July 05, 2016

SERVICE MEMORANDUM

NO: SM1604

SUBJECT: New Diesel Exhaust Fluid (DEF) Tank Assemblies (Gen 5 Tri-Function Sensor)

MODELS AFFECTED: Vision, All American, and TX4, with New 2016 Cummins Engine Features
Blue Bird Production Date Begin: January 18, 2016

The intent of SM1604 is to provide service related information for buses equipped with new Diesel Exhaust Fluid (DEF) tank assemblies. This change ONLY affects Blue Bird buses with Cummins diesel engines that are EPA/CARB certified on highway built by Cummins on January 1, 2016 or later (Blue Bird production date January 18, 2016).

Blue Bird buses equipped with new (DEF) tank assemblies have a Gen 5 Tri-Function Sensor.
The Gen 5 Tri-Function Sensor provides the level, concentration, and temperature of the (DEF) Diesel Exhaust Fluid in the reservoir and returns a defined CAN message for these values. The sensor and controller communicates on a "Private" J1939 data link with the Cummins ECM.

Please see the attached DEF Tank Assembly Service Manual Gen 5 (Tri-Function Sensor) for maintenance, filling, draining, removal, and installation instructions.

If you need service technical support, or have any service related questions, please contact your Blue Bird Field Service Engineer.

Important service note: See service memorandum SM1304 for all EPA/CARB certified buses built before January 18, 2016 with Diesel Exhaust Fluid (DEF) tank assemblies. These buses are equipped with DEF tank assemblies that use Gen 4 "Analog" type level, and temperature sensors.

BLUE BIRD BODY COMPANY
P.O. Box 937 – 402 Blue Bird Blvd – Fort Valley, Georgia – (478) 825-2021

ISO 9001 & 14001 Registered

25190 Bernwood Drive
Bonita Springs, FL 34135
239-405-6100
www.shawdev.com

TB-3019 Rev-A

DEF TANK ASSEMBLY SERVICE MANUAL

Gen 5 (Tri-Function Sensor)

APPROVAL SUMMARY

Written by:

Kiran Muggulla _____12/14/2015

Project Engineer

Shaw Development, LLC

Approved by:

Michael O'Hara _____01/11/2016

Chief Technologist

Shaw Development, LLC

James Carter _____01/11/2016

Engineering-Technology

Shaw Development, LLC

Chris Godfrey _____01/11/2016

Engineering Group Leader

Shaw Development, LLC

Michael Ostertag _____01/11/2016

DEF Business Development Manager

Shaw Development, LLC

INDEX OF REVISIONS

REVISION	DESCRIPTION	APPROVED BY/ DATE
A	INITIAL RELEASE	KM/ 01/11/2016

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 reference, 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.

Mailing Address:

Shaw Development, LLC
25190 Bernwood Drive
Bonita Springs, FL 34135

Phone: (239) 405-6100

Web Address: www.ShawDev.com.

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.

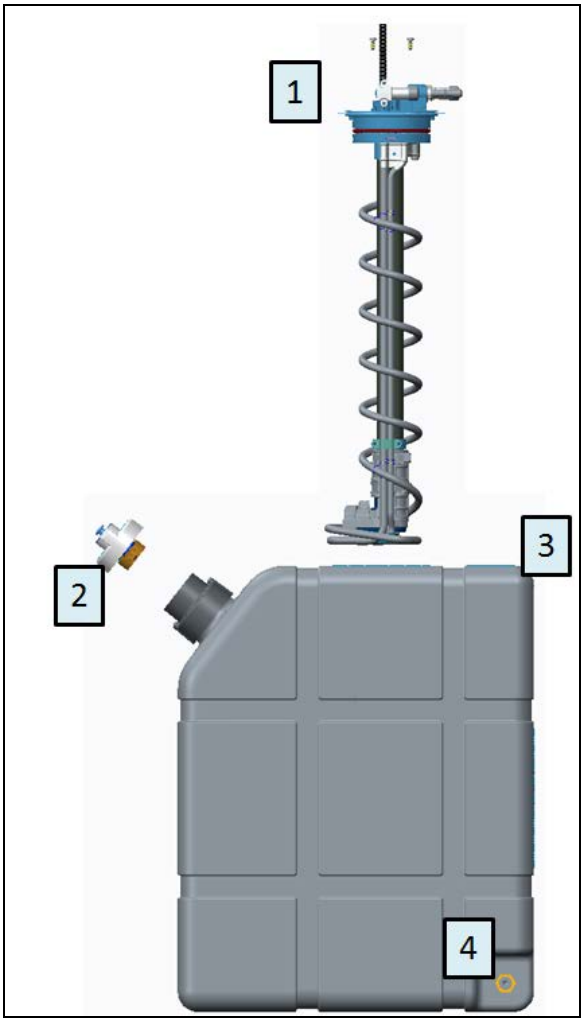
- Freezing point of DEF ≈ -11° C (12.2° F)
- Maximum Temperature Exposure ≈ 50° C (122° F)
- Urea Concentration: ≈ 32.5%, Water Concentration ≈ 67.5%

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

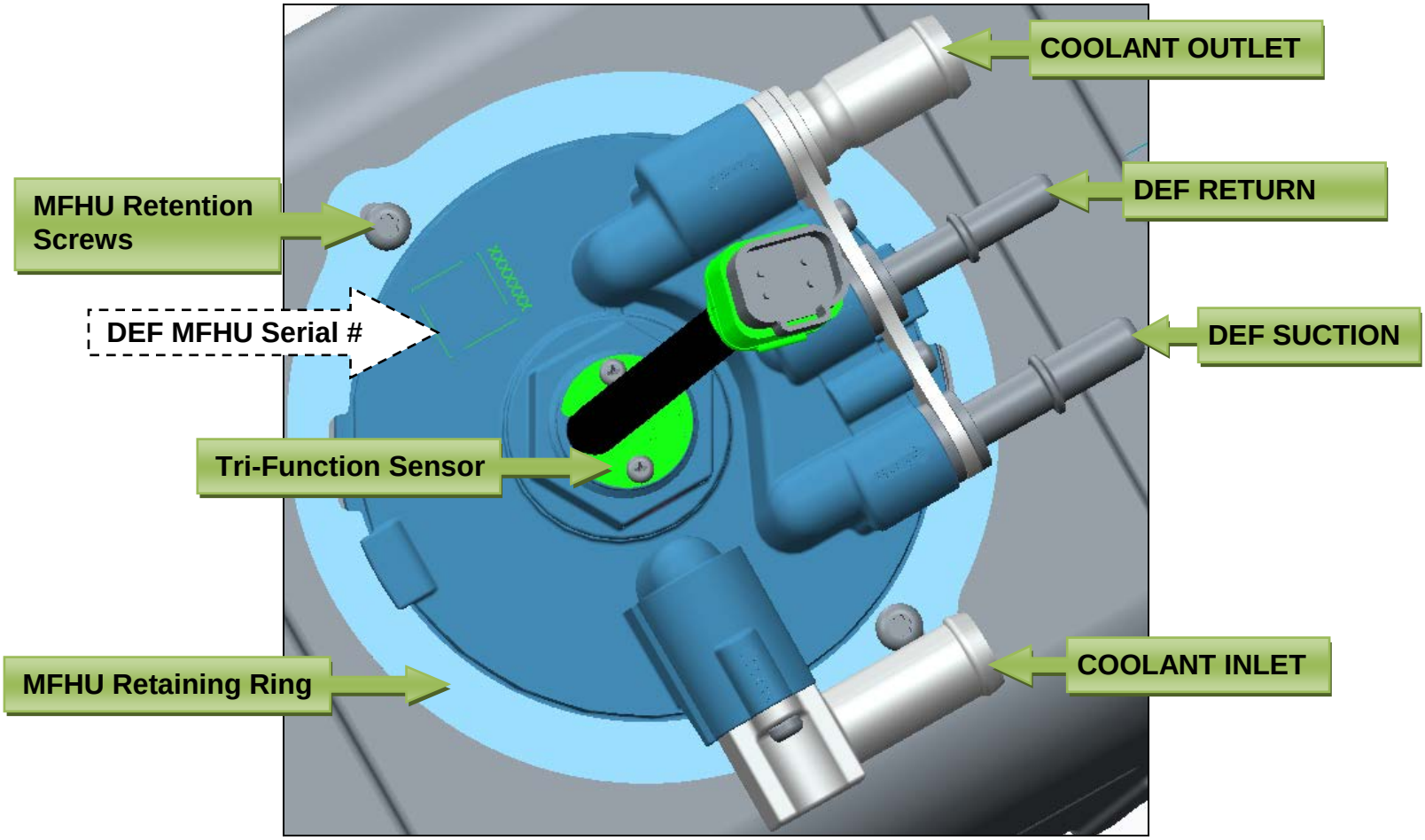


Components
1. Multifunction Head Unit Assembly
2. DEF Cap Assembly
3. Tank & Adapter Assembly
4. DEF Tank Drain Plug

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 top portion of the Tri-Function Sensor, and a 6 digit serial number data matrix code positioned right behind the coolant outlet fitting. (Refer to image below for visual aid)

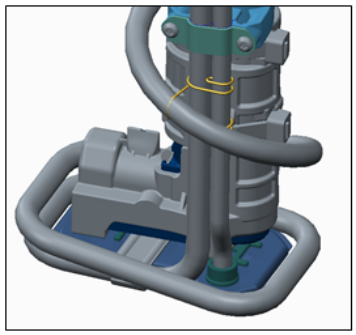
Top view of Multifunction Head unit

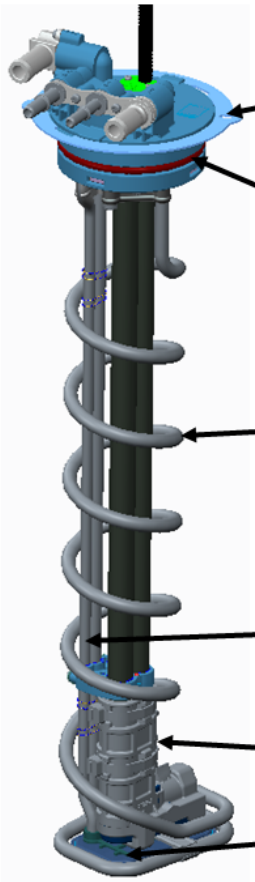


Note: To see the actual image of DEF MFHU Serial number, refer to FAQ's

The bottom assembly of the MFHU consists of a coolant heater tube, a DEF Suction Tube, the bottom portion of the Tri-function Sensor with Spacer, and the 40 micron gradient filter with retention screw. The diagram below identifies each component of the MFHU and provides a description of its purpose. The Tri-function sensor and DEF Suction Filter are described in greater detail in Sections 1.2.1.1 and 1.2.1.2, respectively. The MFHU is designed as a replaceable item. For instructions on removing and installing the MFHU, please refer to section 3.5.

