BLUE BIRD

February 25, 2013

SERVICE MEMORANDUM
NO. SM1304 (Revised July 5, 2016)

MEMO TO: All Blue Bird Dealers

SUBJECT: Gen 4 Analog DEF Level Sensor Troubleshooting

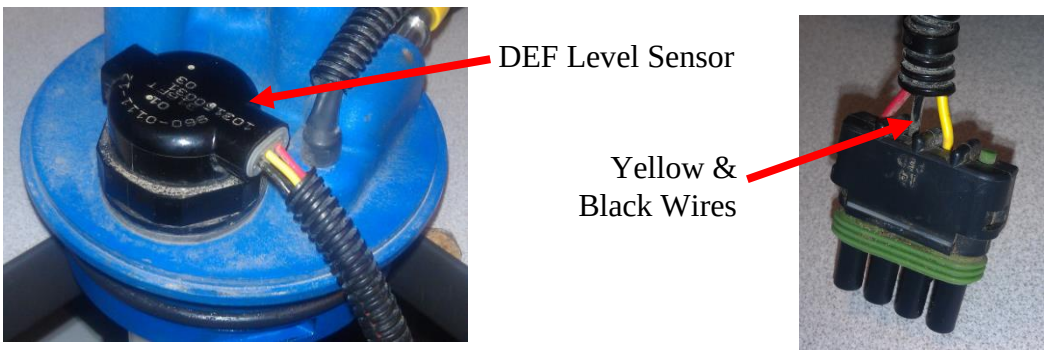
MODEL YEAR(S): 2010-2017

MODEL(S) AFFECTED: All buses with ISB10, ISC10, ISB13, and ISL13 engines, built before 01/18/2016.

If the level of Diesel Exhaust Fluid in the tank does not appear to match the level indicated on the dash cluster, please use the following procedure to check the level sensor. Also see attached Gen 4 Tank Assembly Service Manual.

WARNING: Always follow all Federal, State, Local and Shop safety standards and use proper safety equipment when performing these procedures. Observe all safety precautions to secure the bus from rolling. Park bus on a level surface, apply parking brake, turn off engine and remove key, chock wheels.

1. With the ambient temperature above 11°F (-11°C) and the ignition turned off, fill the tank with DEF until full.
2. Do a visual check on the DEF tank to verify a full tank. Caution: Do not over fill the tank.
3. Wait 15 minutes, then start the bus and let idle for 1 minute.
4. Check DEF level on the dash cluster.
5. If the level is 90% or more the sensor is working properly.
6. If the level is less than 90%, check the voltage across the yellow and black leads of the sensor (while still connected to the vehicle harness and engine running) and see if the voltage is between 0.9 and 0.49 VDC. (Piercing the insulation is not recommended. Accessing the leads through the open end/back side of the connector is preferred).
7. If the voltage is outside of this range, then replace the level sensor.
8. If the voltage is inside of this range, then the level sensor is reading correctly and you should contact your local Cummins dealer for further assistance.



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TB-2859 Rev-A

GEN IV TANK ASSEMBLY SERVICE MANUAL

APPROVAL SUMMARY

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Engineering Liaison

Shaw Development, LLC

INDEX OF REVISIONS

REVISION	DESCRIPTION	APPROVED BY/ DATE
A	INITIAL RELEASE	JAV 1/2/13

TABLE OF CONTENTS

1.0 INTRODUCTION TO SHAW DEF SYSTEM

This manual was created for the purpose of familiarizing users with the Shaw DEF Tank Assembly and its components. Furthermore, this manual provides proper maintenance and installation instructions for the DEF tank assembly. After reviewing this document, readers should gain a clearer understanding of how the Shaw DEF system operates, and what preventive maintenance practices can be performed to extend the life of DEF system.

This document is categorized into four (4) main sections: *Introduction to the Shaw Development DEF System, Operations & Maintenance, Removal & Installation Procedures, and Frequently Asked Questions (F.A.Q.s)*. These sections provide instructions for installation & disassembly (with step by step image assistance), troubleshooting, and cleaning. For quick referencing refer to the Table of Contents for the page locations of applicable topics. If after reviewing this document, there are unanswered question, please feel free to contact us via the following methods.

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NOTE: [Warnings () & Notes (NOTE)] These adjuncts are used throughout the entirety of the document. These points are utilized for the purpose of simplicity and to highlight/emphasize important points to be considered. Warnings call attention to use of materials, processes, methods, procedures, or limits which must be followed precisely to avoid injury to persons and/or damage to the components/equipment. Notes call attention to methods to ease the task at hand.

NOTE: All weights and measurements are in US units and their standard Metric conversions are enclosed in parenthesis. Temperature is called out in degree Fahrenheit, indicated by an F, with Celsius conversion, indicated by a C, following in parentheses.

1.1 GENERAL INFORMATION:

The following subsections provide brief descriptions of the diesel exhaust fluid system and its components.

1.1.1 SCR SYSTEM:

The Selective Catalytic Reduction (SCR) system helps to reduce the emission levels of nitrogen oxides released from the exhaust of diesel engines. This is accomplished when Diesel Exhaust Fluid (DEF) is injected into the engine exhaust system of the vehicle. Once injected, the DEF will undergo a series of reactions that converts Nitrogen Oxides (NO & NO_2) in the exhaust into nitrogen (N_2) and water vapor. Some of the adverse effects caused by increased atmospheric nitrogen oxides concentrations include: promotes acid rain, hampers the growth of plants, and can form with other pollutants to create toxic chemicals.

1.1.2 DIESEL EXHAUST FLUID:

Diesel Exhaust Fluid (DEF), also known as AdBlue or AUS32 (Aqueous Urea Solution 32.5%), is manufactured per ISO-22241. DEF system users are highly recommended to familiarize themselves with this ISO specification. The list below provides a few physical properties of DEF. If further information is required, refer to ISO-22241.

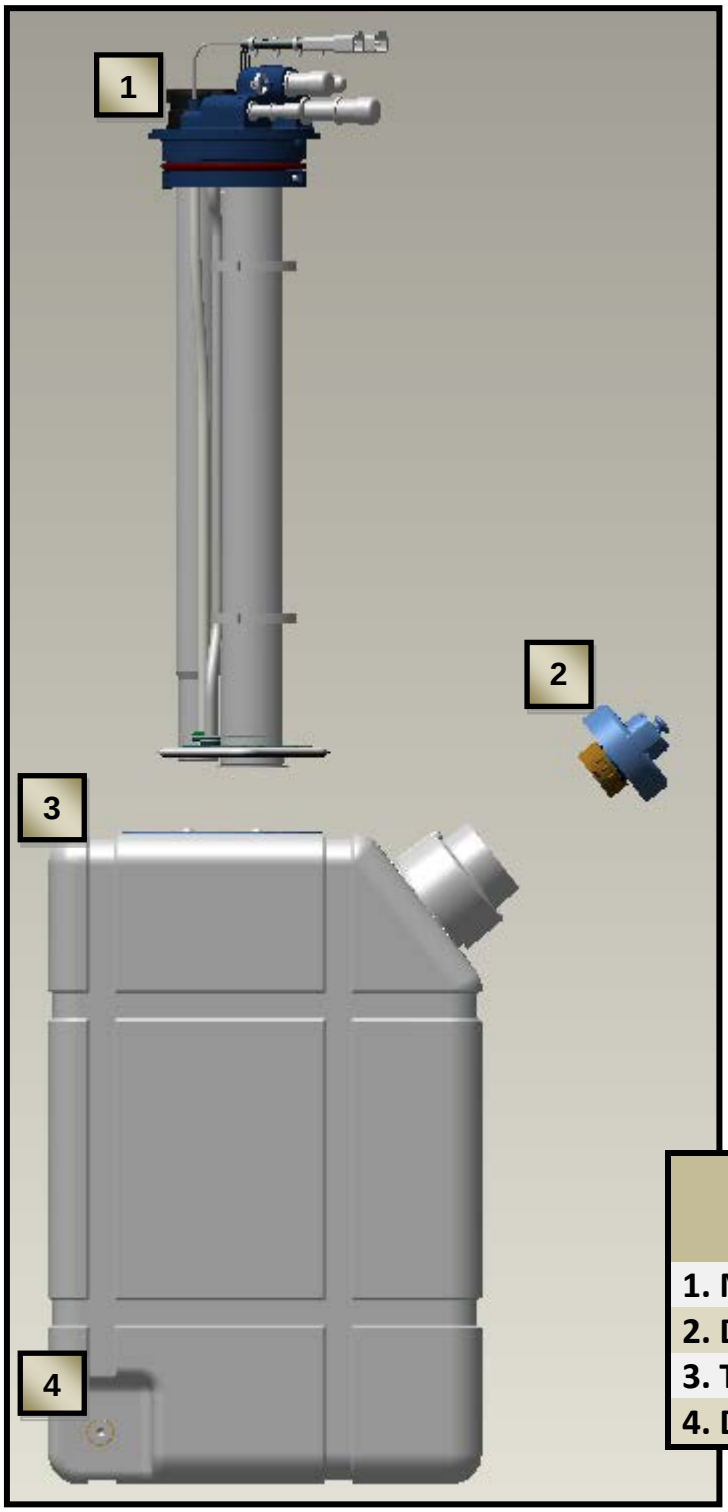
- Freezing point of DEF ≈ 12.2° F (-11° C)
- Maximum Temperature Exposure ≈ 122° F (50° C)
- Urea Concentration: ≈ 32.5%, Water Concentration ≈ 67.5%

DEF is considered a slight irritant. Avoid contact with skin, clothing, or eyes. If it has come into contact with skin, wash the affected area thoroughly with soapy water. If irritation persists, seek medical attention. If it has come into contact with eyes, flush thoroughly with water and seek medical attention if irritation persists. If DEF is ingested, do not induce vomiting, drink plenty of water, and contact a physician if symptoms become present.

1.2 SHAW DEF COMPONENTS

The following section provides a component level breakdown and descriptions of each component. The Shaw Development tank assembly and components will vary from vehicle to vehicle. For detailed descriptions regarding a specific tank assembly model, please refer to the drawing of the part.

DEF Tank Assembly Components



Components
1. Multifunction Head Unit Assembly
2. DEF Cap Assembly
3. Tank & Adapter Assembly
4. DEF Tank Drain Plug

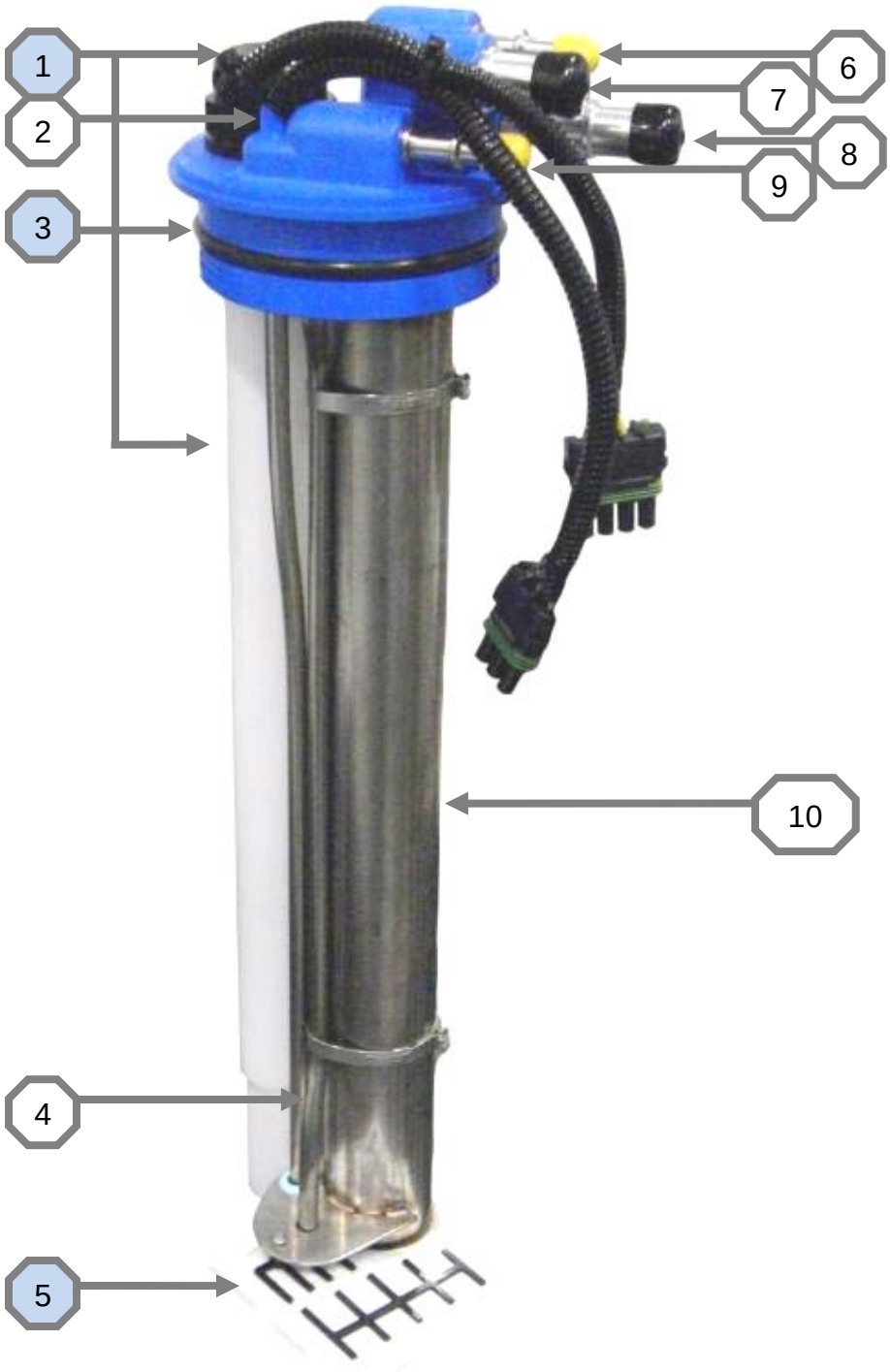
1.2.1 DEF MULTIFUNCTION HEAD UNIT

The Shaw DEF Multifunction Head Unit Assembly (MFHU) can be found on the top surface of the tank in the DEF tank assembly. It is fixed in place by a retaining ring and fastened down by 2 #10-32 screws. While installed in tank, the upper portion of the MFHU can be seen. This upper portion consists of a DEF Suction fitting, a DEF Return fitting, a Coolant Inlet fitting, a Coolant Return fitting, the DEF Level Sensor with wire loom, the DEF Temperature Sensor with wire loom, and a white barcode sticker on the right side of the DEF Suction fitting.

