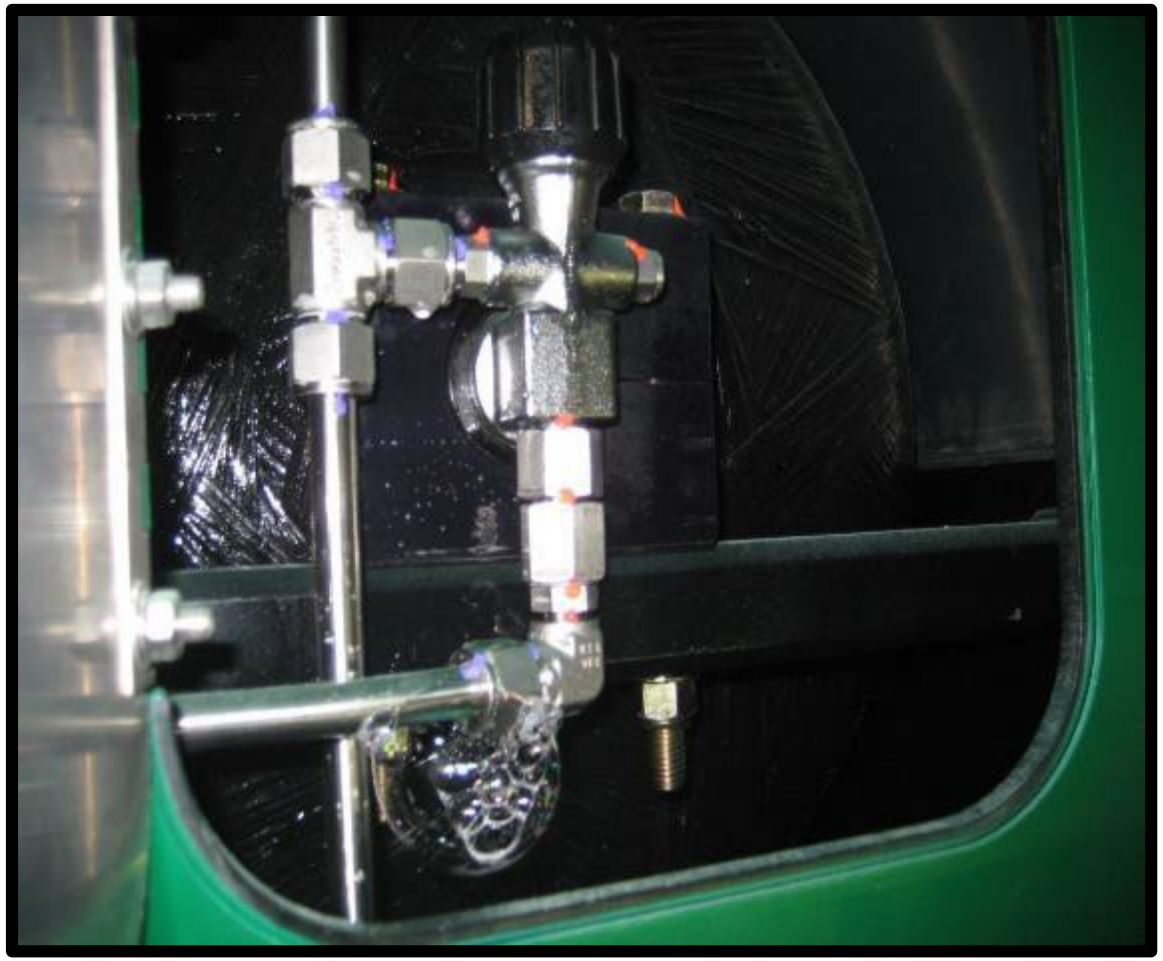
- If using solution, look for bubbling or foaming at point of leak.
- Examine for icing around tubing or connector at point of leak.
- Check for signs of damage to tubing.
- #10802096

Noncorrosive, nonflammable
Temperance Tolerance
–65 to 200°F (–54 to 93°C).

UEI CD100A
Grainger # 8EUN6

CNG Leak Detection (cont.)

When a leak is present the solution will cause bubbles. Always give it at least 10 minutes not all leaks will be very apparent. After a few minutes even a tiny leak will appear in a foam like manner not necessary bubbles. Rinse fluid off after inspection.