Side view of Multifunction Head Unit



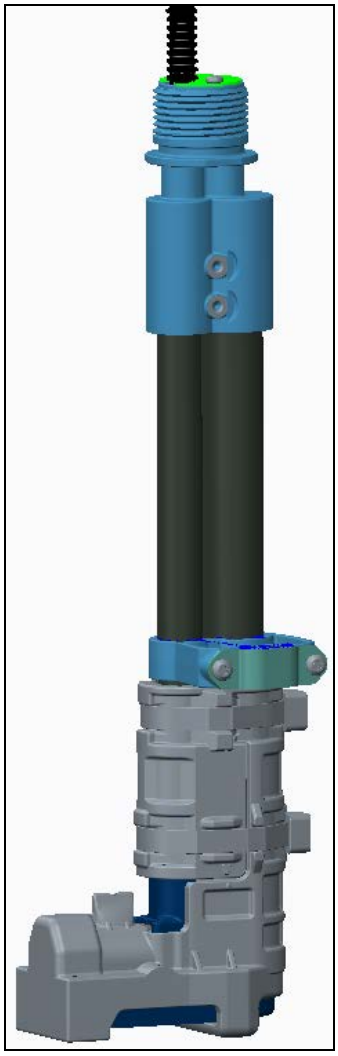


Component	Description
MFHU Retaining Ring	
Bore Seal O-Ring	Prevents leakage of DEF and intrusion of contaminant from entering the tank assembly through the bore seal.
Coolant Heater	Designed to enable heated engine coolant to flow within the tank assembly. This occurs when the DEF is exposed to cold temperatures.
Suction Tube	The point where DEF is drawn from the tank during normal vehicle operations.
Tri-Function Sensor	Refer to Section 1.2.1.1
DEF Suction Filter	Refer to Section 1.2.1.2

1.2.1.1 TRI-FUNCTION SENSOR

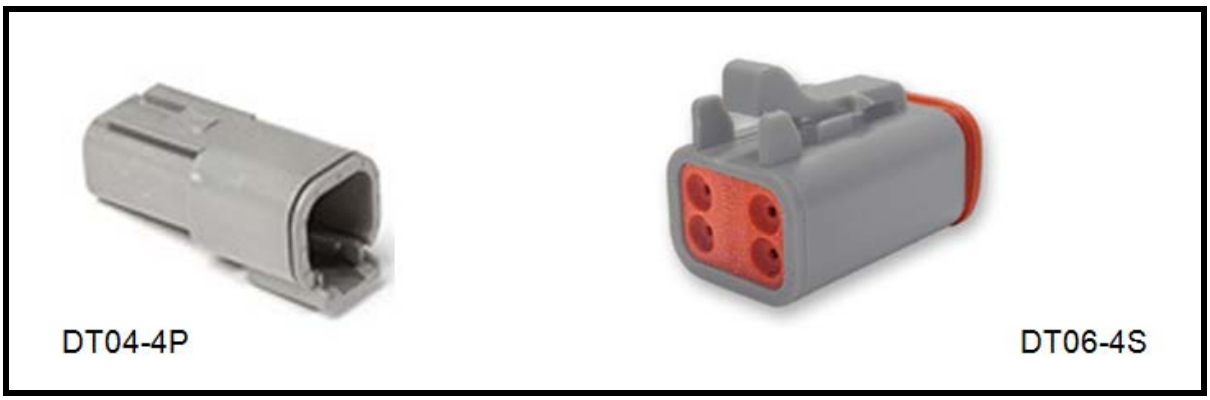
The Tri-Function Sensor is the electrical component of the tank assembly responsible for communicating the temperature, concentration, and level of diesel exhaust fluid in the tank to the engine computer. The sensor is designed and manufactured in accordance with SAE J1939-15 (Reduced Physical Layer) specification. Additionally, the sensor has been designed as a replaceable item for the DEF Tank assembly. For Removing and Installing the Tri-function sensor, please refer to Section 3.7.

Image of Tri-Function Sensor



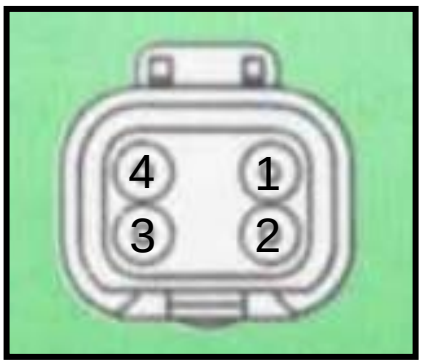
The power circuit requires a 2 amp fuse and must not share its power circuit with unsuppressed inductive loads. Relay coils and DC motors (fans) on the same power circuit should be avoided. The unit utilizes a Deutsch DT04-4P connector with gold plated terminals. The mating connector is the Deutsch DT06-4S (not supplied by Shaw Development)

Image of Tri-function sensor connectors



Wiring Pin-Out for Sensor Connector

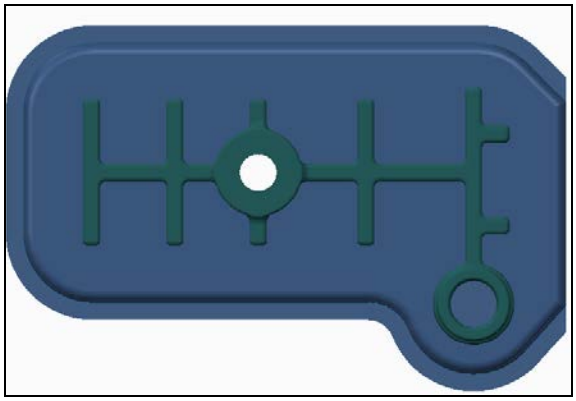
Pin Number	Description
1	CAN LOW
2	CAN HIGH
3	GROUND
4	9-32 VDC

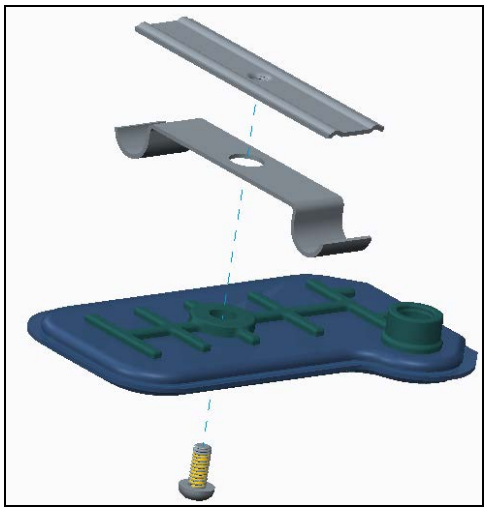


1.2.1.2 DEF SUCTION FILTER

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, the suction filter is replaceable. For instructions on replacing the suction filter, refer to Section 3.6. For instructions on cleaning the DEF tank refer to Section 2.1.1.