The bottom assembly of the MFHU consists of a coolant heater tube, DEF Suction Tube, Level Sensor Focus Tube, and a filter element with retention screw. The diagram below identifies each component of the MFHU and provides a description of its purpose. The Level Sensor, DEF Suction Filter, and Bore Seal O-ring are replaceable components of the MFHU. These items are italicized in the chart below and indicated with the symbol, ○, in the following figure for emphasis. Additionally, the Level Sensor, Temperature Sensor, and DEF Suction Filter are described in greater detail in Sections 1.2.1.1, 1.2.1.2, and 1.2.1.3 respectively. The MFHU is designed as a replaceable item. For instruction on removing and installing the MFHU, please refer to Section 3.5.

	Component	***Description***
1.	***Level Sensor w/ Focus Tube***	Refer to Section 1.2.1.1
2.	**Temperature Sensor**	Refer to Section 1.2.1.2
3.	***Bore Seal O-ring***	Prevents leakage of DEF and intrusion of contaminant from entering the tank assembly through the bore seal
4.	**Suction Tube**	The point DEF is drawn from the tank during normal vehicle operations.
5.	***DEF Suction Filter***	Refer to Section 1.2.1.3
6.	**DEF Return Fitting**	Return Point of the DEF tank assembly
7.	**Coolant Inlet Fitting**	Receives heated coolant
8.	**Coolant Outlet Fitting**	Coolant returns to the vehicle
9.	**DEF Suction Fitting**	Dosing point of the DEF tank assembly
10.	**DEF Heater Tube**	Designed to enable heated engine coolant to flow within the tank assembly. This occurs when the DEF is exposed to cold temperatures.

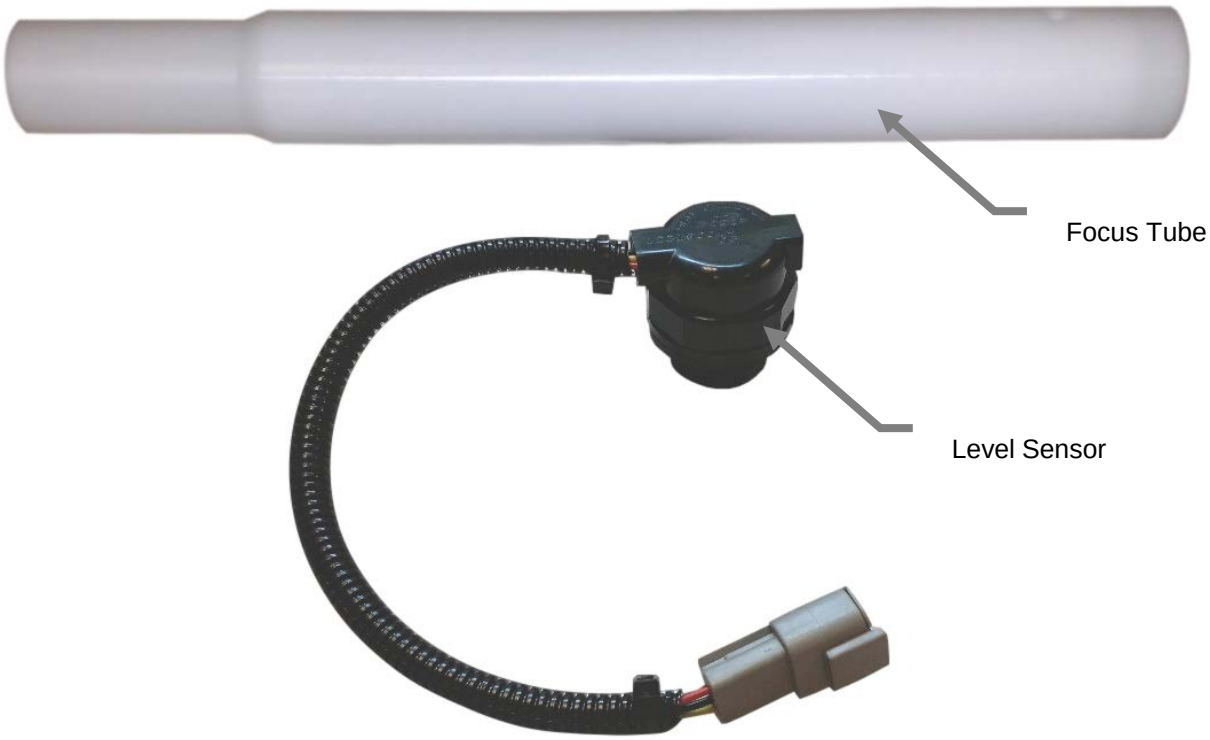
DEF Multifunction Head Unit



1.2.1.1 LEVEL SENSOR

The Level Sensor is the electrical component of the tank assembly responsible for communicating the level of diesel exhaust fluid in the tank to the engine computer. The sensor displayed below is assembled with a Deutsch DTM04 – 3 pin connector, however, other connector styles are available. For information regarding the wiring and voltage input/output for a specific level sensor, please refer to the drawing. If a vehicle is experiencing issues related to the level sensor, it is recommended to perform the troubleshooting procedure described in Section 4.0. The level sensor has been designed as a replaceable item for the DEF Tank assembly. For Removing and Installing the Level Sensor, please refer to Section 3.6.

Image of Level Sensor



1.2.1.2 TEMPERATURE SENSOR

The temperature sensor is the electrical component of the DEF tank assembly responsible for communicating the temperature of the DEF to the engine computer. If the vehicle is experiencing issues related to temperature sensor, it is recommended to perform the troubleshooting procedure described in Section 4.0. The temperature sensor is not a replaceable component of the MFHU.

1.2.1.3 DEF SUCTION FILTER

The DEF Suction Filter is responsible for maintaining the cleanliness of the DEF circulating in the SCR system. Utilizing proper refilling practices is the best method for preventing clogging issues and extending the life of the filter. In the event the tank interior has become contaminated, Shaw Development has designed the filter to be replaceable. For instructions on replacing the filter, refer to Section 3.6. For instructions on cleaning the DEF tank refer to Section 2.1.1.

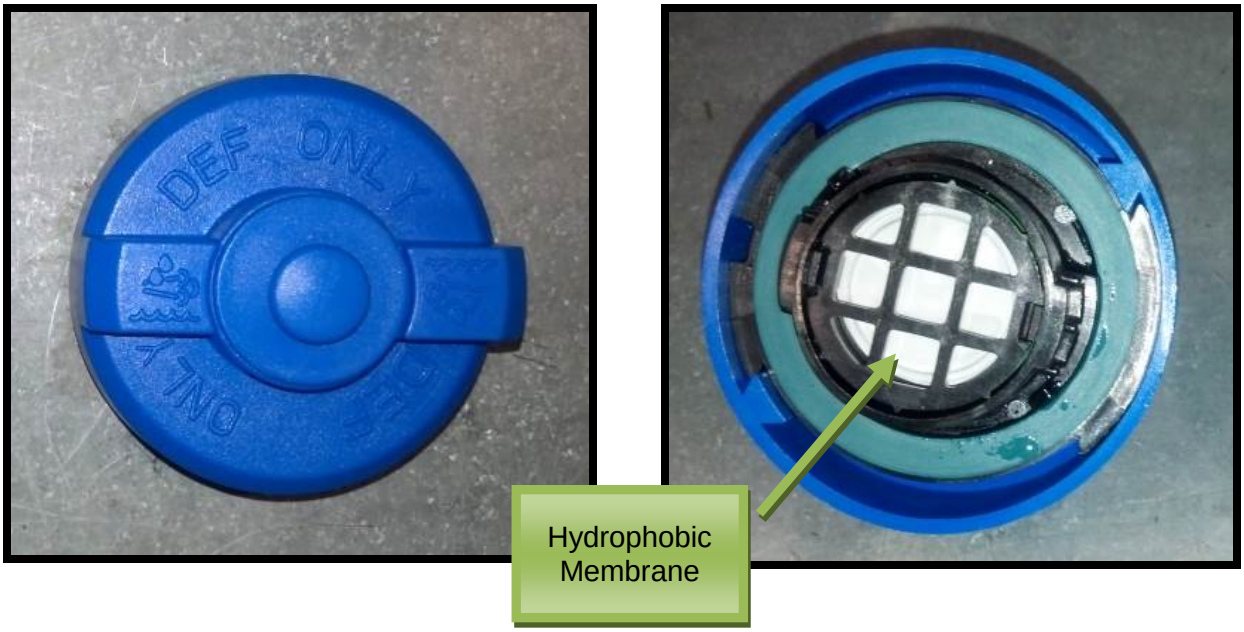
Image of DEF Suction Filter

1.2.2 DEF CAP

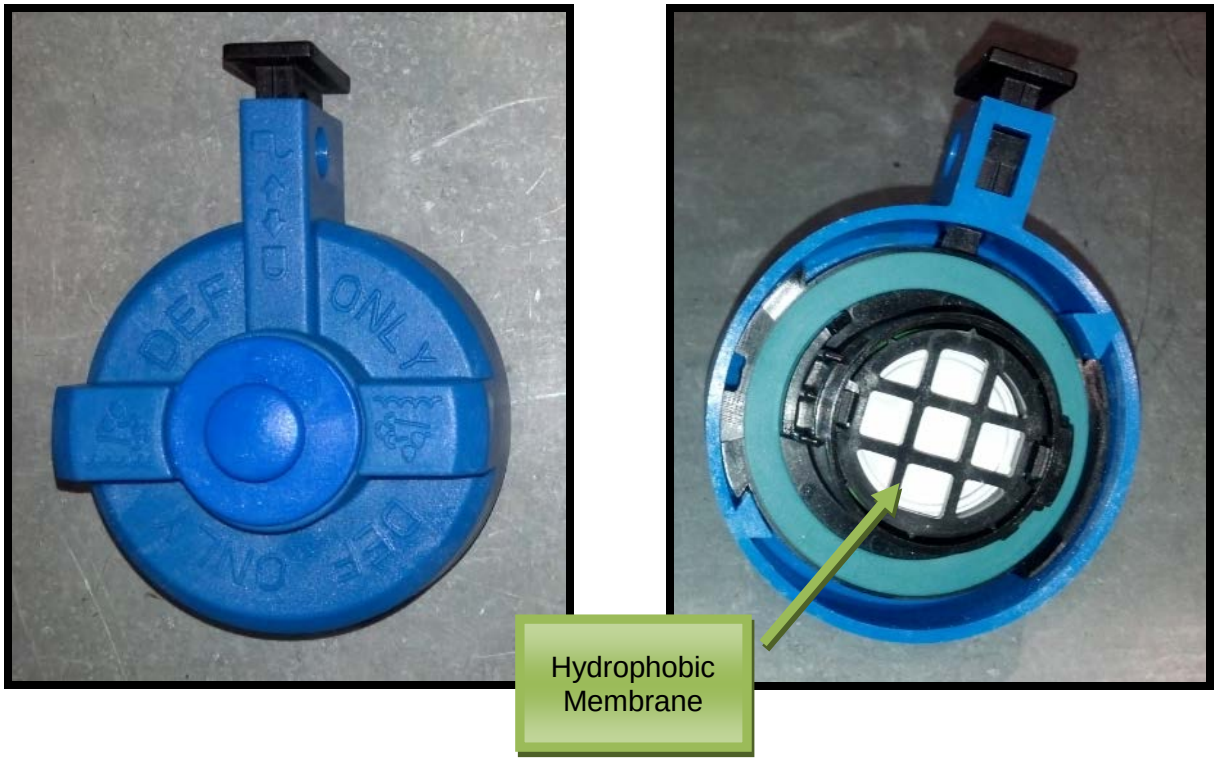
Shaw Development provides 2 standard DEF caps, Locking and Non-locking. The caps are incorporated with a hydrophobic membrane to allow the tank to vent freely. The membrane also prevents DEF fluid from escaping the tank and ingestion of other contaminating fluids from the external environment.

The DEF caps are also designed to create a sealing surface interface with the inlet adapter. The seal also prevents DEF leakage and contamination. Cleanliness of the DEF cap is crucial to maintaining the cleanliness of the DEF and protecting the DEF/SCR system. Proper refilling practices and regular scheduled cleanings can greatly reduce the potential for tank contamination. If the DEF cap appears dirty, refer to Section 2.1.3 for directions on cleaning the DEF cap. The DEF cap is a replaceable item in the event the cap becomes damaged.

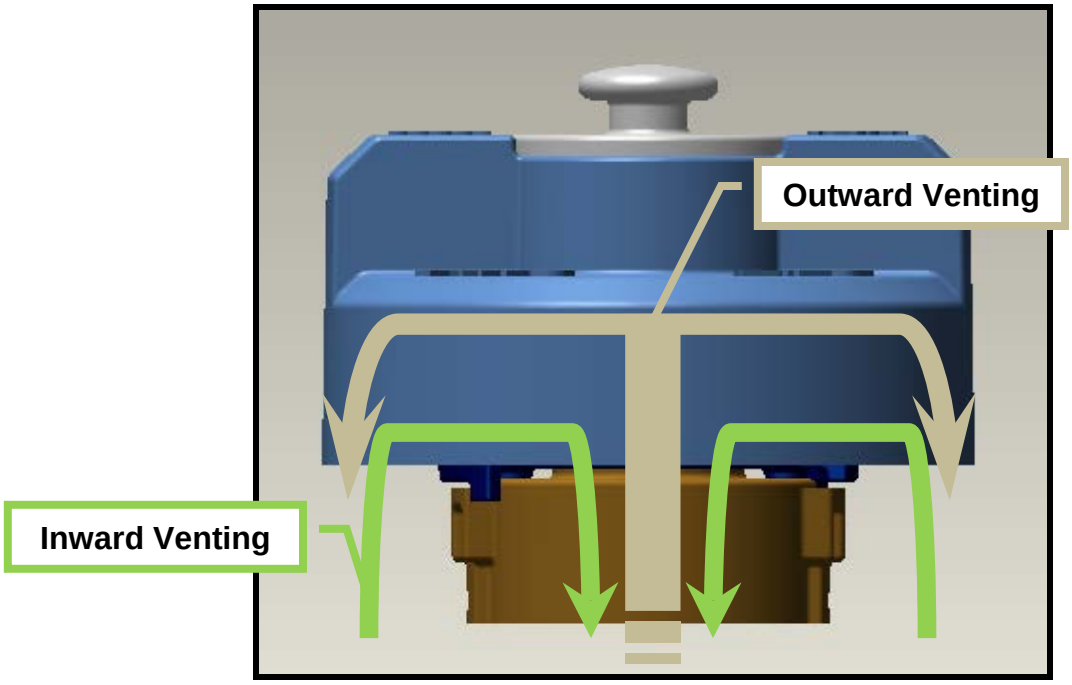
Non-Locking DEF Cap



Locking DEF Cap



DEF Cap Ventilation Pathway



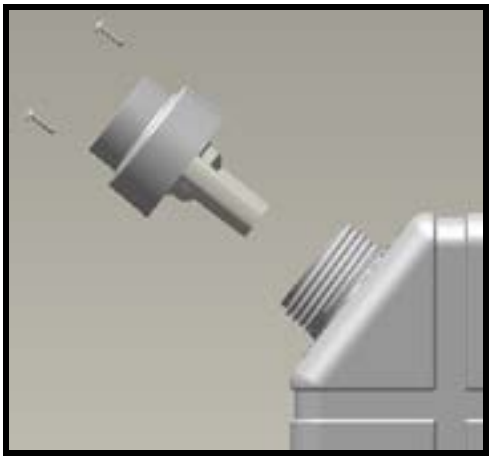
1.2.3 TANK AND ADAPTER ASSEMBLY

Shaw Development offers three tank inlet adapter configurations: Buttress Threaded, Bolt-on, and Remote Fill. All three styles are designed in accordance with ISO-22241. Additionally, each adapter is designed with a magnetic interface; enabling refilling at all ISO-22241 approved fill stations. The following sections provide important information regarding the different fill adapters and their performance.