CNG System Inspection

Visual inspection of entire system

- Hard lines, fittings, flex lines
- Wire harness
- Major components – Regulator, valves, filters, fuel rails

Things to look for

- Kinks in hoses or harnesses, lines in contact with edges or anything that may rub
- Scratches, dents, abrasions in any components
- Mounts are still tight, flexible components (hoses/harnesses) are secured properly
- Torque seals are not broken

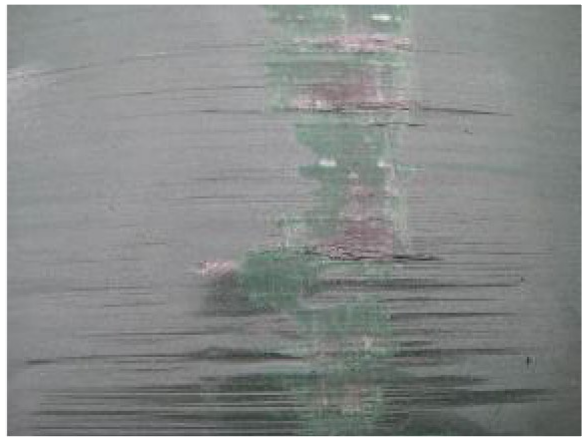
CNG Cylinder Inspection

- Cylinders rely on carbon/fiber wrap to contain pressure, damage to the fibers can compromise the cylinder's ability to hold pressure
- Examples of cylinder damage:

Gauge

Delamination

Impact/Scratch



Abrasion/Rubbing

Cylinder Findings

Cylinder Finding

Service Parts

Service Parts

Major component service parts

Agility PN	Description	PKG QTY	UPS#
63110001	LP Filter, includes element	EACH	
63110000	HP Filter, includes element	EACH	
61190003	HP/LP Filter Element	EACH	4826070
63110002	Regulator	EACH	
61020015	CNG Injector	EACH	
61160019	Injector O-ring	EACH	
10404006	Kill cap, fill receptacle	EACH	4819371
63060009	LP Flex line to engine	EACH	
10300327	HP flex line to fill box	EACH	
20003301	Fill panel defuel cover	EACH	

*Complete parts catalog distributed separately

Service Parts

855-500-2445

UPS Direct Prompt: 6

or

support@agilityfs.com

6 a.m. EST to 8 p.m. EST Monday through Friday

Repair Assistance

Contacting Agility Service Support

Service Support Hot Line

855-500-2445

UPS Direct Prompt: 6

or

support@agilityfs.com

6 a.m. EST to 8 p.m. EST Monday through Friday

Call For:

- ✓ Parts
- ✓ Technical Service
- ✓ Warranty

Depressurize vs. De-Fuel

Depressurize

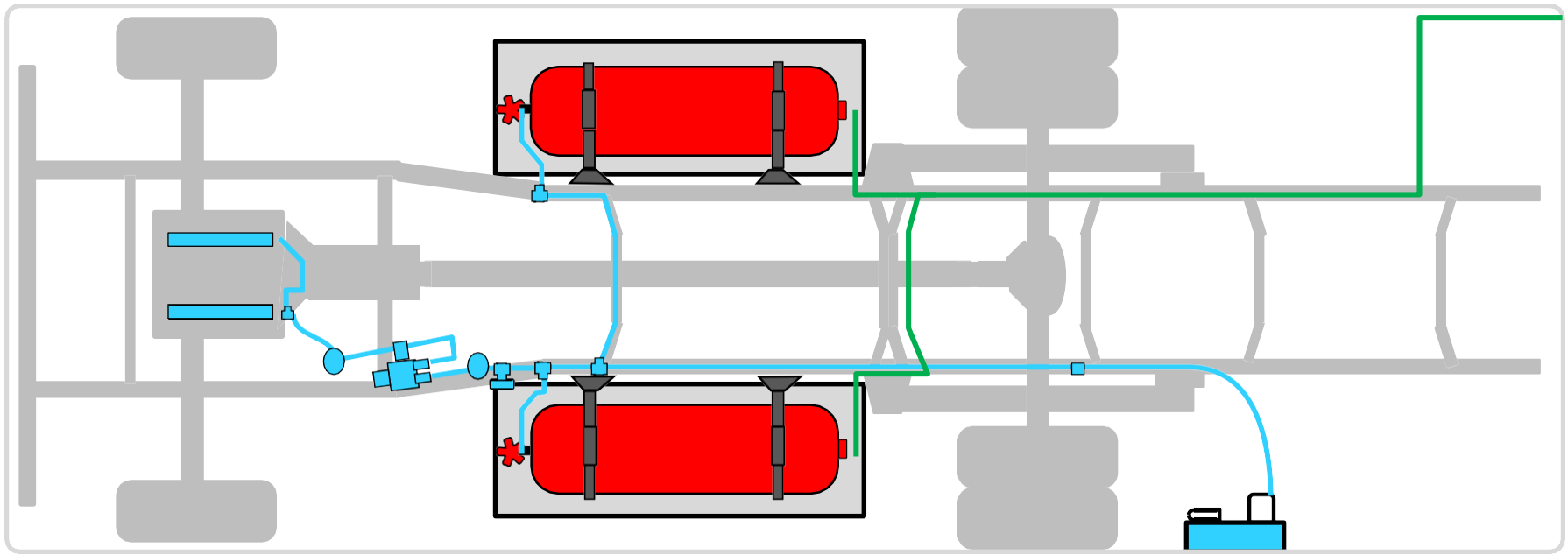
- In order to safely work on a natural gas fuel system, it is necessary to depressurize the fuel path and yet conserve fuel. This is done by isolating the pressure in the cylinder or cylinders from the rest of the system plumbing.