Image of DEF Suction Filter



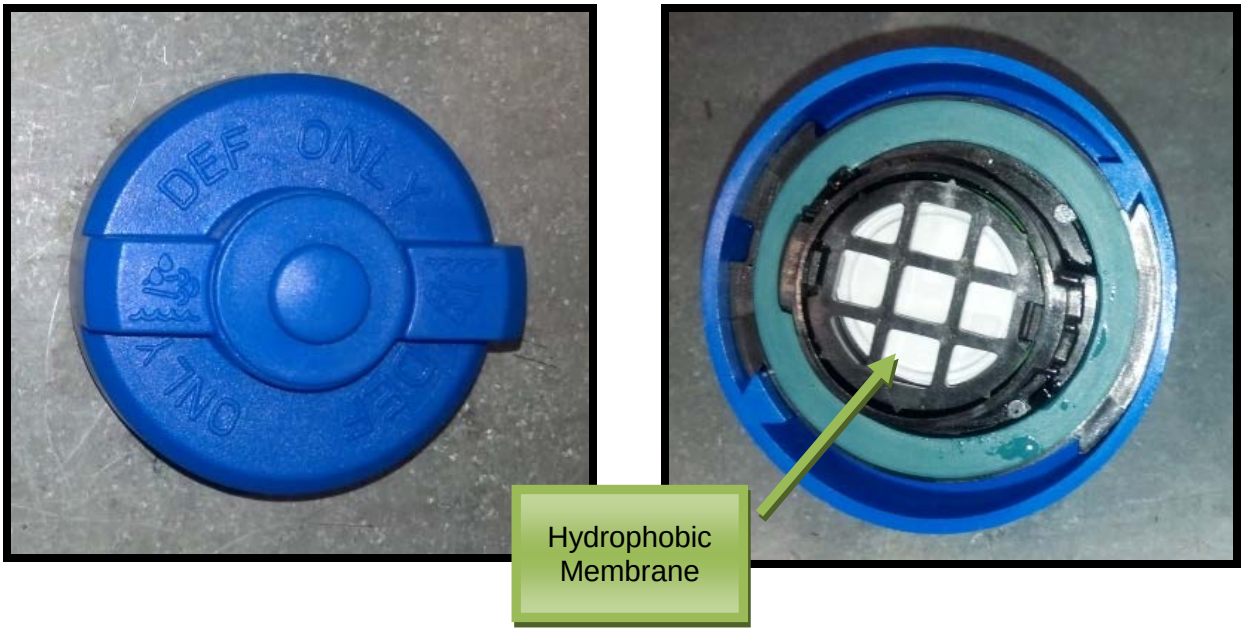


1.2.2 DEF CAP

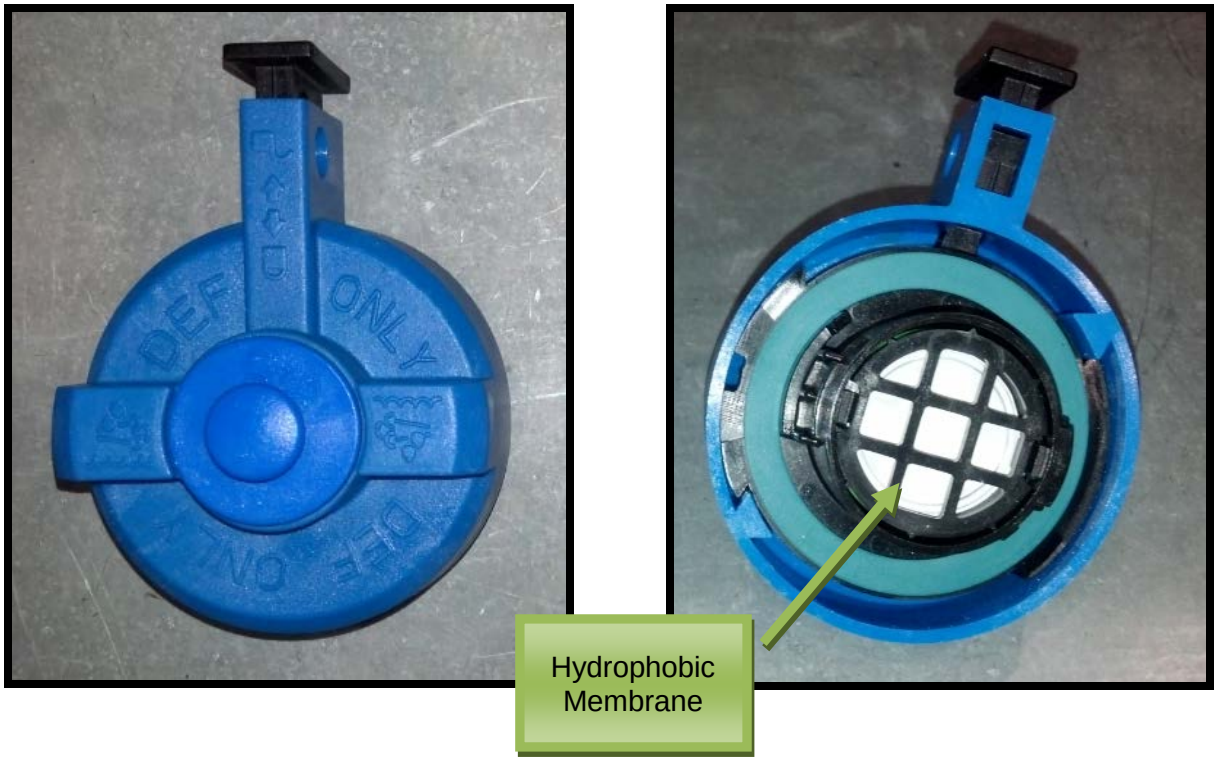
Shaw Development provides 2 standard DEF caps, Locking and Non-locking. The caps include a hydrophobic membrane to allow the tank to vent freely. The membrane prevents DEF fluid from escaping the tank and ingress of other contaminating fluids from the external environment.

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.

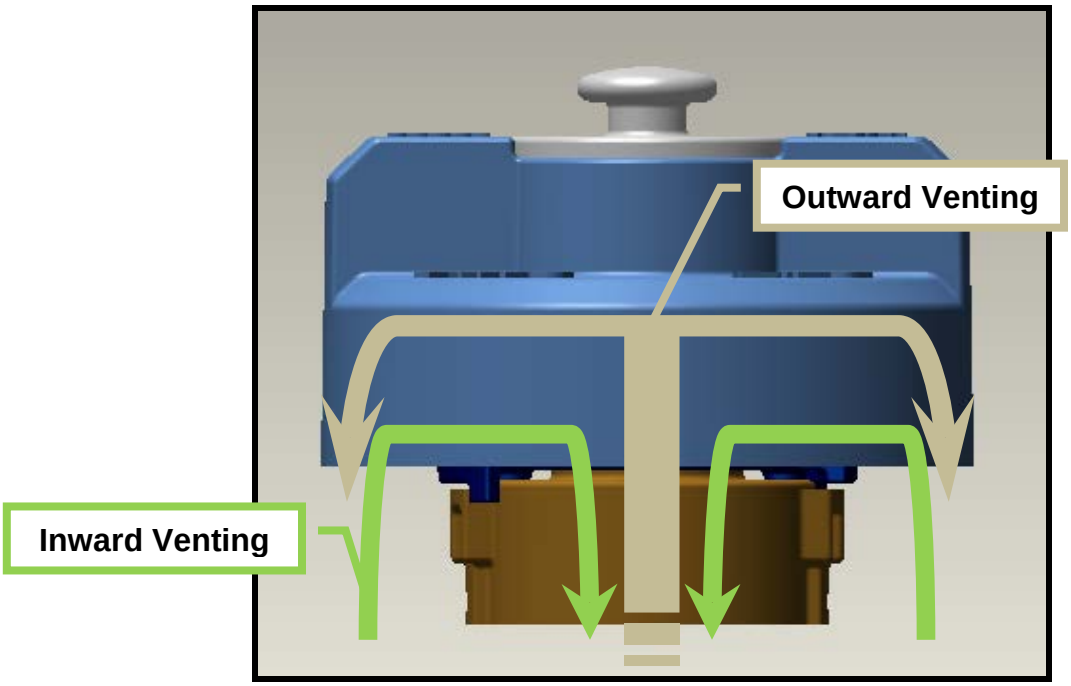
Non-Locking DEF Cap



Locking DEF Cap



DEF Cap Ventilation Pathway



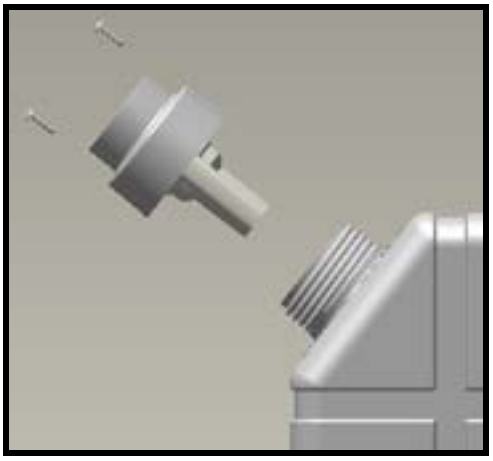
1.2.3 TANK AND ADAPTER ASSEMBLY

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.

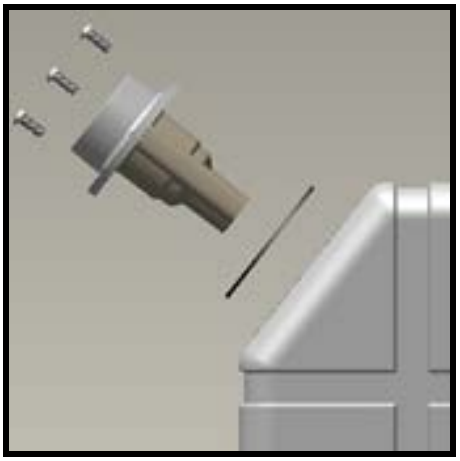
Buttress Thread / Bolt-on Adapters

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



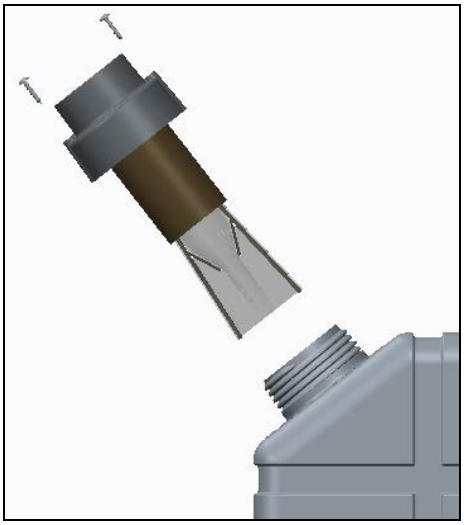
The Buttress Threaded and Bolt-on Adapters perform identically in regards to venting and enabling magnetic actuation of the DEF magnetic fill nozzle. Both adapters are equipped with fill restrictors as indicated in the picture below. The purpose of the fill restrictor is to decrease the potential of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

DEF Inlet Adapters

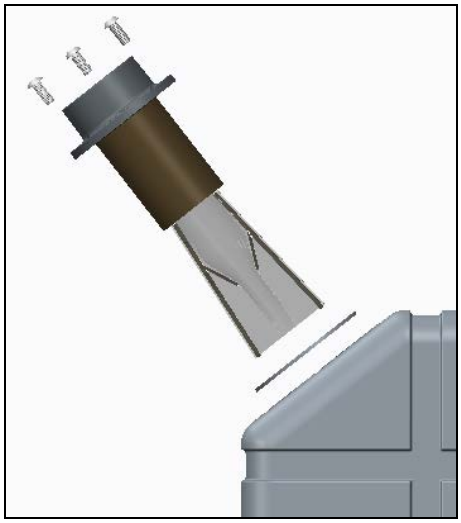
Buttress Thread / Bolt-on Adapters with Fill Port Strainer assembly

The DEF fill port strainer (140 micron gradient) is responsible for minimizing the amount of debris entering in to the DEF tank during DEF fill / refill events. In the event of DEF back splash during tank fill / refill (when the strainer meets the maximum limit of its dirt holding capacity), Shaw Development has designed the fill strainer to be replaceable. Fill port with strainer option is not available for 5 gallon portrait tank configuration. Also, fill port with strainer option is not available for 10 gallon cube tank with buttress thread fill neck design. For instructions on replacing the fill port strainer, refer to Section 3.4