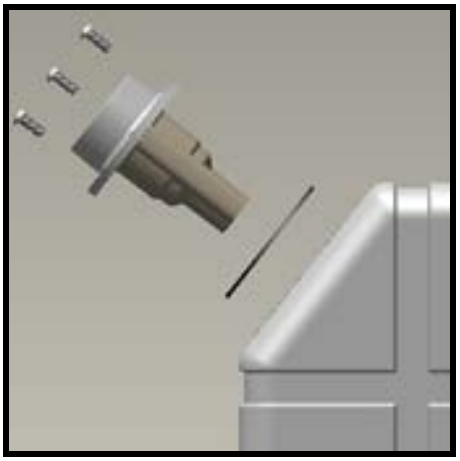
Buttress Thread / Bolt-on Adapters

The Buttress Threaded adapter and Bolt-on adapter differ in how they are fastened to the tank. The Buttress Threaded adapter is threaded onto the tank fill inlet and fixed by 2 screws. The buttress threaded adapter seals the tank/adapter interface with an O-ring located in the upper interior portion of the adapter. The O-ring prevents DEF from seeping out in the event of sloshing. The Bolt-on adapter is fastened to the tank with 6 bolts and sealed with a gasket. Refer to the images below for visual aid. Please note that the adapter assemblies on the DEF tank assembly are not replaceable items.

Buttress Threaded Adapter



Bolt-On Adapter



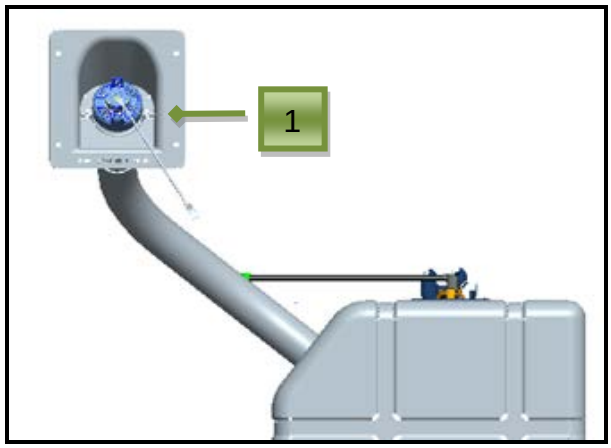
The Buttress Threaded and Bolt-on Adapters perform identically in regards to venting and enabling magnetic actuation of the DEF magnetic fill nozzle. Both adapters are equipped with fill restrictors as indicated in the picture below. The purpose of the fill restrictor is to decrease the potential of overfilling the DEF reservoir. Overfilling the DEF tank could adversely affect the tank's performance and potentially damage to tank assembly in cold environments [ambient temperature ≤ 12°F (-11°C)]. In cold environments, DEF can experience an expansion of up to 15-20%. This expansion will deform and potentially damage to the internal components of the assembly. For information on proper refilling techniques, please refer to Section 3.1.

DEF Inlet Adapters

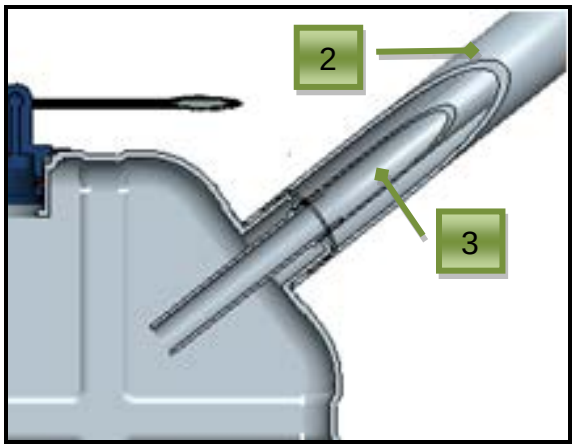
Remote Fill Design

The remote fill design consists of 3 main components: (1) spill pan, (2) outer hose, & (3) inner hose. The images below identify each of these components.

Image of DEF Tank Assembly w/ Remote Fill Adapter Design



Interior of DEF Tank Assembly w/ Remote Fill Adapter Design



The 1” (2.54 cm) inner hose is installed inside the 2” (5.08 cm) outer hose and directs the flow of DEF during refilling. As shown in the image above, the inner hose extends into the tank interior. This extension is critical in preventing the fluid from overfilling the tank during refilling. Any alterations to this extension are prohibited. The 2” outer hose provides a vent path for the tank assembly during refilling and normal vehicle operation. The spill pan assembly is the refill inlet of the remote fill assembly. The outlet of the spill pan adapter is designed with surfaces for the inner and outer hoses to clamp on to.

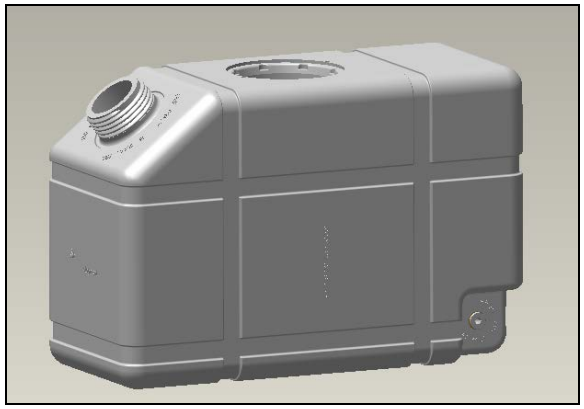
Tank Designs

The standard DEF reservoirs are available in Small, Medium, and Large sizes. Each tank size comes in Landscape (LS) and Portrait (PT) orientations. Small, Medium, and Large reservoirs roughly hold 5 gallons (18.9 L), 10 gallons (37.9 L), and 15 gallons (56.8 L) of DEF respectively. There is also a 10 gallon (37.9 L) Cube design and for large vehicle applications Shaw is introducing a 25 gallon tank assembly. Refer to the chart below for referencing.

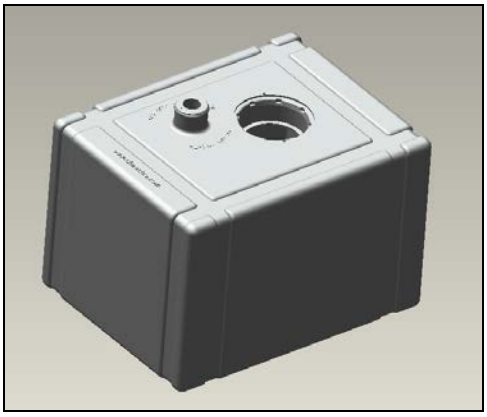
Tank ID	DRC01	DRC02	DRC03	DRC04	DRC05	DRC06	DRC07	Custom
Tank Desc.	5 Gal. LS	5 Gal. PT	10 Gal. LS	10 Gal. PT	15 Gal. LS	15 Gal. PT	10 Gal. Cube	25 Gal. tank

Tank Designs

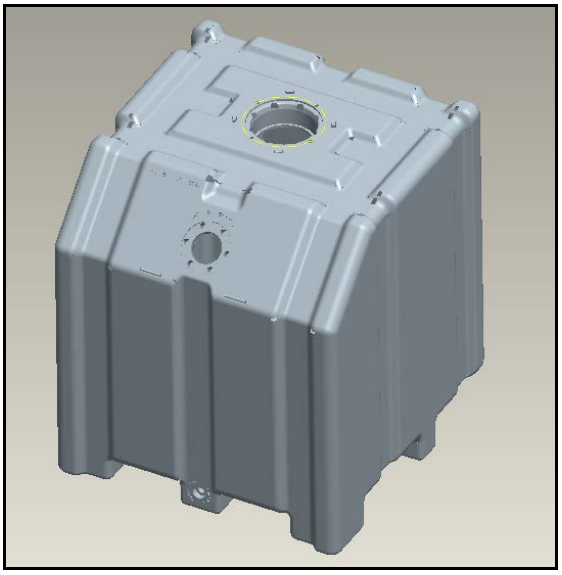
Landscape [LS]



10 Gal Cube



25 Gallon Tank



Portrait [PT]

1.2.4 DEF DRAIN PLUG

The DEF drain plug enables users to drain the tank. Some reasons for draining the tank include DEF contamination, interior cleaning of the tank, and overfill. The DEF drain plug is a replaceable item. For directions on replacing the DEF drain plug or draining the DEF tank assembly via the drain plug, please refer to Section 2.3.

It is highly recommended that DEF drained from the tank be discarded and not reused to prevent contamination.

Image of DEF Drain Plug location

2.0 OPERATION & MAINTENANCE

2.1 CLEANING

Scheduled cleaning of the DEF tank assembly is allowable in preventing DEF contamination and prolonging the life of the DEF tank assembly. The following section provides important information on cleaning the DEF tank assembly. Ensure that these steps are performed correctly in order to avoid contamination and performance related issues.

2.1.1 CLEANING THE EXTERIOR OF THE TANK ASSEMBLY

1) Verify the area around the refill inlet is clean enough to remove the DEF cap without debris falling into the inlet of the adapter. If so, remove the cap and inspect the underside for cleanliness.

    a. If the underside of the cap appears dirty, refer to Section 2.1.3 for cleaning. Once cleaned, replace the cap firmly on the DEF adapter.

    b. If the underside of the cap does not appear dirty, continue to step 2.

2) Verify the DEF cap is securely fastened to the adapter. Inspect the rest of the tank assembly for any noticeable leak paths where water can penetrate.

    a. If leak paths are found, contact your Shaw DEF tank provider and inform them of the defect.

    b. If no defects are found continue to step #3.

3) Begin rinsing the tank assembly using water (and soap if needed). With the exception of the cap/adapter interface, the tank assembly can withstand pressures up to 2000 psi for pressure washing. Do Not apply direct pressure to the Cap/Adapter interface. Ensure all debris (i.e. dirt, fuel, oil, hydraulic fluid, etc.) is completely rinsed off and pay close attention to areas near the MFHU and the top side of the cap adapter assembly.

2.1.2 CLEANING THE INTERIOR OF THE TANK ASSEMBLY

The interior of the tank assembly may need to be cleaned in the instance of tank contamination. Tank contamination is the intrusion of liquid and particles that do not make up 32.5% concentrated DEF. If left untreated, contamination can cause clogs along the DEF hose lines and/or damage components of the SCR system. The following instructions describe the proper steps for cleaning the interior of the Shaw DEF tank assembly.

1) Drain the tank. For instruction on removing and installing the DEF drain plug refer to Section 2.3. Properly discard the contaminated DEF.

Do not attempt to filter or otherwise reuse the contaminated DEF.

2) Once the tank has been completely drained, remove the Multifunction Head Unit from the tank. Refer to Section 3.4A for instructions on removing the MFHU.

3) Once the MFHU is removed, inspect the debris saturation of the filter element to determine if the filter needs to be replaced.

    a. If the filter is damaged or dirty, replace the filter. Refer to Section 3.5 for instructions for replacing the DEF filter element.

    b. If the filter is not damaged or dirty, continue to step 4.

4) Begin to rinse out the interior of the DEF tank using an ordinary hose or pressure washer. Attempt to rinse all the debris out through the drain port of the tank. Detergent may be used to clean off the tank. Ensure that all the

areas where debris can potentially enter the tank is cleaned off, to include: bore seal, DEF cap, interior and exterior of the adapter assembly, and the drain port.

a. If the DEF cap needs to be cleaned, refer to Section 2.1.3 for instruction on cleaning the DEF cap.

5) Rinse off the MFHU from top to bottom with low pressure, ensuring that all the debris has been removed.

6) Reinstall the MFHU per Section 3.4b.

7) Reinstall the drain plug per Section 2.3 to fill the tank and verify no leakage occurs.

2.1.3 CLEANING THE DEF CAP

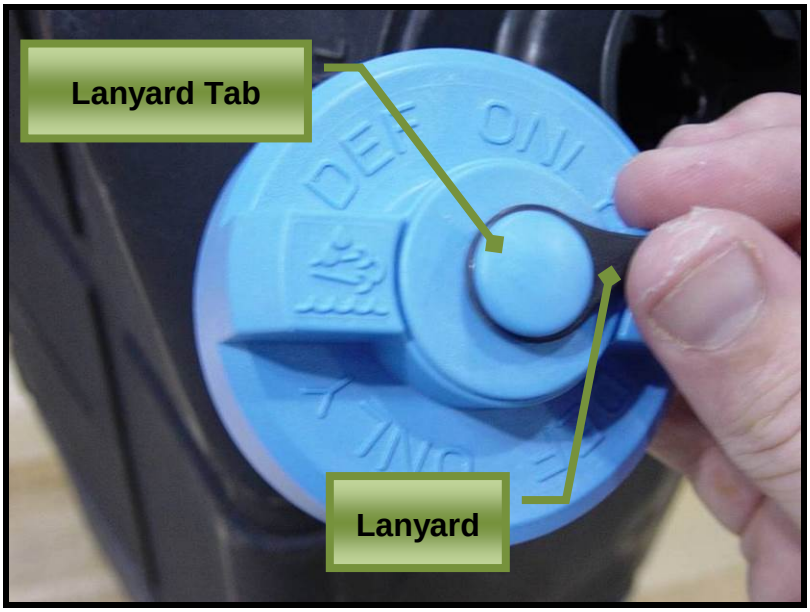
Poor maintenance practices may incur buildup of DEF crystals and debris on the outer surface and under side of the DEF cap. If left untreated, contaminants may accumulate. This accumulation may compromise the main seal of the cap and eventually infiltrate the tank interior. As mentioned in Section 2.1, tank contamination can impact the overall performance of the entire vehicle SCR system. Cleaning the cap will help in preventing DEF contamination. The following procedure provides instructions for cleaning the DEF cap.