De-Fuel

- When work must be done on the fuel system upstream (before) of the cylinder shut off valve, fuel inside the cylinder must be removed (vented) or stored elsewhere.

De-fueling is required when servicing cylinders, cylinder valves, PRDs, PRD supply tubing or performing hot work closer than 6 ft. (2 m).

CNG Fuel System Pressure Zones



Defuel

- Cylinders
- Cylinder hand valve
- Cylinder PRDs

Depressurize

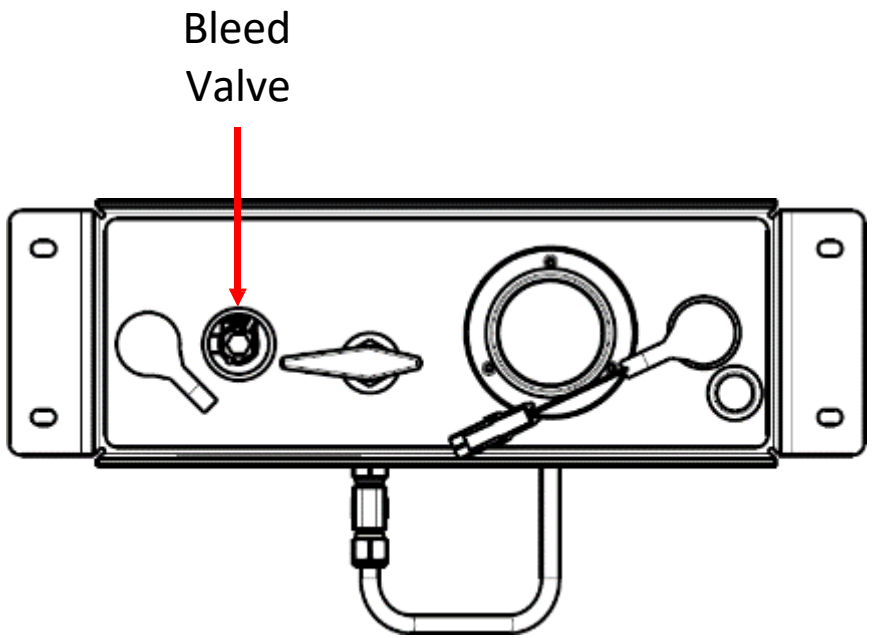
- ¼ Turn valve
- Filters
- Regulator
- Fuel rails/injectors
- HP/LP fuel lines

Unpressurized

- PRD lines
- PRD vent

Depressurizing Procedure

1. Isolate the CNG cylinders on the vehicle by turning all manual shutoff valves clockwise to the “OFF” position.
2. Verify the quarter turn shutoff valve on the chassis frame is open.
3. Start and run the engine until the engine stalls to expend all fuel in the lines
4. Remove the defuel shield on the FMM
5. With a 7/16” socket to open the bleed valve. This allows any additional fuel to vent out.
6. Leave the bleed valve in the “OPEN” position.
7. Once you determine the system has been depressurized, it is safe to continue.



Leak Repair

Important

- Ensure the system is depressurized before repairing any leaks.
- Maintenance and repair must be performed by qualified personnel.

Perform leak repairs in the order shown below.

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

1. If a leak is detected, depressurize the system.
2. Once the system is depressurized, tighten the leaky fittings. Re-pressurize the system.
3. When the system is pressurized, conduct a leak test.
4. If this does not stop the leak, depressurize the system again.
5. Remove fittings that are leaking and make sure the mating surfaces are clean. Check any O-rings for signs of damage.
6. Replace the leaking tubes and reinstall the fittings according to the Swagelok guidelines for tube fittings and SAE torque settings for O-ring boss fittings as specified. Once the fittings have been reinstalled, re-pressurize the system and test for leaks.
7. If the leak cannot be repaired, the component should be replaced.
8. If replacement is necessary, obtain replacement parts, install them, perform a leak test and fix any leaks.