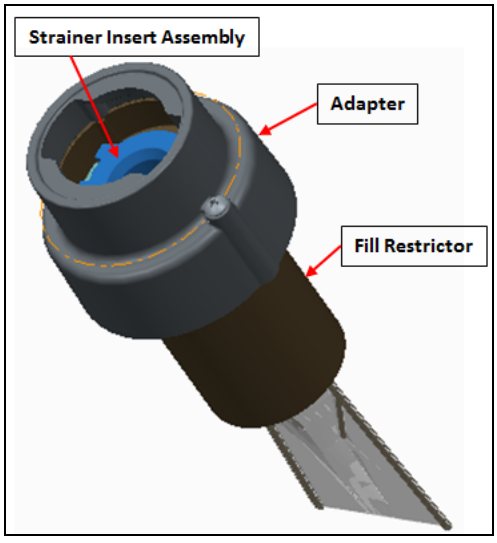
Buttress Threaded Adapter with Strainer



Bolt-On Adapter with Strainer



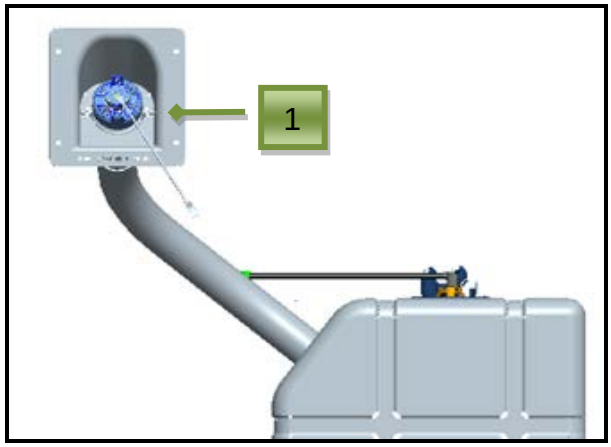
DEF Inlet Adapter with Strainer



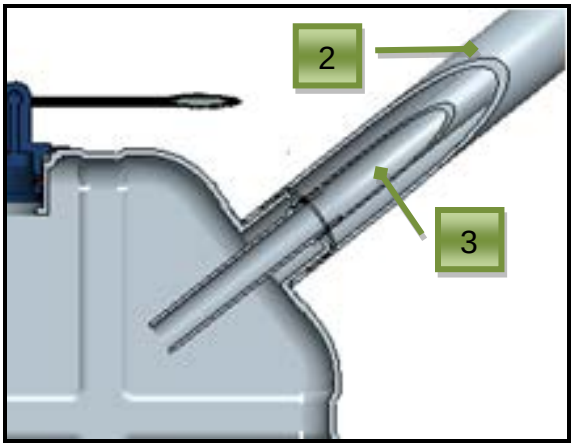
Remote Fill Design

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.

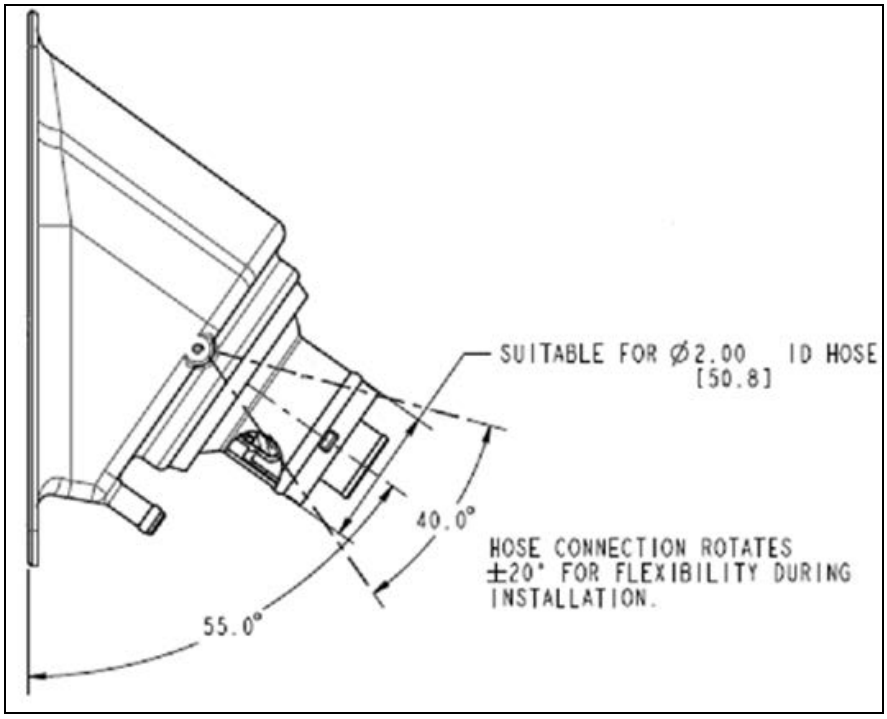
Image of DEF Tank Assembly w/ Remote Fill Adapter Design



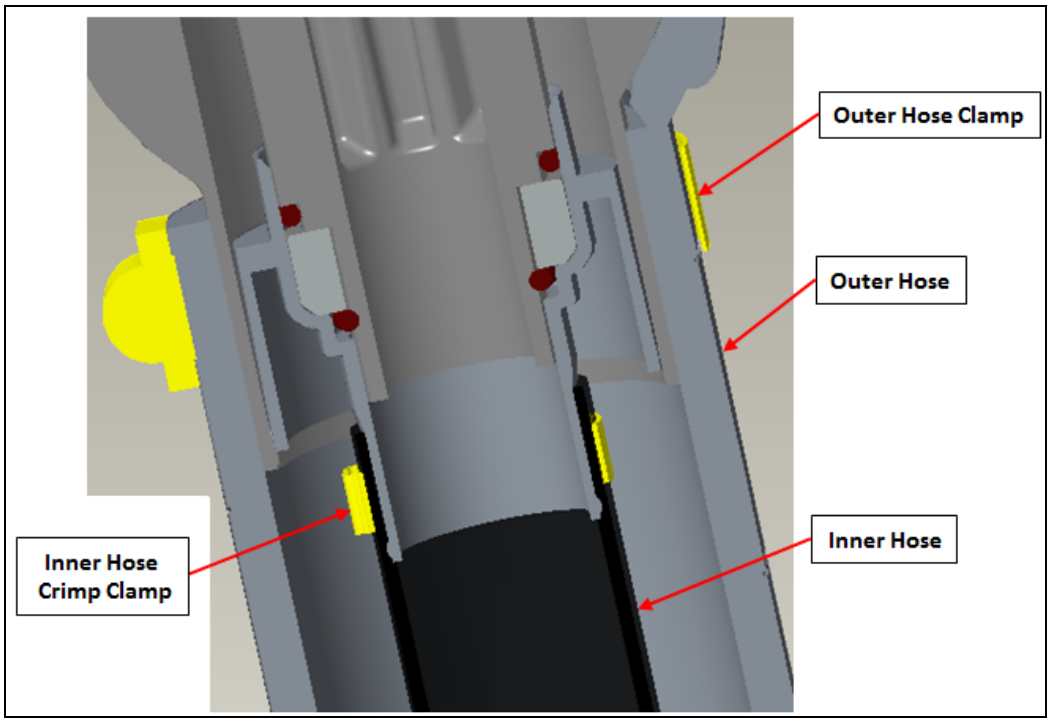
Interior of DEF Tank Assembly w/ Remote Fill Adapter Design



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. The spill pan is also capable of rotating +/- 20° for flexibility during installation (refer to image below for visual aid). This enables the remote fill design to adapt to a variety of configurations.

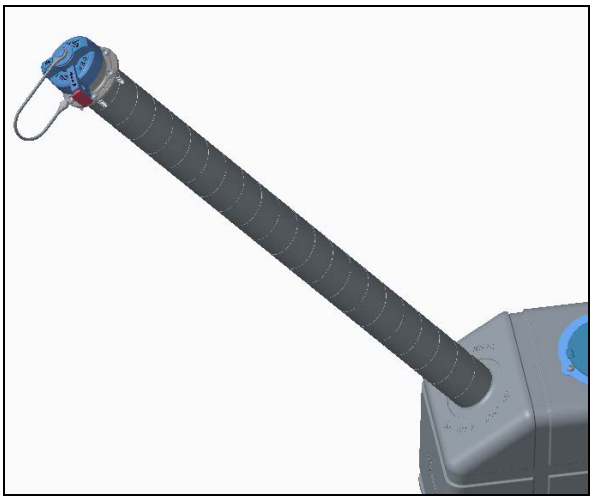


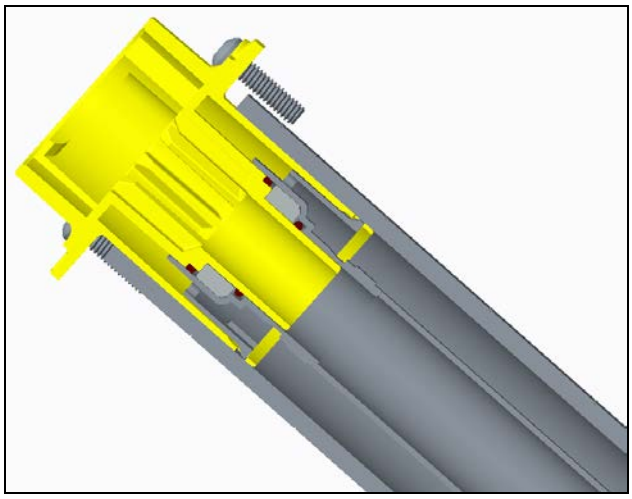
Below image shows clamping of the hoses (Both inner and outer) to the outlet of the spill pan adapter.