1) Wipe off the cap and adapter to prevent any debris from entering through the inlet.

2) Grip the cap and turn counter clockwise unit the cap stops turning.

3) Pull the cap off of the adapter (If the cap has a lanyard, it will still be attached to the reservoir).

Lanyard Only Caps: Take the lanyard attached to the Lanyard Tab of the cap and slide it over the tab so that the cap can be removed. See two photographs below.



4) Place the cap in a pan of water filled such that the level of the water is half way between the bottom of the blue base and the surface where the words “DEF ONLY” resides. Allow the cap to soak for approximately five (5) minutes. See the photograph below.

Ensure the cap does not become completely immersed in water as this may affect the venting capabilities of the cap.

5) Shake cap so that any remaining water within the cap assembly is drained.

6) If any DEF crystals or dirt remain on the seal, wipe the seal with a damp cloth.

7) Wipe down the tank adapter with a damp cloth. Replace the cap onto the adapter.

8) Turn the cleaned cap clockwise until it stops.

Lanyard Only Caps: To re-attach the lanyard, take the small opening of the lanyard and slide it over the Lanyard Tab of the cap so that it fits into the groove.

2.2 FILLING THE DEF TANK

When filling the DEF tank assembly, ensure the filling process or procedure is in compliance with following cautionary notes provided below. If further clarification for handling, storing, and transporting DEF is required, please refer to ISO-22241. It is critical that vehicle operators safely and properly execute refilling practice while adhering to these notes to avoid potential performance related issues of the Shaw DEF system and SCR system.

Do not put DEF in the fuel tank, or any fluid other than DEF in the DEF reservoir. This will cause engine damage and/or damage to the SCR unit.

Use only API (American Petroleum Institute) or DIN certified Diesel Exhaust Fluid (per ISO-22241). Improper fluids or contaminated DEF may lead to high Nitrogen Oxide emissions and damage the SCR system including the DEF assembly. If the DEF tank is considered contaminated refer to Section 2.1.2. Contaminated SCR systems should be serviced at an authorized dealer.

Do NOT use DEF beyond its expiration date or if it has been stored in conditions over 86°F (30°C) for extended periods of time. This temperature exposure will cause degradation to the DEF.

Do NOT attempt to top off the tank. Overfilling the tank can inhibit the tank's overall performance and potentially damage the assembly due to expansion of the fluid.

Ensure the cap and adapter are clean prior to cap removal and filling; this helps prevent tank contamination. Clean off any DEF that may have spilled onto the tank to maintain cleanliness of the tank assembly.

2.2.1 STATION OR BULK FILLING VIA PUMP AND NOZZLE

Nozzle filling is the preferred method of refilling the DEF tank assembly. All approved DEF fill stations should utilize magnetic actuating DEF nozzles designed per ISO-22241. Shaw Development has designed the Shaw DEF adapters in accordance with ISO-22241 to compliment the functionality of DEF nozzles. Furthermore, Shaw DEF adapters are designed to prevent overfilling when using the magnetic actuating DEF nozzle. The procedure below describes how to fill the DEF tank with an ISO-22241 approved magnetic actuating DEF nozzle.

Nozzle filling the DEF tank Assembly

1) Prior to removing the DEF cap, inspect the outside surface of the cap and surrounding areas for any signs of debris that may fall into the tank when the cap is removed.

   a. If debris has accumulated on the DEF tank assembly, clean it off before removing the cap. Refer to section 2.1.1 for instructions on cleaning the DEF tank assembly.

   b. If no debris is found, continue to step 2.

2) Inspect the cleanliness of the underside of the DEF cap.

   a. If the cap appears dirty, try to clean it off. Refer to Section 2.1.3 for instruction on cleaning the DEF cap. Once cleaned, replace the cap firmly on the DEF adapter.

   b. If the cap does not appear dirty, refer to step 3

3) Set the cap aside unless the cap is attached to a lanyard. If the cap is not attached to a lanyard, ensure that it is placed in a location where it is not vulnerable to debris exposure.

4) Insert the nozzle securely into the inlet adapter.

5) Depress the nozzle handle, enabling DEF flow into the tank assembly.

6) Continue DEF flow until the nozzle automatically shuts off.

Do NOT repeatedly depress the nozzle handle after the nozzle's initial automatic shut-off as this might cause the DEF tank to overfill.

7) Remove the nozzle and replace the cap onto the adapter.

2.2.2 BOTTLE FILLING

Bottle filling is the least preferred method for refilling the DEF tank. Bottle filling is considered a high risk refilling method for a variety of reason. Some of these reasons include:

- Increased potential for overfilling the tank assembly.
- Increased potential for physical contact with the fluid.

- Increased potential for spillage.

It is highly recommended to fill the DEF tank assembly using an authorized ISO-22241 approved DEF nozzle. The following procedure will provide instructions for bottle filling the DEF tank assembly.

NOTE: Bottle filling should only be conducted with DEF containers that have been approved by and have been stored in accordance with ISO-22241-3. Additionally, ensure the container(s) are not contaminated with insoluble particles in the fluid (i.e. insects or dirt), or bottles that have been knowingly stored continuously at temperatures greater than 86°F (30°C) for more than 18 months.

Bottle filling the DEF tank assembly requires the use of Personal Protective Equipment to include but not limited to goggles and gloves.

Bottle Filling the DEF tank assembly

1) Take the cap off of the Diesel Exhaust Fluid bottle. Twist the spout onto the opening until it becomes locked into place (if applicable).

2) Prior to removing the DEF cap, inspect the outside surface of the cap and adapter for any signs of debris that may fall into the tank when the cap is removed.

   a. If debris has accumulated on the DEF tank assembly, clean it off before removing the cap. Refer to section 2.1.1 for instructions on cleaning the DEF tank assembly.

   b. If no debris is found, continue to step 3.

3) Insert the outlet end of the spout into the inlet of the adapter until the end of the spout is seated completely in the fill port.

4) If attempting to top off the tank, fill the tank slowly while frequently checking for the DEF fluid line to rise to the bottom of the adapter inlet. When checking the fluid line in the tank, bring the DEF bottle to level and lower the bottle to where the remaining DEF in the spout returns to the container. Then remove the spout from the adapter inlet by hand and look for the fluid line inside the tank adapter inlet. If the fluid line is not at the desired level, replace the spout and continue refilling.

NOTE: DEF will not completely fill the spout of the bottle while flowing; air will also be trapped inside.

5) When the reservoir has been filled, place the DEF cap back onto the tank.

6) Uninstall the spout from the container and place the cap back on the bottle.

7) If the container still has DEF inside, store it for later use, otherwise, dispose of the container and nozzle in the correct manner.

8) Clean any spilled DEF immediately with fresh water to prevent corrosion to the system or vehicle components.

2.3 DRAINING THE DEF TANK ASSEMBLY

The DEF tank assembly is capable of quick draining via the removal of the DEF drain plug. The following procedure describes how to safely remove the DEF drain plug from a filled DEF tank assembly.

Refer to vehicles service manual for safety regulations and recommendations when servicing the vehicle.

Draining of the DEF tank needs to be conducted in a well-ventilated area, as the ammonia vapors may cause irritation.

NOTE: It is highly recommended that the volume of DEF drained from the DEF reservoir be properly discarded to avoid potential contamination of the DEF tank assembly. If the DEF is expected to be reused or stored for later use, the fluid should be contained and stored in compliance with ISO-22241. Failure to comply may result in degradation of the DEF.

<u>DEF drain procedure via removal of the DEF drain plug</u>

1) Turn vehicle off.

2) Position an auxiliary reservoir directly beneath the drain plug outlet. Ensure that the opening of the auxiliary reservoir is wide enough for the DEF to flow into with spillage, and the reservoir is large enough to carry the volume of DEF in the DEF reservoir without spillage.

3) Remove the DEF cap and set aside on a clean surface.

4) Using the ¼" Allen Wrench, unscrew the drain plug from the reservoir by turning in the counterclockwise direction. Place drain plug in a location that is free from debris.

5) Allow tank to drain to desired level.

6) Rethread the plug onto the drain plug port by screwing in the clockwise direction. Tighten the plug 40 - 60 in. lbs. (4.5 – 6.7 N m) of torque.

7) Refill the tank to verify no leakage occurs.

3.0 REMOVAL AND INSTALLATION INSTRUCTIONS

The following sections provide instructions for removing and/or installing various components of the DEF tank assembly.

3.1 DEF TANK MOUNTING BRACKET

Complete DEF Tank assembly w/ mounting brackets and tank hanger assembly

Positioning of DEF tank assembly on vehicle

When mounting the DEF tank assembly onto a vehicle the following criteria should be verified to prevent potential damage or impaired functionality to the DEF tank assembly.

Avoid mounting DEF reservoirs in areas that are debris prone or exposed to high temperatures as this may damage the reservoir and/or contaminate the DEF.

The bracket material should be compatible with intermittent exposure to DEF such as splash.

Ensure the tank assembly is protected from projectile debris during vehicle operation. The degree of protection will vary with vehicle applications.

Ensure any hoses being routed in close proximity to the mounting brackets are protected against any sharp edges, movement, and friction against the brackets, as this could cause a leak and/or damage to the SCR System.

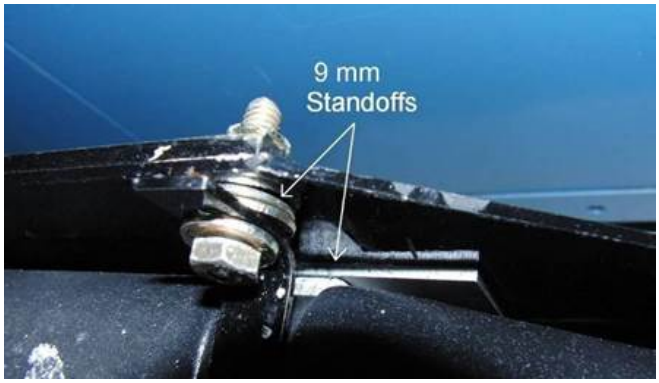
Ensure the tank assembly is not a step point.

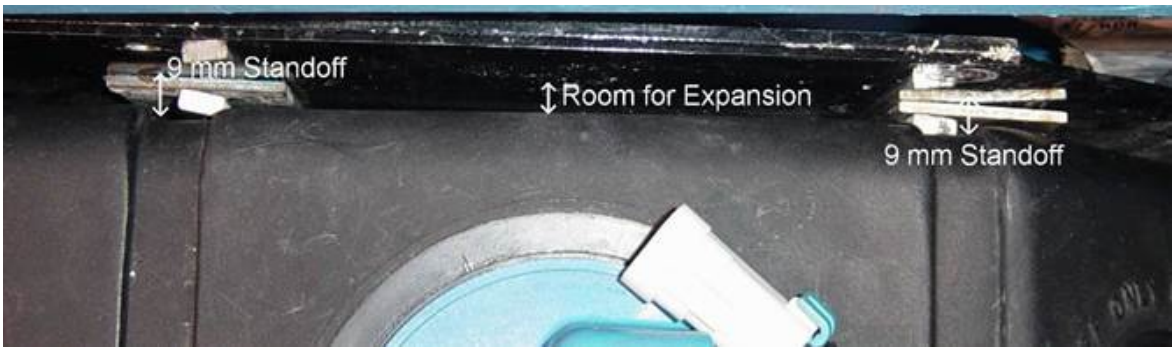
Ensure the nozzle clearance meets ISO-22241 allowing for easy access for filling and avoid areas where the reservoir could be exposed to service fluids.

The DEF tank assembly should be mounted with easy access to the drain port on the bottom corner of the tank in the instance the tank may need to be drained. Additionally, the drain port should be away from critical components on the vehicle.

The tank should never be mounted in such a way that the tank becomes deformed (i.e. concave/convex sidings, indentation, etc.)

If the DEF Tank Assembly is mounted against a wall or on multiple sides, a minimum of 9 mm standoff should be available between the reservoir's strap grooves with the mounting bracket wall or sides, and strap bolts with mounting bracket wall and sides, to allow room for expansion.

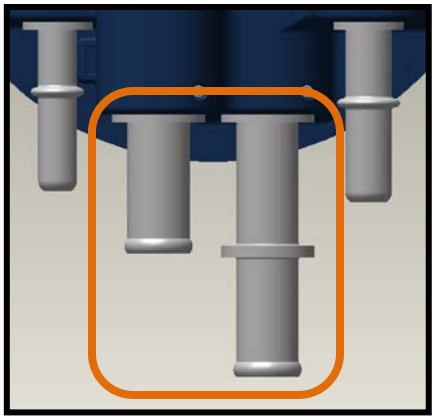




3.2 COOLANT HOSES

The coolant fittings used for the coolant hose interface on the Multifunction Head Unit are hose bead fittings. The hose bead design enables easy disassembly for servicing. (Refer to images below for visual aid)

Top view of MFHU w/ Hose Beaded Coolant Fittings



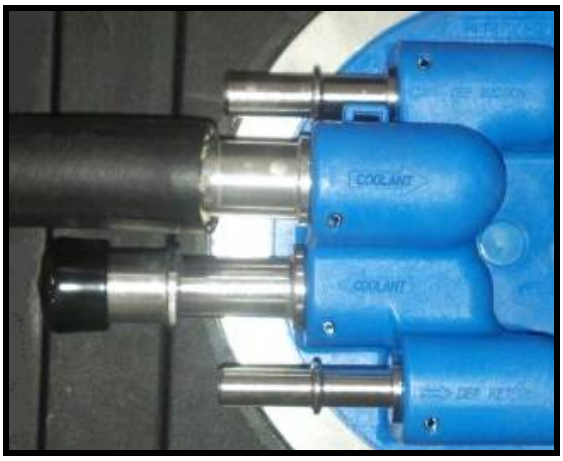
Procedure for installing Coolant Hoses:

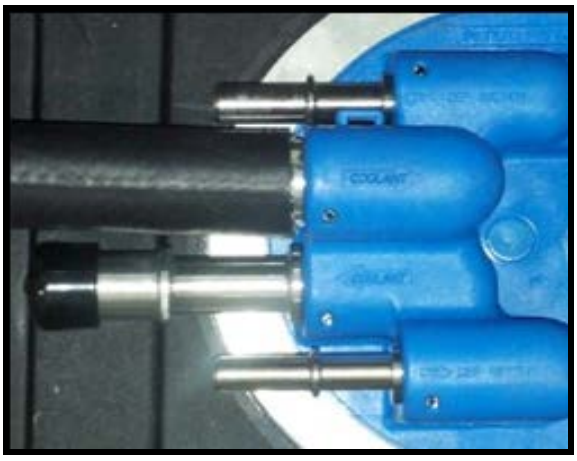
The following procedure provides instructions for properly installing the coolant hoses onto the coolant fittings of the head unit. This procedure displays the use of worm clamps; however other forms of fasteners can be used.