Safety Steps for Repair of Leaks

1. Before fixing a leak at a connection, depressurize the system completely. This step is very important.
2. Once the system has been depressurized, use the proper tools to address the leaking tube connection and or valve.
3. Tighten up the leaking tube fitting by using the proper back-up wrench to support the body of the fitting and then use a wrench to snug-up the tube fitting nut.
4. If removing existing lines; when replacing finger tighten nut and turn ½ turn from finger tight with proper size wrench.
5. If the leak cannot be fixed, the component and or the tubing shall be replaced.

Connecting with Ford IDS Tool

1. Open Ford IDS program.
2. Select “Manual Vehicle Entry”.
3. Select the check mark in bottom right corner or press ENTER to continue.
4. Select “All Other”.
5. Enter vehicle Tear Tag “VBW0”
6. Select the check mark in bottom right corner or press ENTER to continue.
7. Select vehicle Model Year.
8. Select “Yes” to confirm vehicle details.
9. In this screen, the VIN should be a series of “#” signs. Do not enter anything, then select the check mark in bottom right corner or press ENTER to continue.
10. The Ford IDS tool is connected. To read PCM codes:
    a. Select the Red Tool Box icon at the top of the IDS program
    b. Select “Self Test” then “All CDMTCs”

Warranty

Warranty Calls

Is This A Down Vehicle?

Year of Vehicle:

Make and Model:

Unit number:

Mileage/Hours:

Engine:

VIN:

System Serial #:

Type of System:

Symptoms:

Codes:

High and Low Pressures:

Dash Gauge Reading:

Photo of Problem (if applicable):

Repairs or Checks done so far:

Items needed for Tech/Warranty 1-855-500-2445 prompt 6

support@agilityfs.com

https://agilityfs.freshdesk.com/support/home

Warranty

3 yr/60,000 miles

- All Agility supplied components
- Engine fuel system
  - Fuel rails
  - Injectors and spacers
- Chassis mounted fuel system
  - Cylinders and mounts
  - Fuel lines
  - Valves, solenoid, regulator
  - PRDs and vent lines
  - Wiring harnesses
  - Electrical components

Warranty Support

855-500-2445

UPS Direct Prompt: 6

or

support@agilityfs.com

https://agilityfs.freshdesk.com/support/home

6 a.m. EST to 8 p.m. EST Monday through Friday

Support Resources

Helpful Videos

Agility Fuel Solutions
http://www.agilityfs.com/agility-fuel-systems-academy-video-library.html
Natural Gas Academy
http://www.cumminswestport.com/natural-gas-academy-videos
Swagelok Videos
Tube Fitting Advantage
http://www.youtube.com/watch?v=CpdXPAaNnyk
Swagelok Fitting Assembly One Inch and Under
http://www.youtube.com/watch?v=jB_Nyje_HNE
Swagelok Tube Fitting Installation
http://www.youtube.com/watch?v=FdthSQDH8qk
Port Connector Assembly
http://www.youtube.com/watch?v=6nDvW1ZGIaM
Cap Assembly
http://www.youtube.com/watch?v=JzUa9aiQeJ8
Using a Hand Tube Bender
http://www.youtube.com/watch?v=Eo95bjm7WFM

For More Information

www.fordups.com

http://www.agilityfuelsystems.com

http://www.afdc.energy.gov/

http://http://www.ngvamerica.org/media-center/technical-and-safety-documents/

http://shop.csa.ca/en/canada/personnel-certification-programs/compressed-natural-gas-cng-fuel-system-inspector-certification/invt/2703393

https://www.youtube.com/channel/UCH1-yzuKiwz9kyAEJmdrLxg

http://www.government-fleet.com/article/story/2014/11/upgrading-a-maintenance-facility-for-cng.aspx

http://www.slideshare.net/WiCleanCities/considerations-for-garage-maintenance-shops-when-using-cng-lpg

https://www.youtube.com/watch?v=ukYJOakHGc4

https://www.youtube.com/watch?v=aTnmnlSmvpM

https://www.youtube.com/watch?v=lpHVgRzPVmw

http://catalog.nfpa.org/Alternative-Fuel-Vehicles-Training-Program-for-Emergency-Responders-Online-Training-P15552.aspx?icid=D533

Ford UPS Web Page

Agility® fuel solutions

www.fordups.com

Go there now on your smart phone

UPS Resources

“I-GATE”