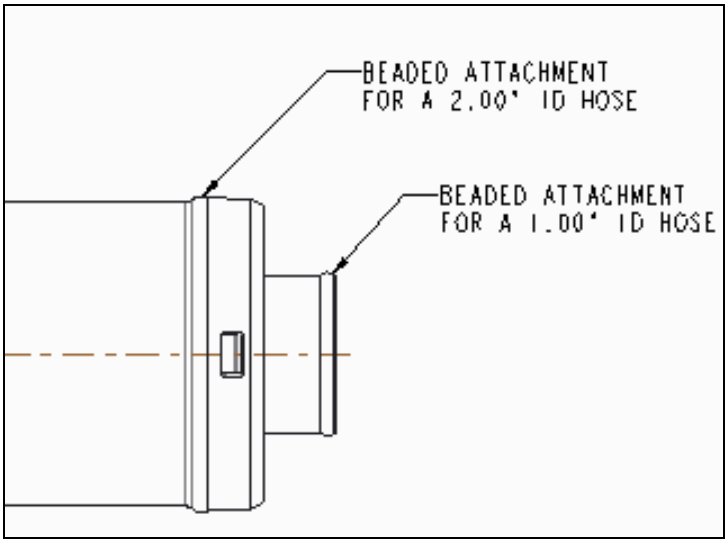


Bolt on adapter design for remote fill:

See the images below for the Bolt on style remote fill option. This does not include a spill pan.







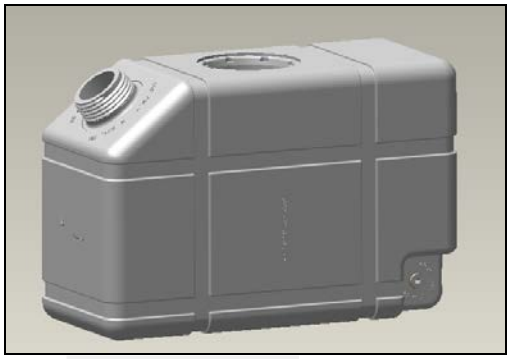
Note: The remote fill port must be properly supported to prevent damage to the DEF tank.

DEF Tank Designs

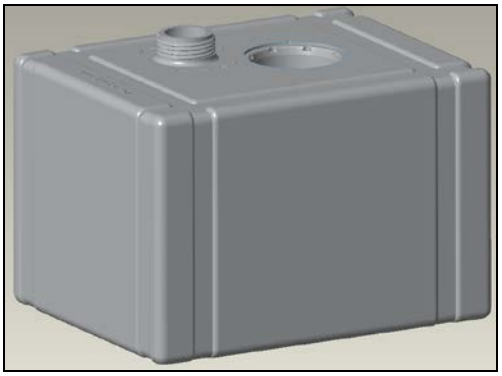
The standard DEF tanks are available in Small, Medium, and Large sizes. Each tank size comes in Landscape and Portrait orientations. Small, Medium, and Large tanks roughly hold 5 gallons (18.9 L), 10 gallons (37.9 L), and 15 gallons (56.8 L) of DEF respectively. There is also a 10 gallon (37.9 L) Cube and a 25 gallon (94.6 L) tank designs available. Refer to the chart below for reference. The tank fill neck comes in hose barb, buttress thread and bolt on designs.

Tank ID	DR501	DR502	DR503	DR504	DR505	DR506	DR507	DR525
Tank Description	5 Gallon LS	5 Gallon PT	10 Gal. LS	10 Gal PT	15 Gal LS	15 Gal PT	10 Gal Cube	25 Gal
Tank Designs								

Landscape [LS]

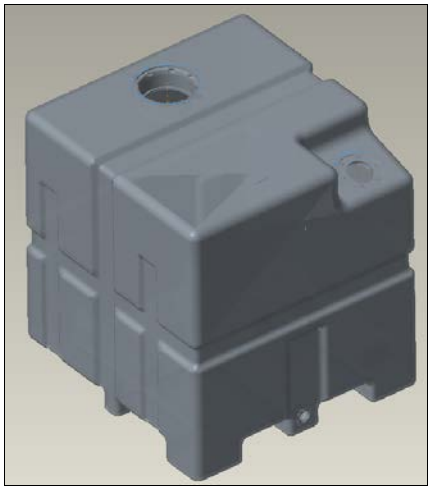


Cube



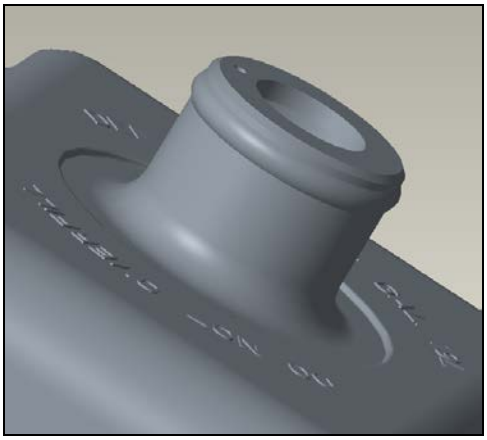
Portrait [PT]

25 Gal

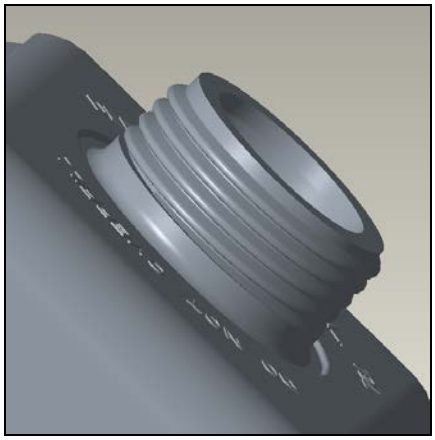


DEF Tank Fill neck Designs:

DEF tank designs are available in hose barb, buttress thread and bolt on fill neck styles respectively. 25 gallon DEF tank is only available in Bolt on fill neck design.



Hose Barb



Buttress Thread

Bolt On

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.

It is highly recommended not to add any new features to the drain port or use non-Shaw components other than the Shaw Drain Plug.

Image of DEF Drain Plug location

2.0 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. 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 3.5A for instructions on removing the MFHU.

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

    a. If the filter is damaged or dirty, replace the filter. Refer to Section 3.6 for instructions for replacing the DEF suction filter.

b. If the filter does not appear to have any discrepancies, 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 3.5B.

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

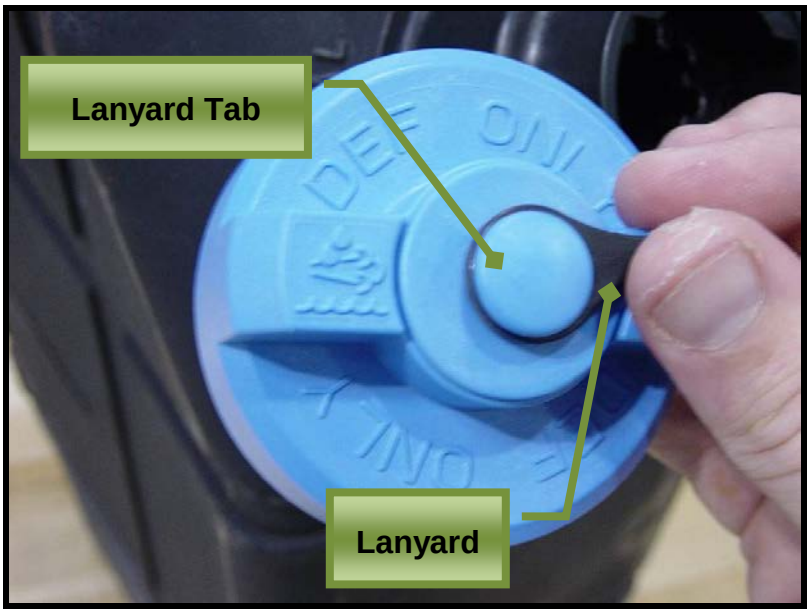
Periodic maintenance may be required as crystallized DEF can build up on the seal surface and under side of the DEF cap. If left untreated, contaminants may accumulate. This accumulation may compromise the main seal of the cap and eventually infiltrate the tank interior. As mentioned in Section 2.1, 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 DEF tank).

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.

NOTE: The Tri-Function Sensor is expected to report a default value (slow response times) particularly with respect to the DEF Concentration reading during the initial filling of DEF tank. This is typically due to air bubbles sticking to the surfaces of the DEF concentration measurement window.

DO NOT put DEF in the fuel tank, or any fluid other than DEF in the DEF tank. 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.

<u>Nozzle filling the DEF tank Assembly:</u>

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 have been knowingly stored continuously at temperatures greater than 30°C (86° F) 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 tank has been filled with DEF fluid, 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.

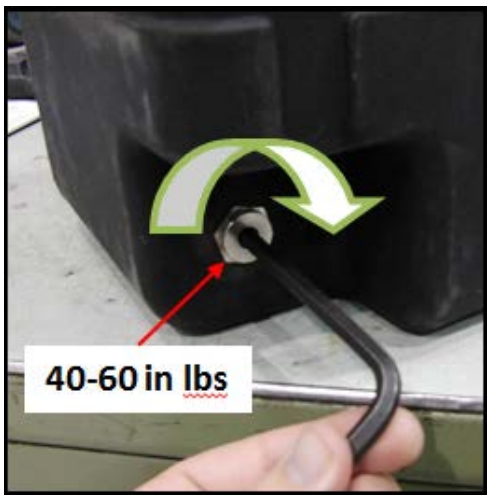
Refer to vehicles service manual for safety regulations and recommendations when servicing the vehicle.

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 tank be properly discarded to avoid potential contamination of the DEF tank assembly. Refer to your Standard operating Procedure or ISO-22241 for proper disposal of DEF. Do not dispose of DEF down a drain as this may cause clogging 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. Make sure the vehicle is 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 tank 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 DEF tank 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. Re-thread 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

Example of 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 tanks in areas that are debris prone or exposed to high temperatures as this may damage the DEF tank 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.

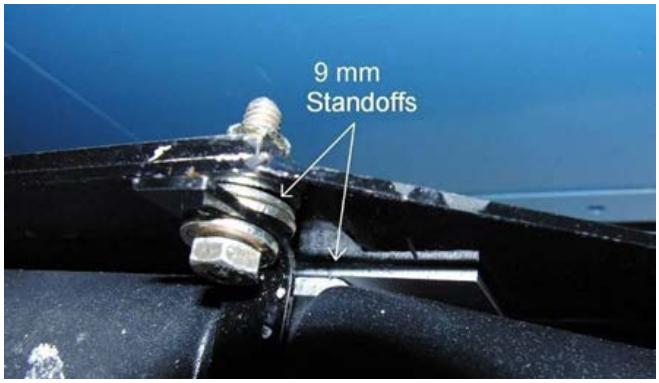
Ensure the tank assembly is not a step point.