NOTE: During initial installation, avoid removal of the fitting caps until the coolant hoses are ready for installation. This prevents debris from entering the coolant lines.

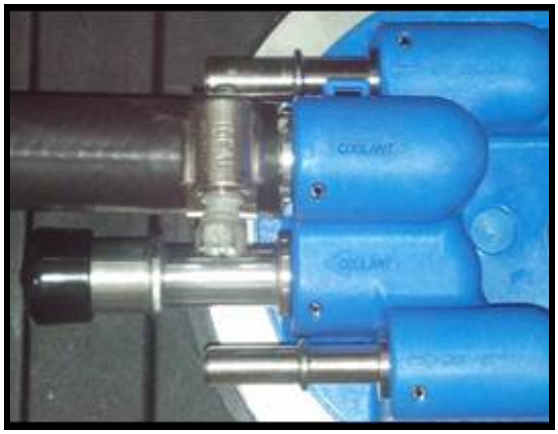
1) Slide the hose clamp over the hosing before installing on the head unit.

2) Push the hosing onto its respective coolant fitting. Refer to the arrows on the mounting base indicating the direction of the coolant flow. The hose should be pushed up onto the stopping point of the fitting.





3) Slide the hose clamp over the hose covering the fitting up to approximately 2/3 the length of the fitting.



4) Tighten with a flathead screwdriver until the clamp feels snug.

Do not over tighten the hose clamp as this may cut through the hosing and may cause a fluid leak.

Ensure the clamp is oriented in such a way that does not conflict with the installation of the other coolant and DEF hoses and for ease of future servicing.

After assembly, confirm the hoses themselves aren't kinked in any location, are free of debris, and aren't close to any kind of heat source and sharp edges.

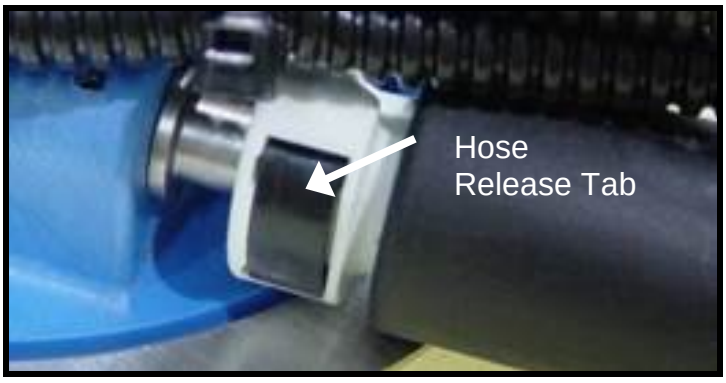
3.3 DEF HOSES

The purpose of this section is to demonstrate the proper procedure for removing and installing the DEF hoses. The DEF Hoses vary in length and connector size and are in accordance with SAE J2044 fittings. Additionally, some DEF hoses are electrically heated to prevent icing inside the hoses in cold environments. It is important to verify hose length, quick connector size, and wire connector are all correct prior to installation.

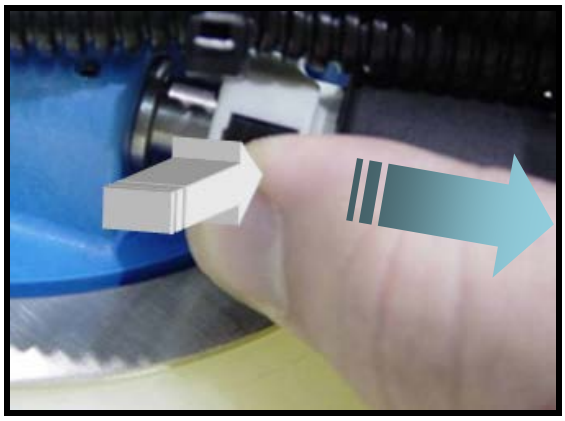
After assembly, confirm the hoses themselves aren't kinked in any location, are free of debris, and aren't close to any kind of heat source and sharp edges.

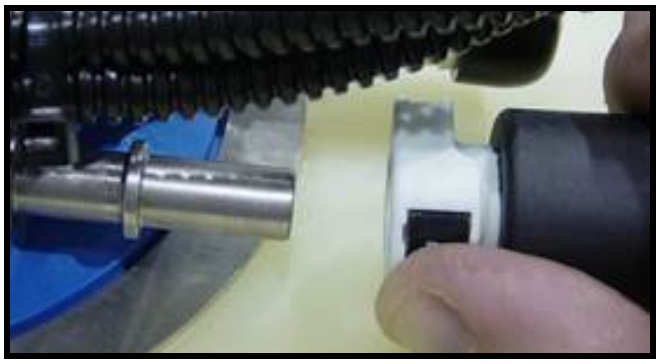
<u>Install of DEF Hoses (Outward facing release tab):</u>

1) Turn the hose so that the DEF fitting release tab can be accessed



2) Place thumb over the tab and push inwards, while simultaneously applying a pulling force on the hose connector. Completely remove the hose off the fitting.



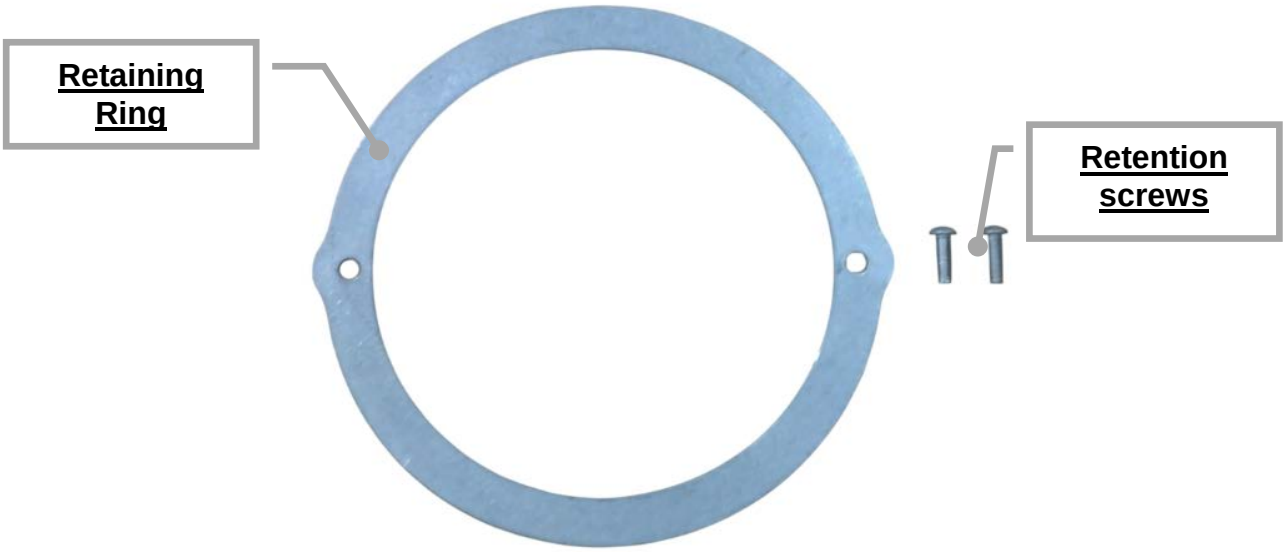


3) Replace with new hose and connector, pushing onto the fitting until an audible click can be heard and the hose and connector are locked into place.

3.4 MULTIFUNCTION HEAD UNIT ASSEMBLY

The purpose for this procedure is to demonstrate the proper steps for installing the Multifunction Head Unit in a DEF tank. Failure to adhere to the following procedure increases the risk of damaging the DEF reservoir assembly and/or personnel. Below is a list of terms used to describe different components of the MFHU.

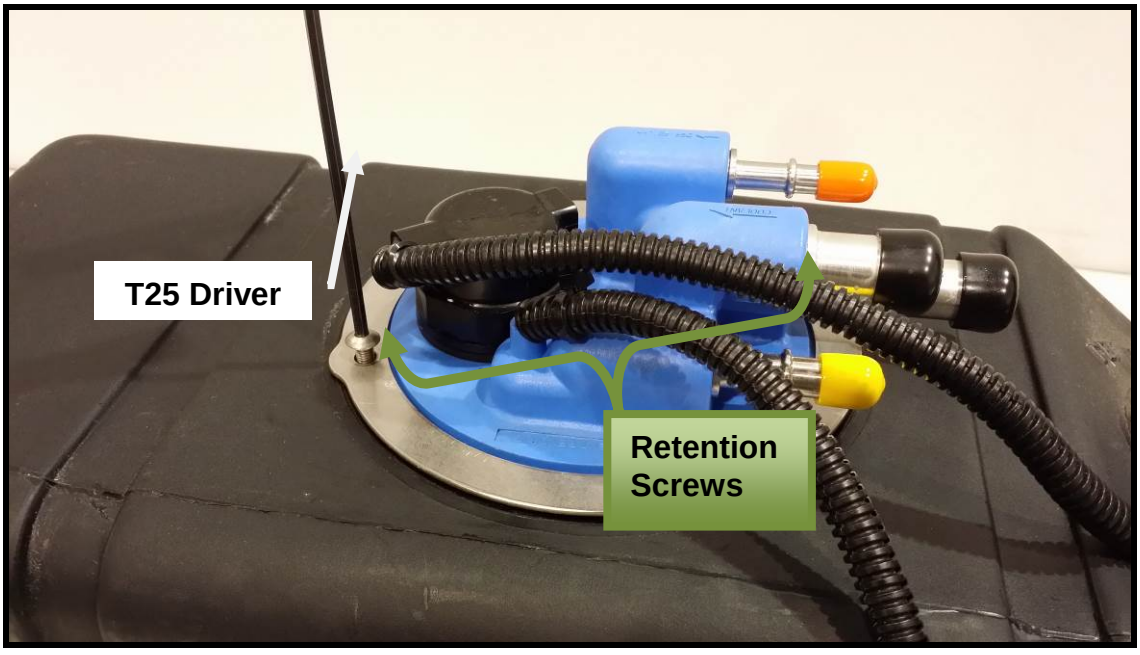
DEF Multifunction Head Unit Components Terminology

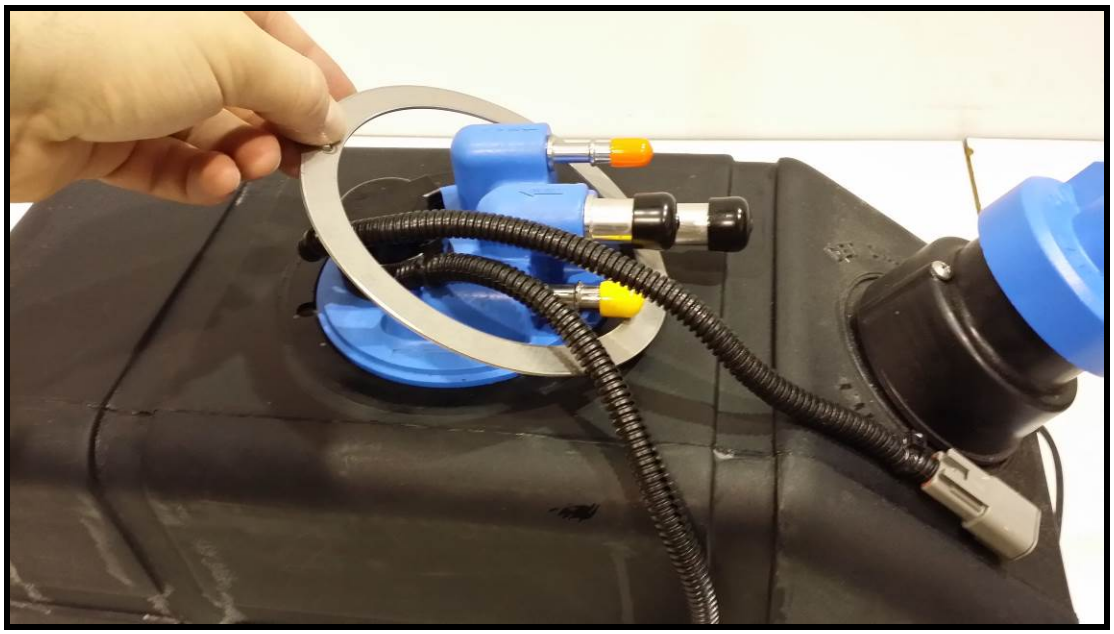


A) MFHU Removal Instructions:

Removal and installation of the Multifunction Head unit requires the use of Personal Protective Equipment including but not limited to goggles and gloves.