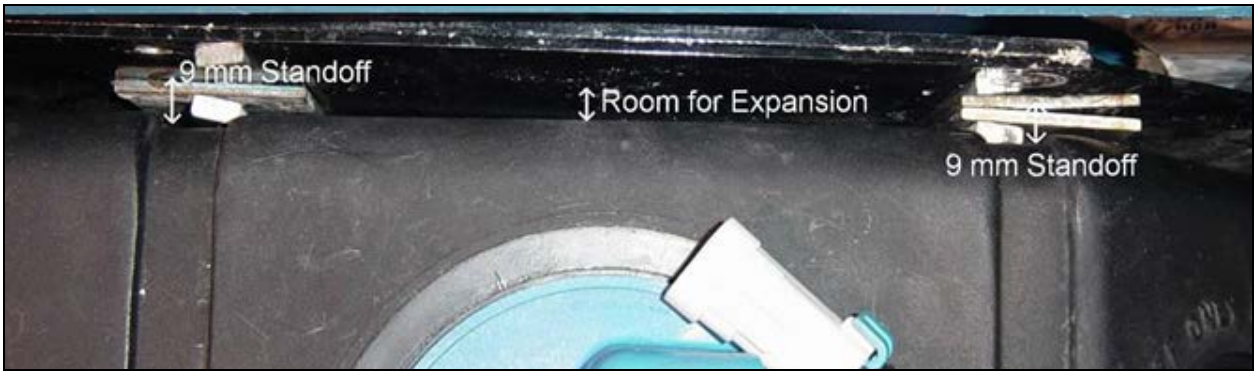
Ensure the nozzle clearance meets ISO-22241 allowing for easy access for filling and avoid areas where the DEF tank could be exposed to service fluids.

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 tank's strap grooves with the mounting bracket wall or sides, and strap bolts with mounting bracket wall and sides, to allow room for expansion.

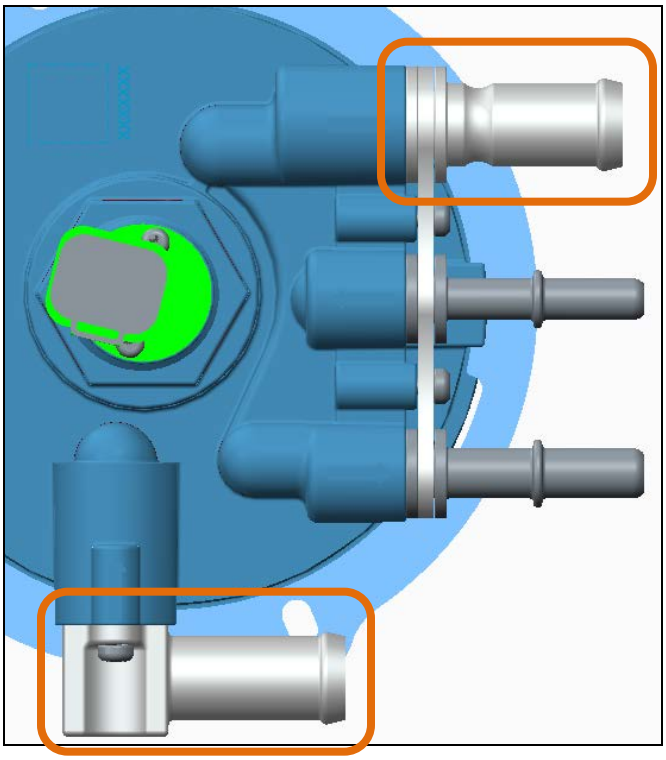




3.2 COOLANT HOSES

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 indicated by the arrows. 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.

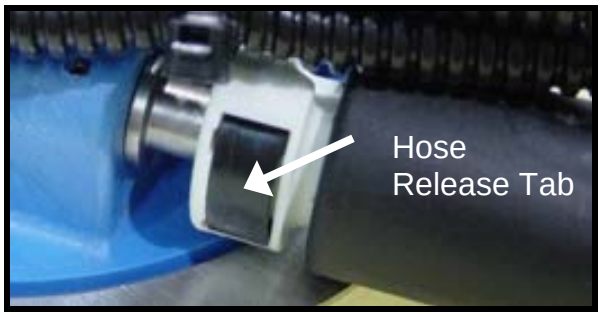
3.3 DEF HOSES

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.

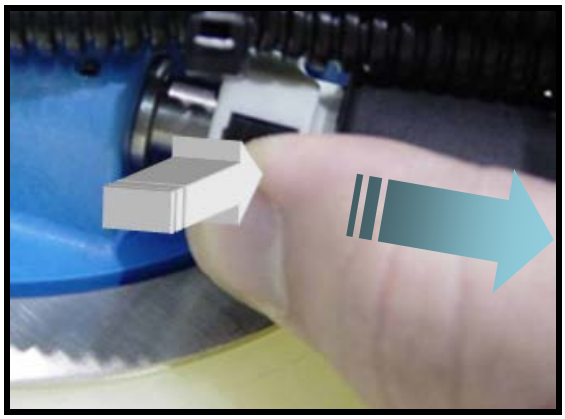
After assembly, confirm the hoses themselves aren't kinked in any location, are free of debris, and aren't close to any kind of heat source and sharp edges.

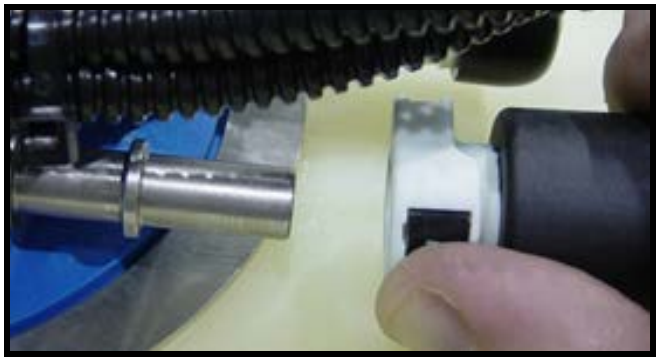
<u>Install of DEF Hoses (Outward facing release tab):</u>

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.





DO NOT use any tools to pop out the hose release tabs as this may cause damage or breakage of the tabs.

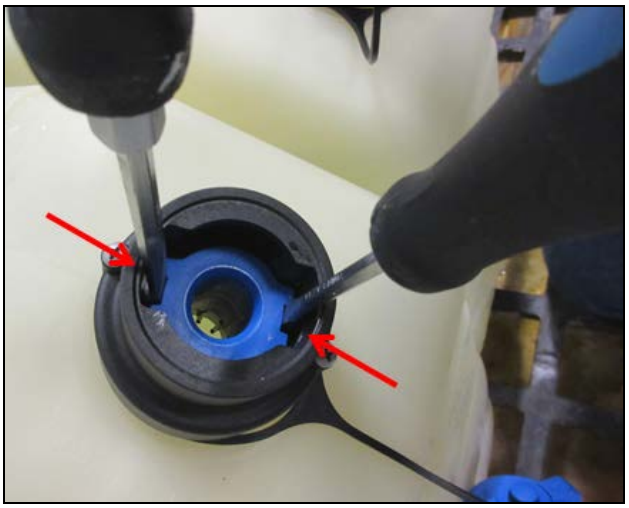
3) Replace with new hose and connector, pushing onto the fitting until an audible click can be heard and the hose and connector are locked into place.

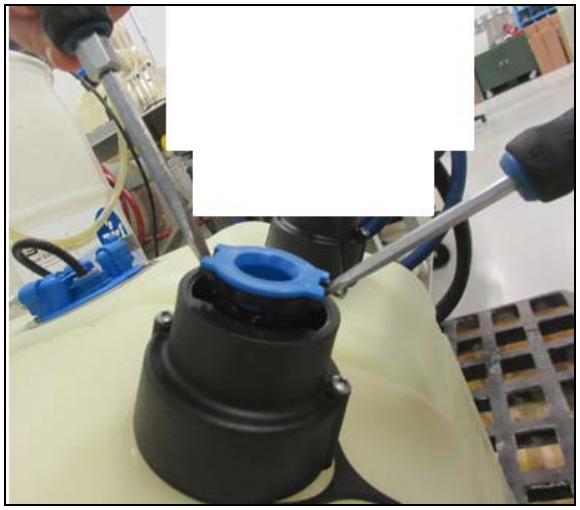
3.4 FILL PORT STRAINER

This section demonstrates how to properly remove and install the fill port strainer assembly from the DEF tank.

Fill Port Strainer Removal Procedure:

Use two flat-headed screwdriver's to carefully lift up/remove the strainer assembly from the tank adapter, while pressing on both the strainer tabs inwards simultaneously. See below photographs for reference.