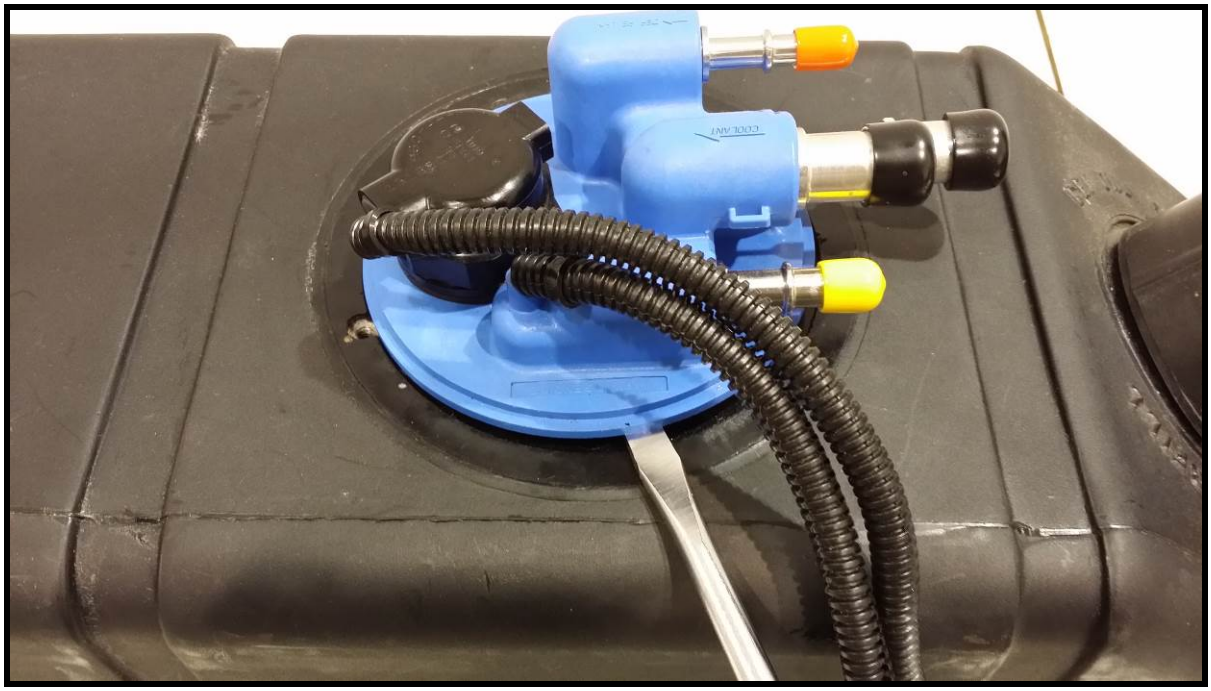
1) . Using a T25 Torx Driver, unscrew the retention screws that secure the Retaining Ring to the reservoir. Remove the retaining Ring.





2) Using a flathead screwdriver, gently pry around where the head unit is connected to the reservoir while simultaneously pulling on the top of the unit. Continue until DEF mounting base is free from reservoir.

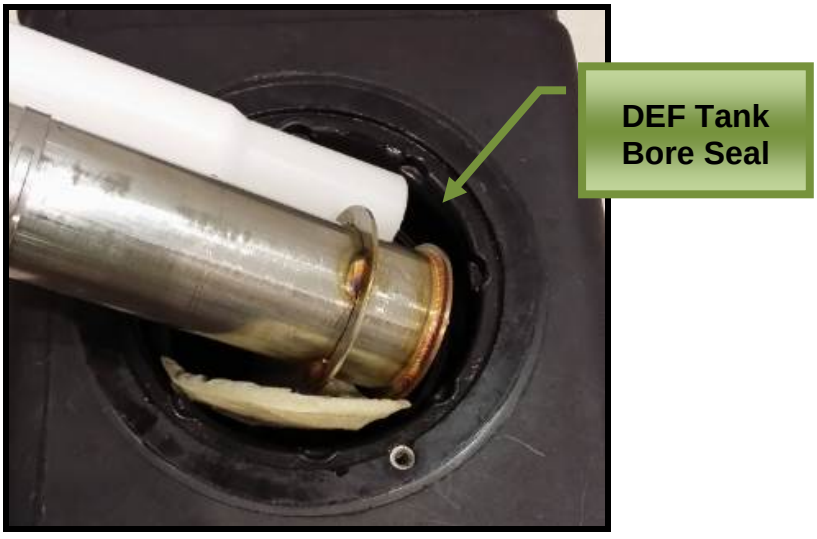
***DO NOT** pull on the wires or fittings.*



3) Pull the DEF head unit out until the bottom of the header is at the bottom of the tank bore.

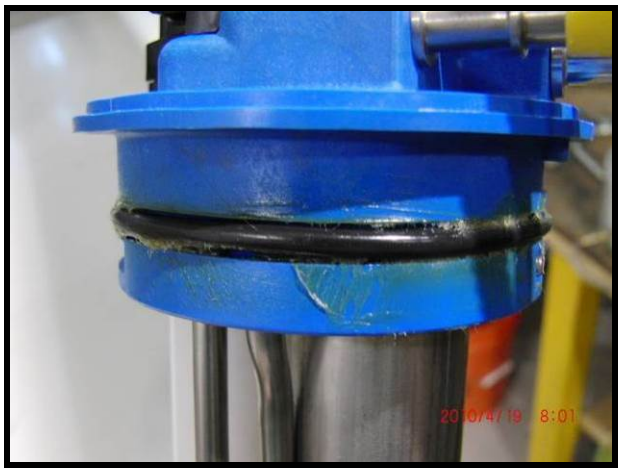
4) Angle the head unit and fold the filter element upwards. Continue to carefully remove the header out of the tank bore until completely freed.

DO NOT pull directly out as this might damage the head unit and bore seal.



B) MFHU Installation Instructions

5) Apply a thin layer of O-ring lubrication to the Bore seal O-ring.



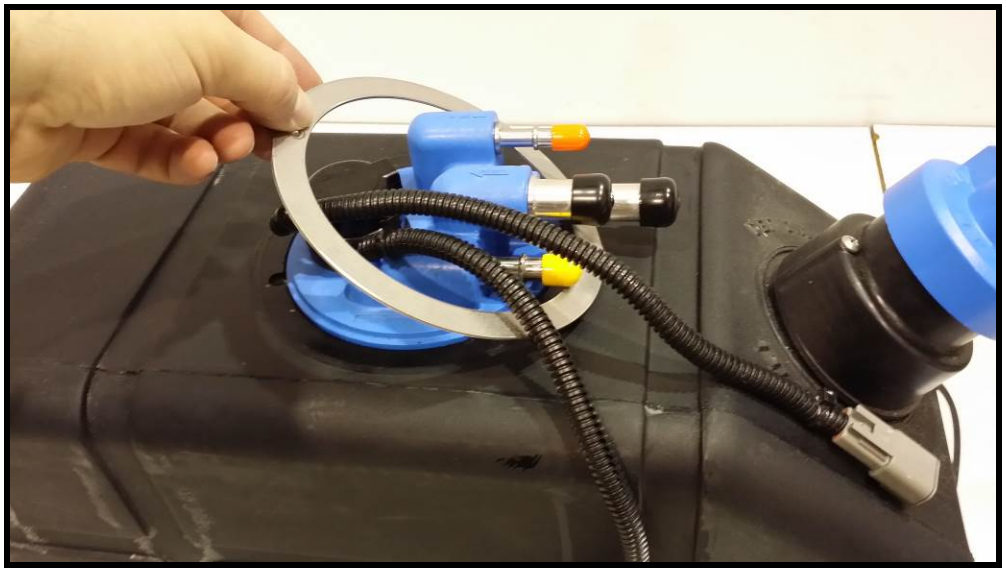
6) Fold the filter element upward and position the bottom of the header inside the tank bore at an angle. Work the header until the bottom of the header and filter are inside the tank.

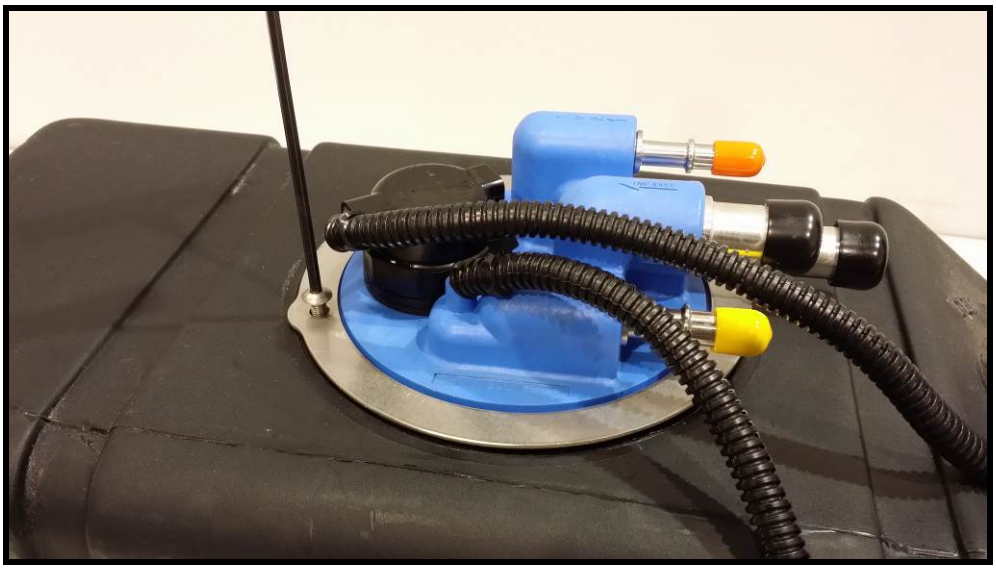
DO NOT push the MFHU directly into the tank as this could damage the unit.

7) Position the DEF head unit in the desired orientation and press on the top of the blue mounting base until it is completely seated in the tank bore.

DO NOT press directly on the fittings.

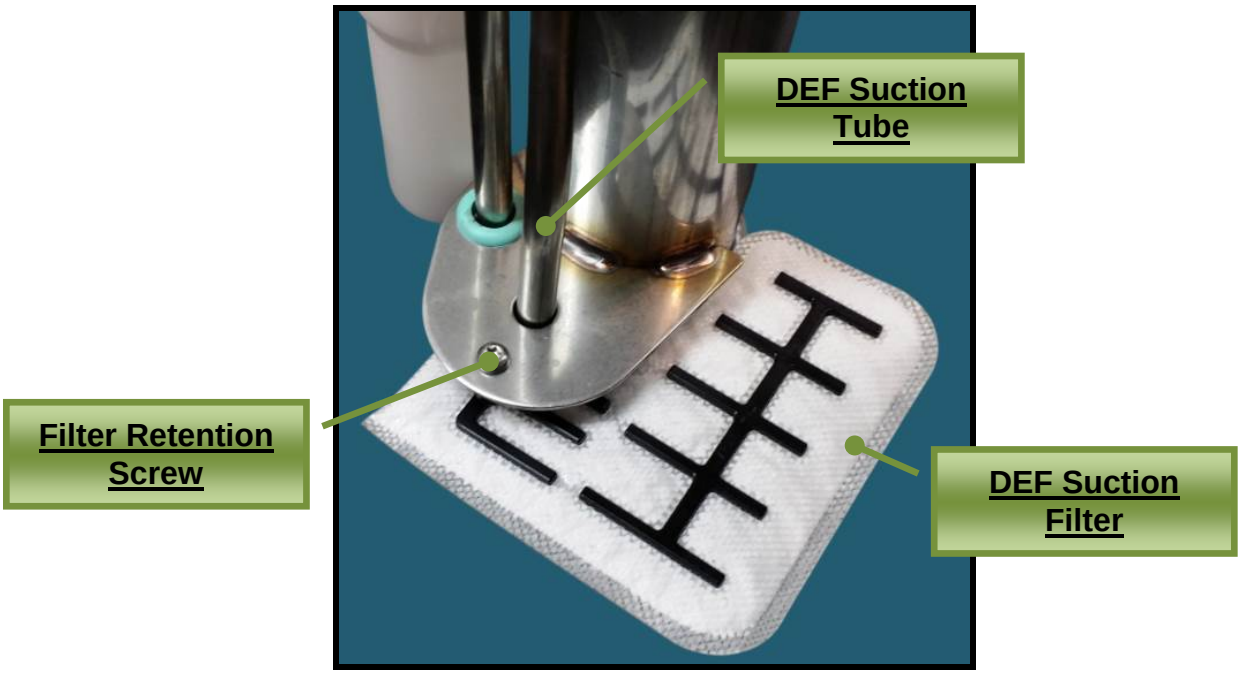
8) Replace the retaining ring on Head unit and install the retention screws using the T25 Torx wrench. Recommended torque on screws is 20 - 30 in-lbs (2.26 – 3.38 N m).





3.5 DEF SUCTION FILTER

This section demonstrates the proper steps for removing and installing the DMC series DEF Multifunction Head Unit DEF suction filter. As mentioned previously, the DEF Suction Filter is located at the bottom of the Multifunction Head Unit assembly thus requiring the head unit to be removed from the DEF reservoir. For instructions on how to remove the MFHU, please refer to Section 3.4A.

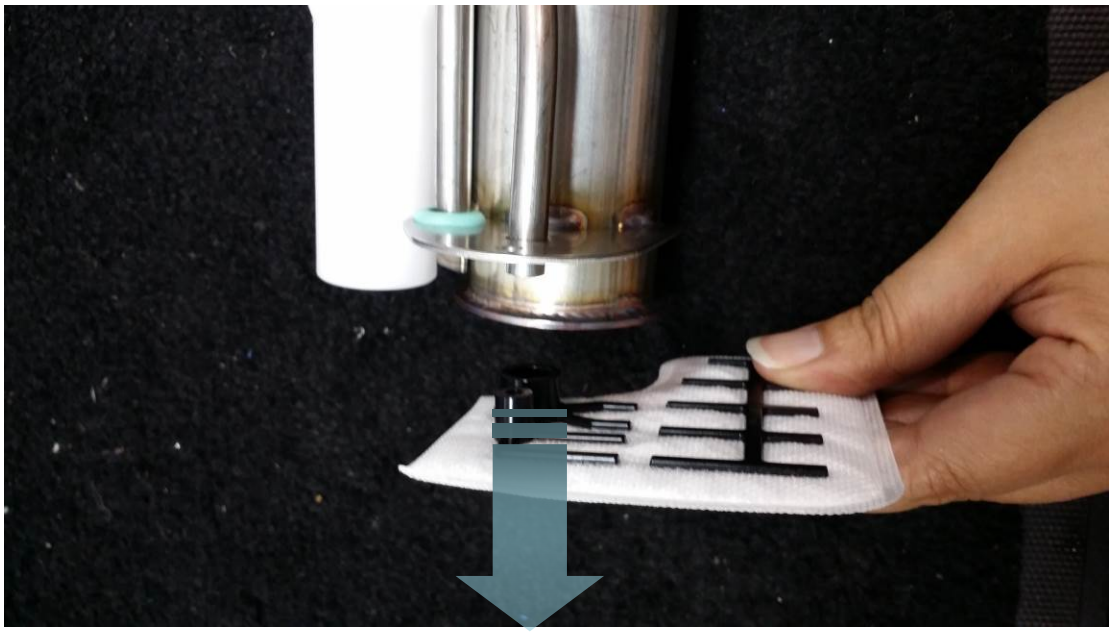


Filter Removal & Installation Procedure

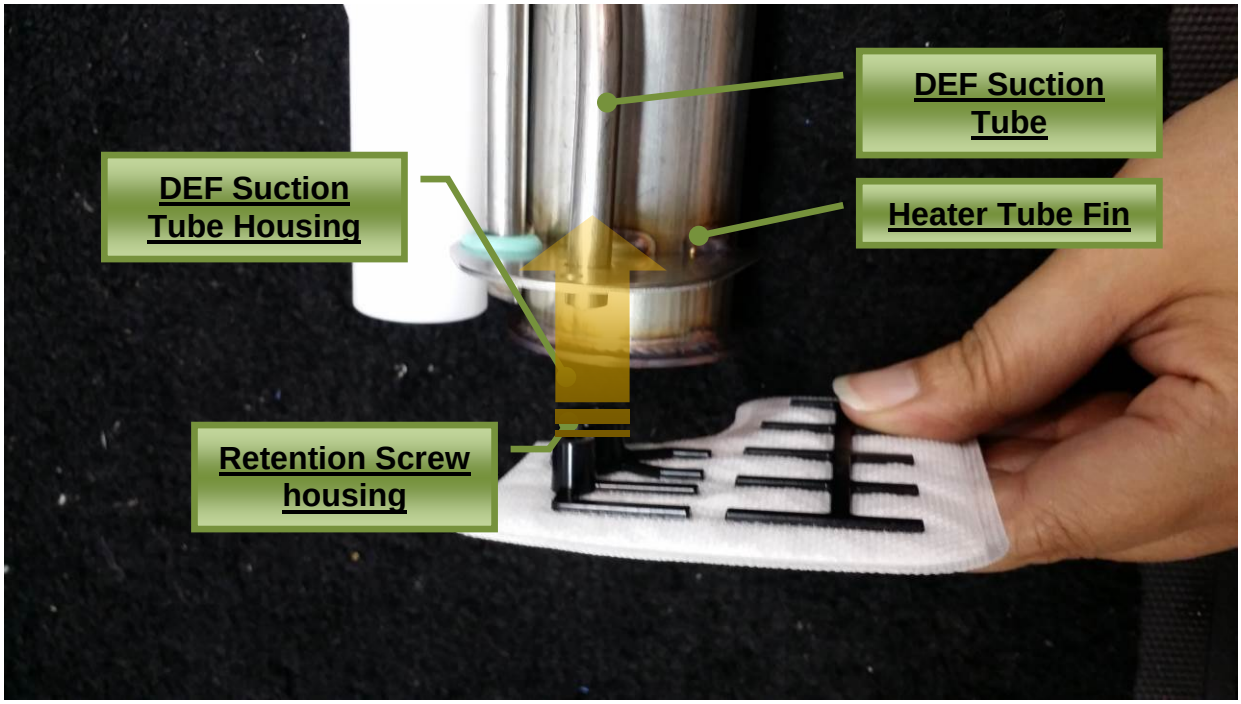
NOTE: The following procedure begins after the MFHU has been removed from the DEF reservoir. For instructions on removing the MFHU, please refer to Section 3.4A.

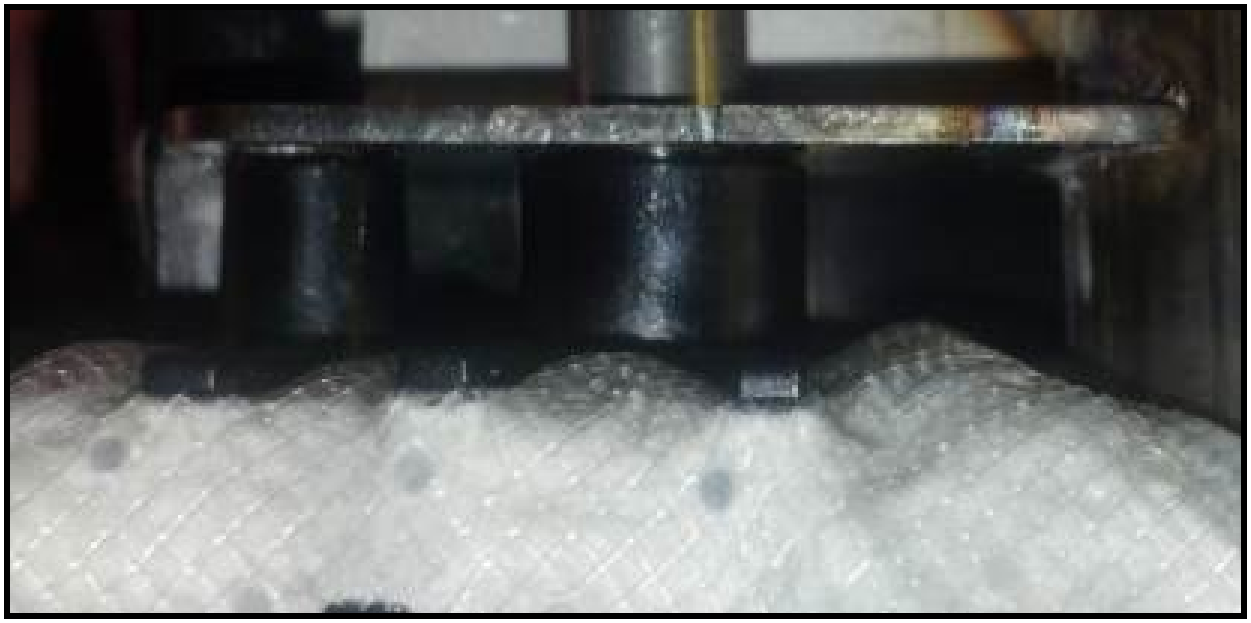
1) Locate the filter retention screw and remove using the T15 screw driver. Discard the screw.

2) Pull the old filter off of the suction tube and discard.



3) Position the new filter's suction tube housing onto the bottom of the suction tube and press the filter flush against the bottom of the heater tube fin. Align the filter so the filter retention screw can screw into the retention screw housing.





4) Install the retention screw.

5) Once the retention screw is installed, the MFHU will be ready to be installed into the tank. Refer to Section 3.4B for instructions.

3.6 LEVEL SENSOR

This section demonstrates the proper steps for removing and installing the Air-coupled Level sensor from the Multifunction Head Unit. The DEF level sensor is a component of the Multifunction Head Unit Assembly thus requiring the head unit to be removed from the DEF reservoir. For instructions on how to remove the MFHU, please refer to Section 3.4A.

1) Once the head unit is removed from the tank assembly, ensure that the header is an environment with minimal risk of contamination. Grip the Focus Tube and hand loosen counter-clockwise until it becomes unattached from the head unit.

2) Snip off the zip ties to remove the split wire loom from the wires connected to the sensor. Remove and discard the zip tie.

3) Use groove lock pliers or a wrench to firmly grip the base of the sensor and turn it counter clockwise to loosen it from the head unit.

4) Lubricate the gasket of the new sensor with a thin layer of DEF compatible petroleum jelly or oil, and then screw the new sensor into place until the bottom lip of the sensor is touching the top of the head unit.

5) Use the groove lock pliers or wrench to tighten so that the wires are in the original position (shown in second image below).

6) Locate where the focus tube will be positioned on the underside of the head unit. Situate the focus tube so that the inner threaded side of the tube will be tightened over top of the threaded projection from the sensor on the underside of the head unit. Tighten focus by hand until snug.

7) Combine the wire looms and feed the new zip tie through the header base hook and around the wire looms. Tighten only until the wire looms are secured. Clip off the excess of the zip tie.

8) The head unit is ready to be reinstalled back into the tank. Refer to Section 3.4B.

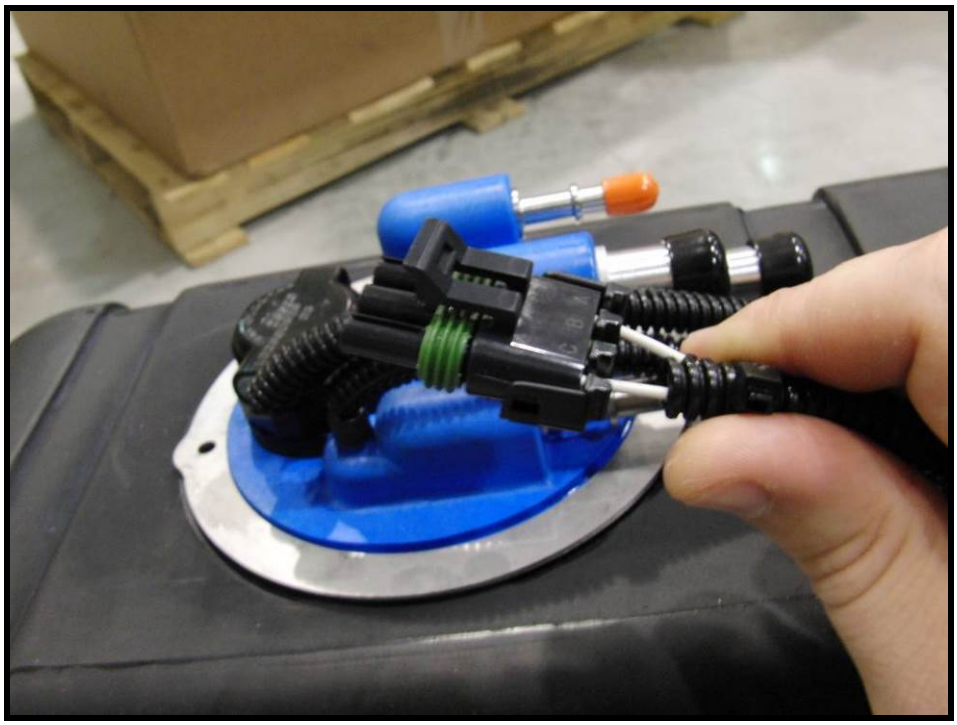
4.0 TROUBLESHOOTING PROCEDURES

The following procedures are recommended for testing the components on the Shaw DEF tank assembly in the field. If further assistance is required please contact Shaw Development.

4.1 TEMPERATURE SENSOR

The temperature sensor is a straight forward thermistor (resistor that varies with temperature). To verify the functionality of the sensor, disconnect the temperature sensor connector and place a simple ohm meter across the two temperature sensor leads (white wires, they are not polarized). (Refer to images below).

(OHM READING)



Disconnect temperature sensor from vehicle

Use an ohm meter to get a reading from the connector leads and correlate the reading to a temperature

To verify the accuracy of the sensor, identify the temperature sensor part on the vehicle in the chart below. Using the measured resistance acquired from the previous step, compare the expected temperature to the actual temperature of the DEF.

Temperature Sensor Resistance Chart

C°	F°	960-0501-00 960-0503-01	960-1001-00 960-1003-01	960-3301-00 960-3303-01
		Resistance Readings		
-40	-40	10705	23342	109591
-35	-31	8060	17336	79167
-30	-22	6125	13018	57816
-25	-13	4699	9877	42665
-20	-4	3635.5	7569	31798
-15	5	2835.5	5855	23925
-10	14	2228.5	4569	18165
-5	23	1764.5	3596	13912
0	32	1406.5	2854	10743
5	41	1128.5	2282	8362
10	50	912	1838	6558
15	59	742	1491	5180
20	68	607	1217	4121
25	77	500	1000	3300
30	86	414.1	826.6	2659
35	95	344.85	687.3	2156
40	104	288.65	574.6	1759
45	113	242.85	482.7	1443
50	122	205.25	407.4	1190
55	131	174.25	345.2	986.3
60	140	148.6	293.7	821.7
65	149	127.3	250.8	687.9
70	158	109.45	214.9	578.5
75	167	81.9	184.7	488.7
80	176	71.25	159.3	414.6
85	185	62.2	137.7	353.2
90	194	54.45	119.4	302.1
95	203	47.845	103.8	259.4
100	212	42.085	90.45	223.5

4.2 LEVEL SENSOR

The procedure below describes how to test the Level Sensor. The sensor must be wired to the vehicle with the vehicle running, because the Dosing Unit completes the output circuit of the Level Sensor. However, the vehicle must be off (no power to the sensor) during volume change in the tank. Failure to do so will result in inaccurate voltage readings. It is recommended to conduct this test at different DEF levels to ensure the sensor is recalibrating appropriately. To test the sensor a simple volt meter across the yellow and black leads will correlate to the DEF's level, while a volt meter across the red and black leads will correlate to the voltage being supplied to the unit. Prior to testing, ensure the sensor is receiving the correct voltage form the battery source. At this printing, there are 4 different level senders, each for a specific engine application.