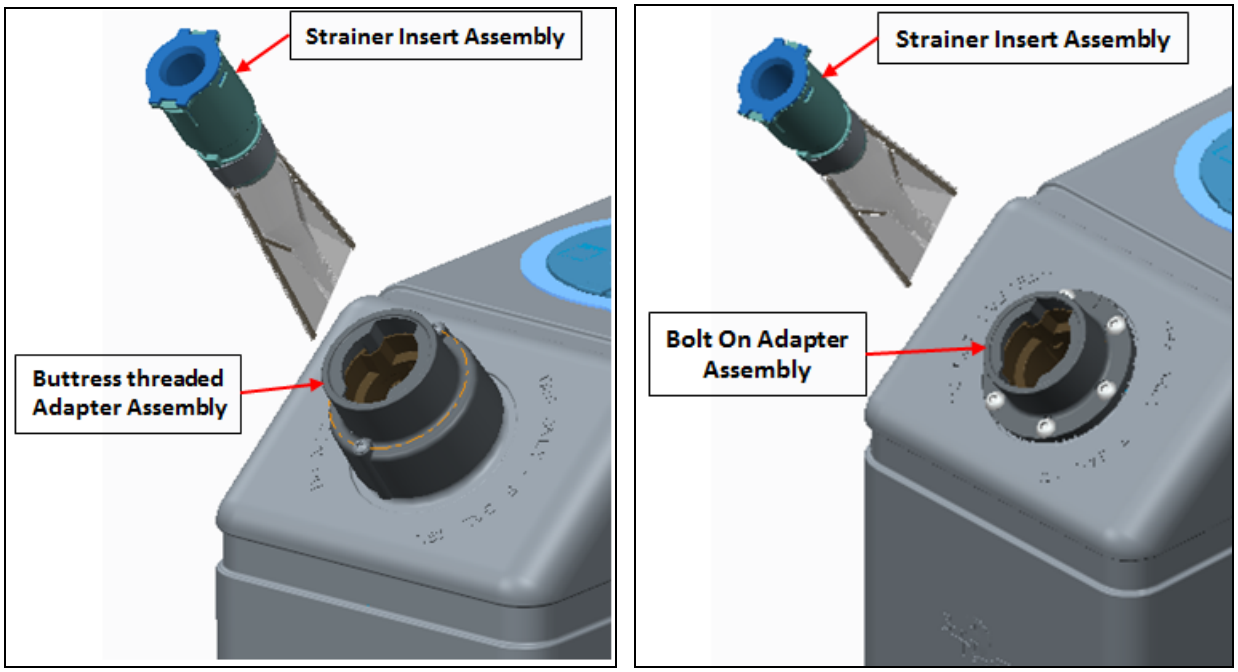




It is important to make sure that the DEF tank is clean before and after the strainer replacement process, to reduce debris intrusion into the tank. For instructions on cleaning the DEF tank refer to sections 2.1.1 and 2.1.2

Fill Port Strainer Installation Procedure:

Remove the DEF cap and insert the strainer assembly into the DEF tank adapter per the orientation shown below. Push the strainer until it clicks into place.

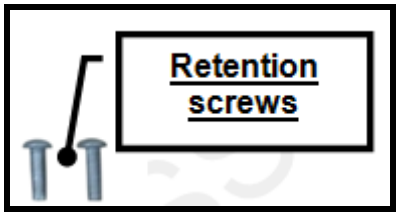


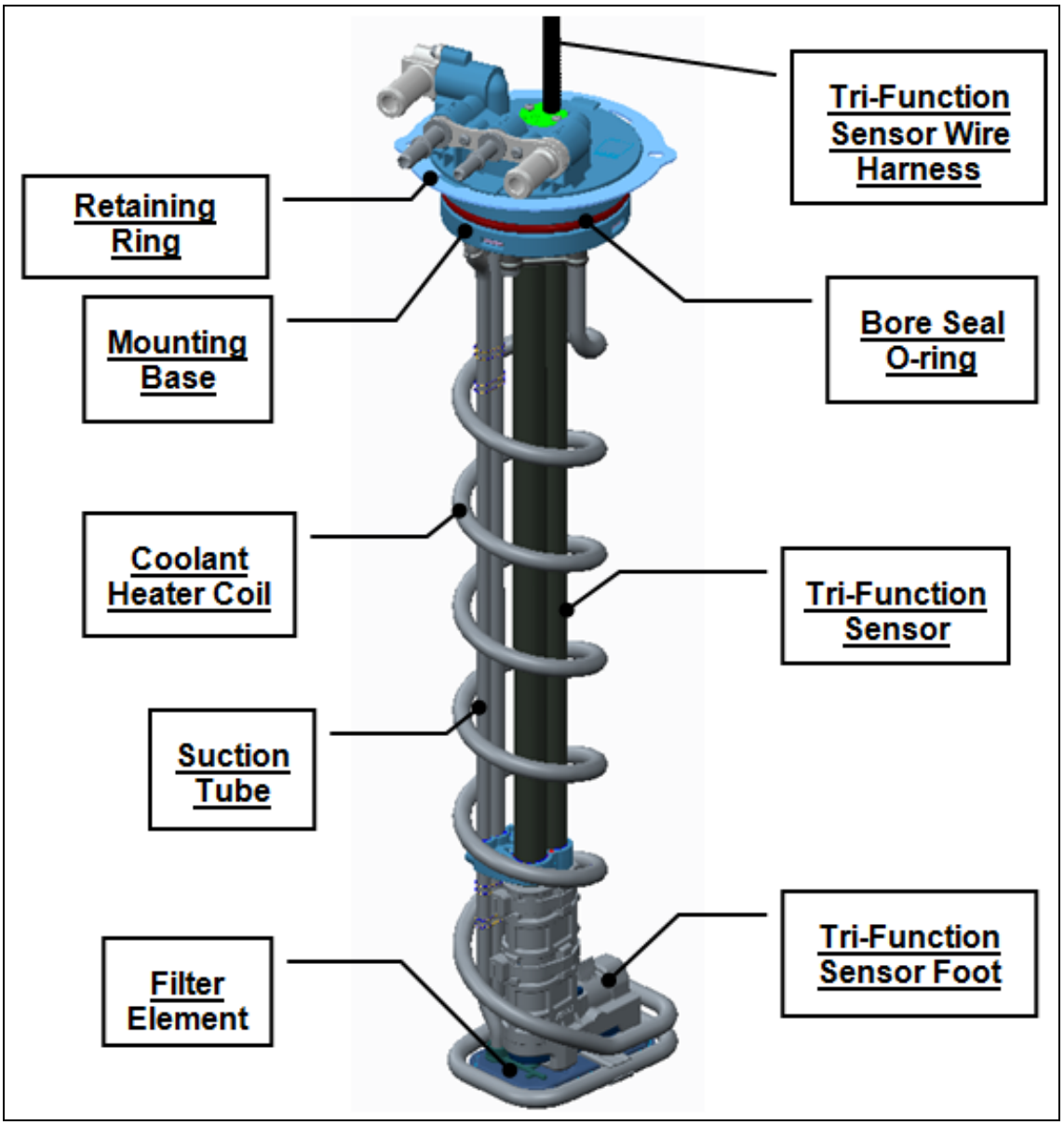
3.5 MULTIFUNCTION HEAD UNIT ASSEMBLY

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

It is important to make sure that the DEF tank is clean before and after the MFHU replacement process, to reduce debris intrusion into the tank. For instructions on cleaning the DEF tank refer to sections 2.1.1 and 2.1.2

DEF Multifunction Head Unit Components Terminology

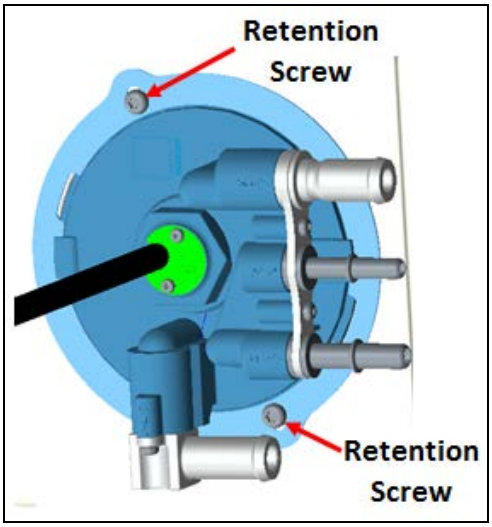




Section A: MFHU Removal Instructions

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

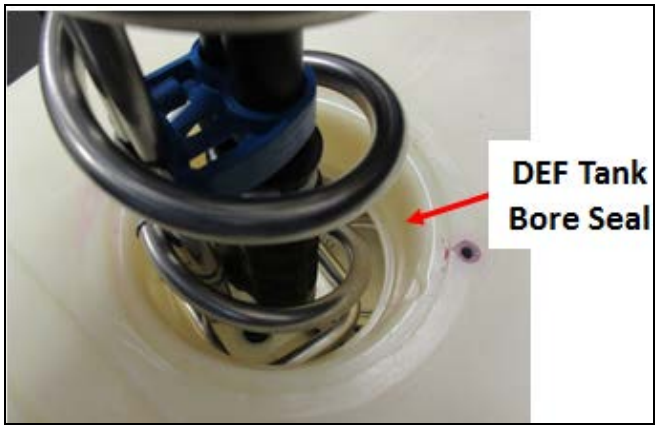
1) Using a T25 Torx Driver, unscrew the retention screws that secure the Retaining Ring to the DEF tank.



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

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.

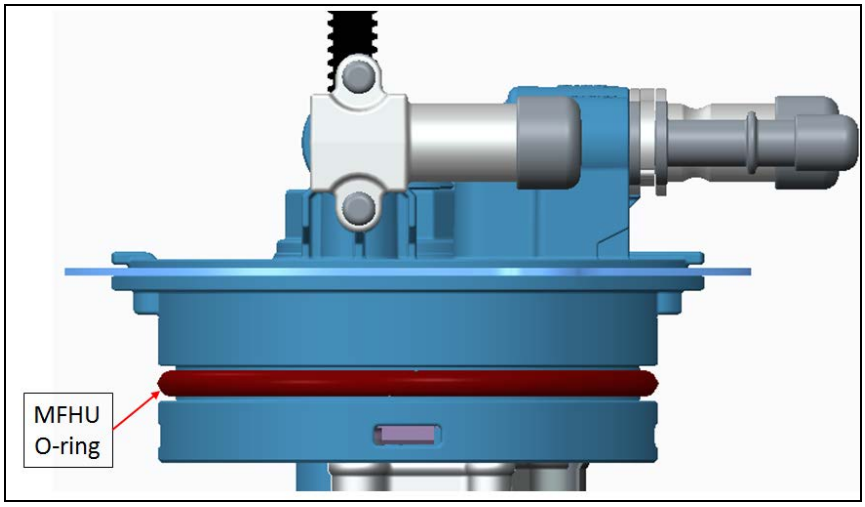


4) Angle the heel of Tri-function sensor foot upward and rotate the header until the bottom of the header is positioned inside the tank bore. When the bottom of the header is in the tank bore, fold the filter downward towards the interior of the tank. Continue to carefully remove the header out of the tank bore until completely freed.