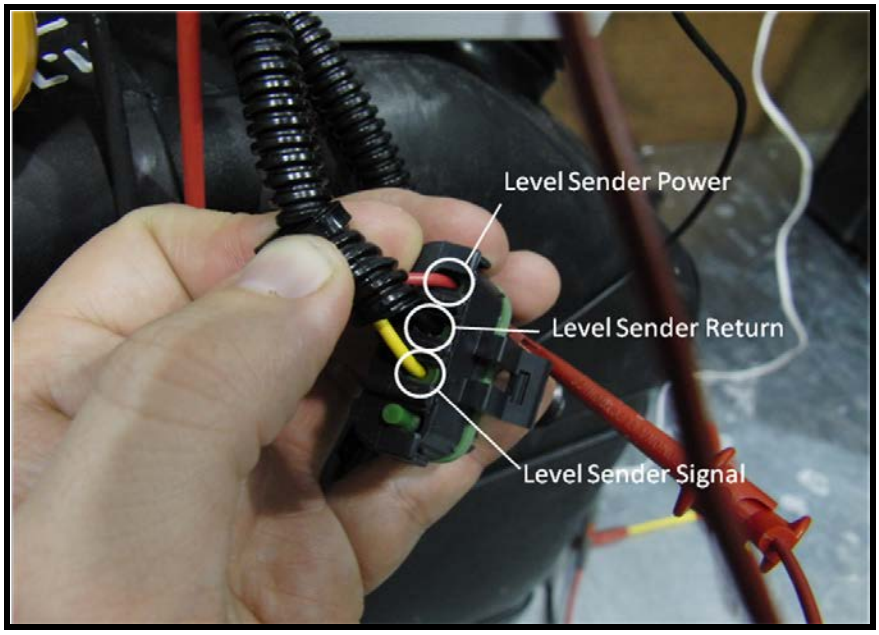
B/H: 960-0111/0121-XX General Readout	
Out (VDC)	Fluid Height
4.00	0%
3.91	5%
3.79	10%
3.64	15%
3.43	20%
3.13	25%
3.00	30%
2.86	35%
2.69	40%
2.49	45%
2.25	50%
2.11	55%
1.96	60%
1.79	65%
1.59	70%
1.37	75%
1.23	80%
1.07	85%
0.90	90%
0.71	95%
0.50	100%

D / J: 960-0113/0122-XX General Readout		
Out (Ohms)	Out (VDC)	Fluid Height
14000	2.59	100%
10284	2.47	95%
8074	2.36	90%
6534	2.24	85%
5384	2.13	80%
4497	2.01	75%
3799	1.9	70%
3237	1.79	65%
2767	1.67	60%
2375	1.56	55%
2035	1.44	50%
1748	1.33	45%
1493	1.21	40%
1272	1.1	35%
1076	0.99	30%
902	0.87	25%
744	0.76	20%
601	0.64	15%
471	0.53	10%
353	0.41	5%
240	0.3	0%

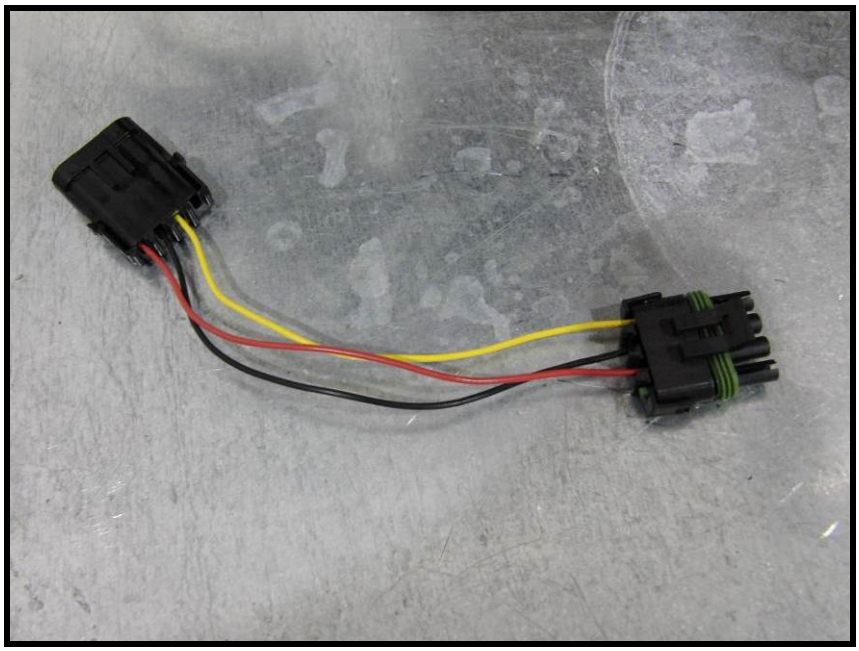
Quick Reference				
Level %	B: 960-0111-XX H: 960-0121-XX	A: 960-0114-XX G: 960-0123-XX	D: 960-0113-XX J: 960-0122-XX	F: 960-0119-XX K: 960-0124-XX
0	4.00 VDC	0.50 VDC	0.30 VDC	4.50 VDC
50	2.25 VDC	2.50 VDC	1.45 VDC	2.50 VDC
100	0.50 VDC	4.50 VDC	2.60 VDC	0.50 VDC

Sensor's Part Number	Voltage between Yellow and Black Leads		Voltage required between Red and black
	Empty	Full	
960-0114-xx	0.50 VDC	4.5 VDC	9-18 VDC
960-0111-xx	4.0 VDC	0.5 VDC	9-18 VDC
960-0113-xx	0.3 VDC	3.0 VDC	9-18 VDC
960-0119-xx	4.5 VDC	0.5 VDC	9-18 VDC
960-0123-xx	0.50 VDC	4.5 VDC	18-32 VDC
960-0121-xx	4.0 VDC	0.5 VDC	18-32 VDC
960-0122-xx	0.3 VDC	3.0 VDC	18-32 VDC
960-0124-xx	4.5 VDC	0.5 VDC	18-32 VDC

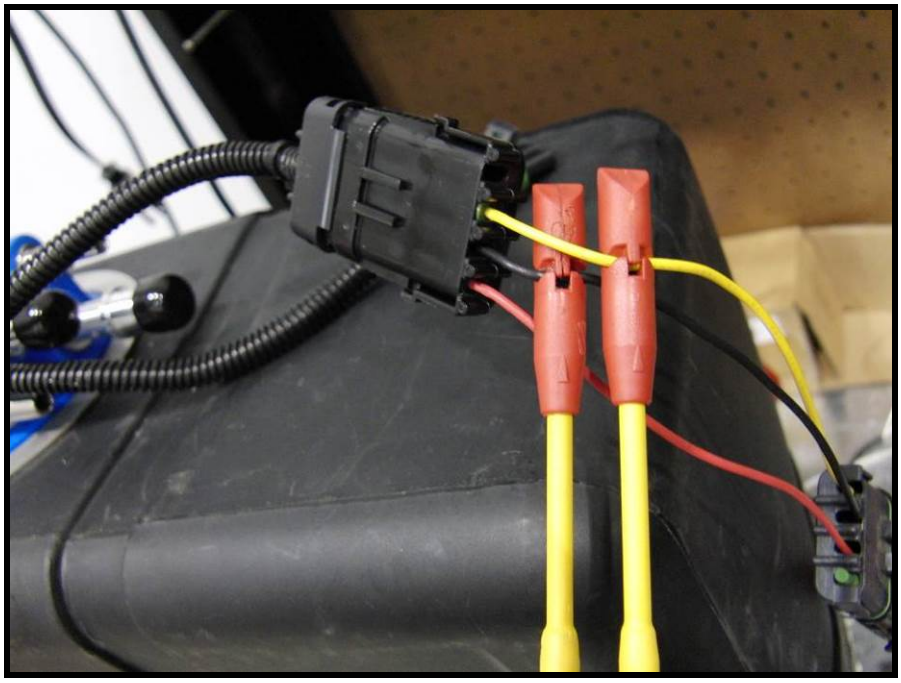
Level sensor wire reference and nomenclature



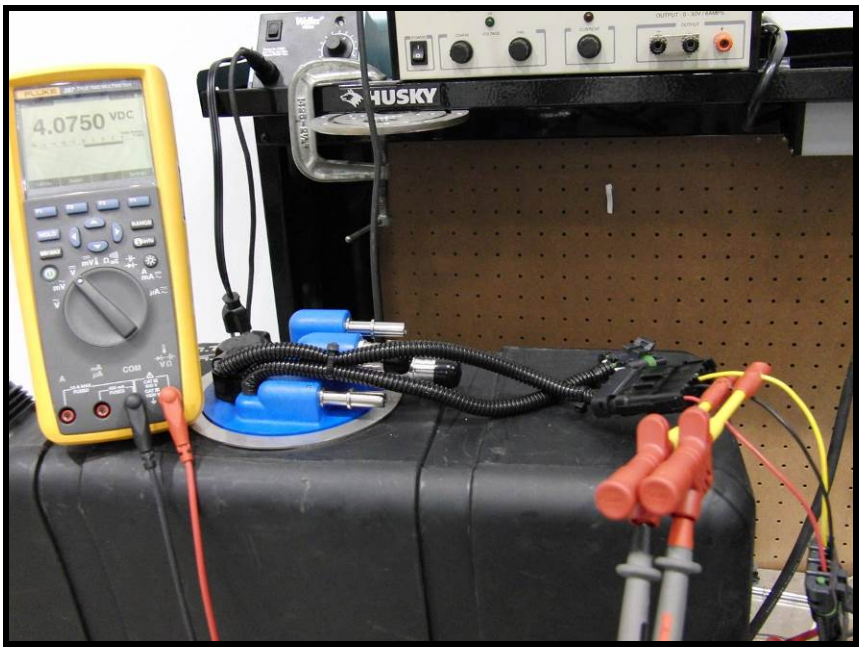
METHOD 1 (RECOMMENDED)



Unhook the connector and attach a jumper between the tank and vehicle connector.

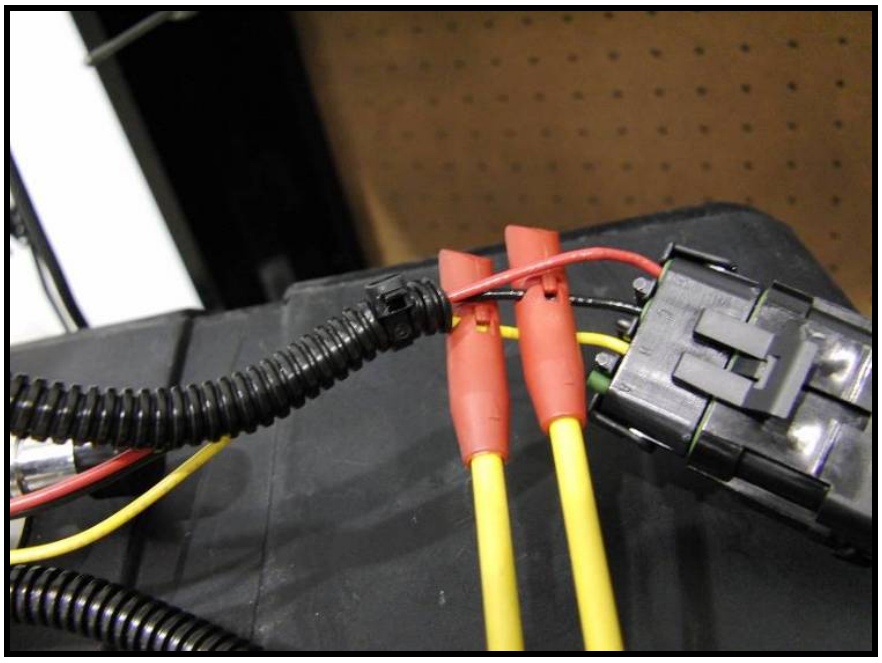


While the vehicle is running, attach Insulation Piercing Test Clips to the power (Red) and Return (Black) to ensure appropriate voltage is provided to the sensor. Next, attach the Clips to the Signal (Yellow) and Return (Black) wires of the jumper to measure the signal voltage being provided to the engine computer.

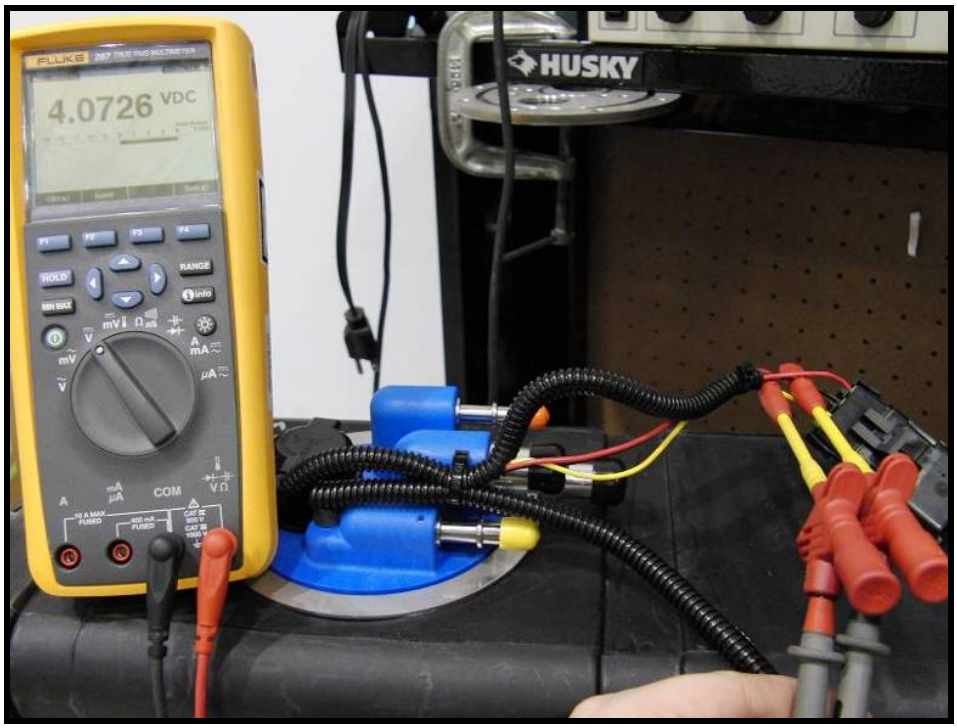


Use a volt meter to get a voltage reading from the connector leads (black wire to black lead and yellow wire to red lead) and correlate the reading to a fluid level.

METHOD 2



While the vehicle is running, attach Insulation Piercing Test Clips to the power (Red) and Return (Black) to ensure appropriate voltage is provided to the sensor. Next, attach the Clips to the Signal (Yellow) and Return (Black) wires of the jumper to measure the signal voltage being provided to the engine computer.



Use a volt meter to get a voltage reading from the connector leads (black wire to black lead and yellow wire to red lead) and correlate the reading to a fluid level. The small pin is designed to allow self-healing of the insulation, though one can also apply a small amount of Liquid Electrical Tape to the wire after removal of the test clips.

NOTE: Clips can also be used on the red and black wires to get a voltage reading from the vehicle.

5.0 FREQUENTLY ASKED QUESTIONS (F.A.Q.s)

➢ What information should be collected before calling Shaw for troubleshooting related issues?

✓ Providing the following information will help in expediting the troubleshooting process and Warranty process. The Italicized items are required in order to process a warranty claim.

NOTE: All warranty claims must be submitted to the immediate supplier of the tank.

1) *OEM of vehicle*

2) *Part number of suspect Shaw component (Level sensor, Tank assembly, Coolant control Valve, etc.). If unable to acquire the part number, please contact supplier.*

   a. *If the issue is related to the DEF tank assembly, provide the serial number of the DEF tank assembly (refer to image below for location of SN)*

3) All Fault Codes related to the incident

4) *Vehicle mileage / hours of operation*

5) Location of failure (City, State, Territory)

6) Date of failure

7) Description of failure

➢ What could cause my DEF level gauge to read intermittently?

✓ Intermittent level readings could be caused by a variety of circumstances ranging from bent pin connectors, kinked wires, inadequate power provided to sensor, etc. It is for this reason that Shaw has developed the level sensor troubleshooting procedure referenced in section 4.2. Performing this procedure safely and efficiently determines if the sensor is suspect and is a good starting point for troubleshooting the rest of the circuit. If there are specific questions regarding the procedure or the level sensor please contact your Shaw Development parts provider.