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

Section B: MFHU Installation Instructions

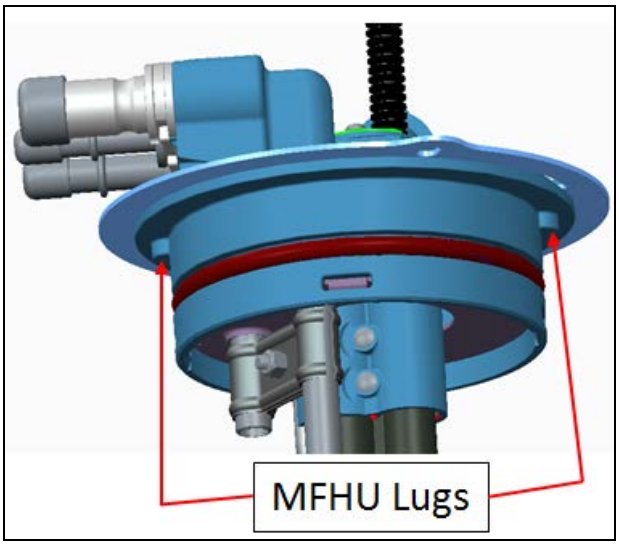
5) Apply a thin layer of DOW UCON LB-625 or Shaw Product Engineering Approved Equivalent O-ring lubrication to the Bore seal O-ring.

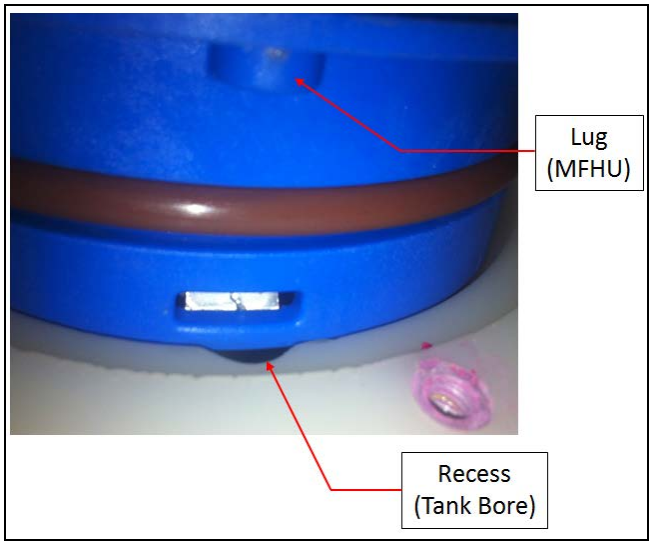


6) Tilt the header to an approximate 45˚ angle, with respect to the top of the tank. With the heel of the Tri-Function Sensor foot angled upward, place the toe of the heater coil into the tank bore. Gradually work the bottom portion of the DEF head into the bore opening until completely inserted in the tank.

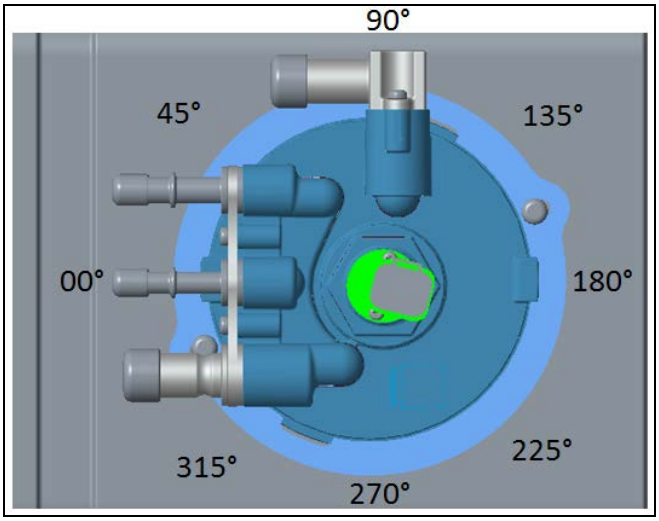
DO NOT push the MFHU directly into the tank as this could damage the unit.

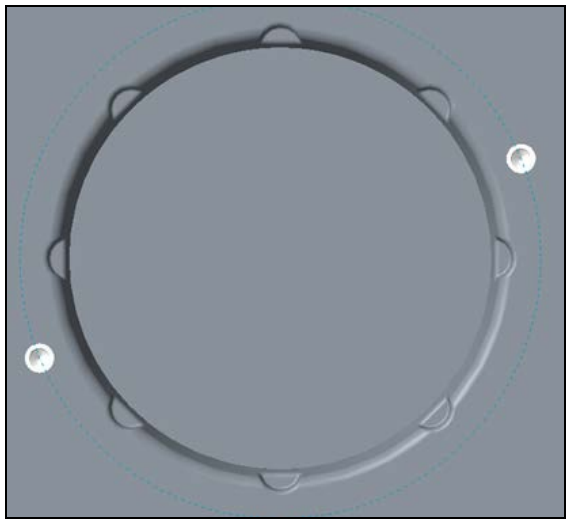
7) Position the DEF head unit in the desired orientation (lugs on the MFHU should align with the cut out/recess on the tank bore and the Coolant and DEF Fittings should orient as shown in the image below) and press on the top of the blue mounting base until it is completely seated in the tank bore.





<u>Orientation of the MFHU fittings on DEF tank</u>:

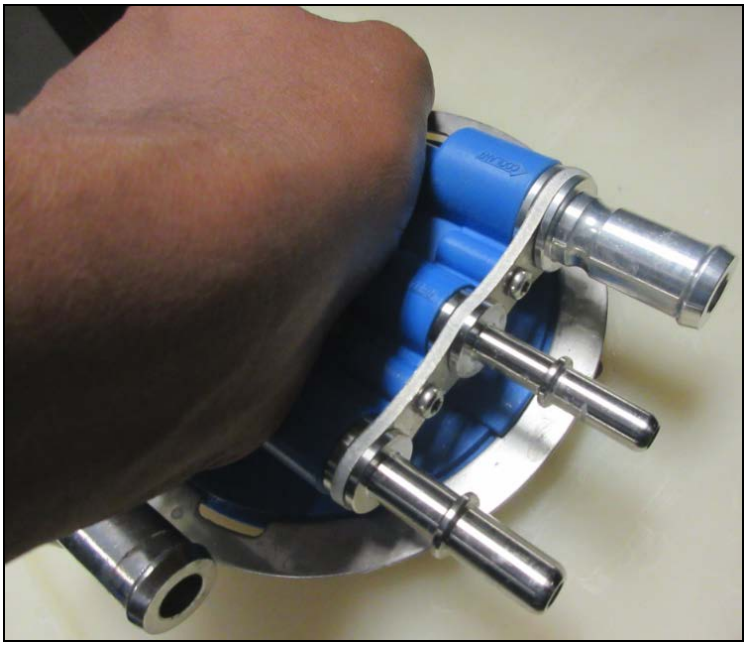




90° and 135° fitting orientations are not available for 5 gallon Portrait tank (DR502) configuration.

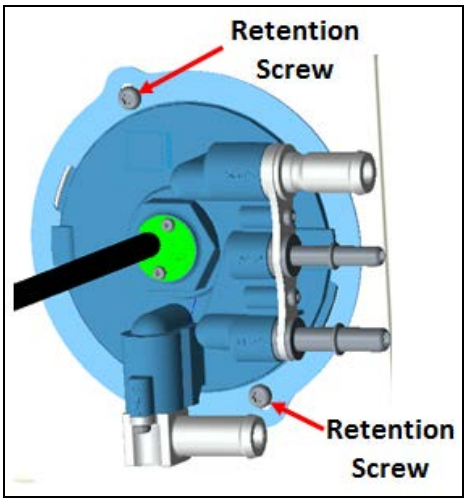
135°, 180° and 225° fitting orientations are not available for 10 gallon cube tank (DR507) configuration.

DO NOT push down on top of the blue mounting base until the MFHU is oriented correctly to align with the tank bore.



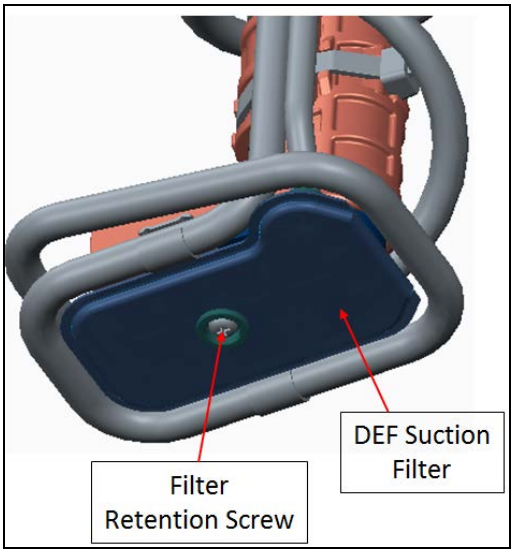
DO NOT press directly on the fittings.

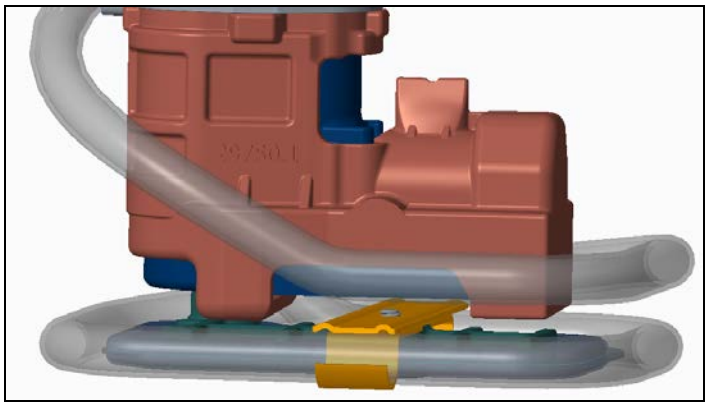
8) Position the retaining ring on head unit to align with the tank mounting holes and install the retention screws using the T25 Torx driver. Recommended torque on screws is 20 - 30 in-lbs (2.26 – 3.38 N m).

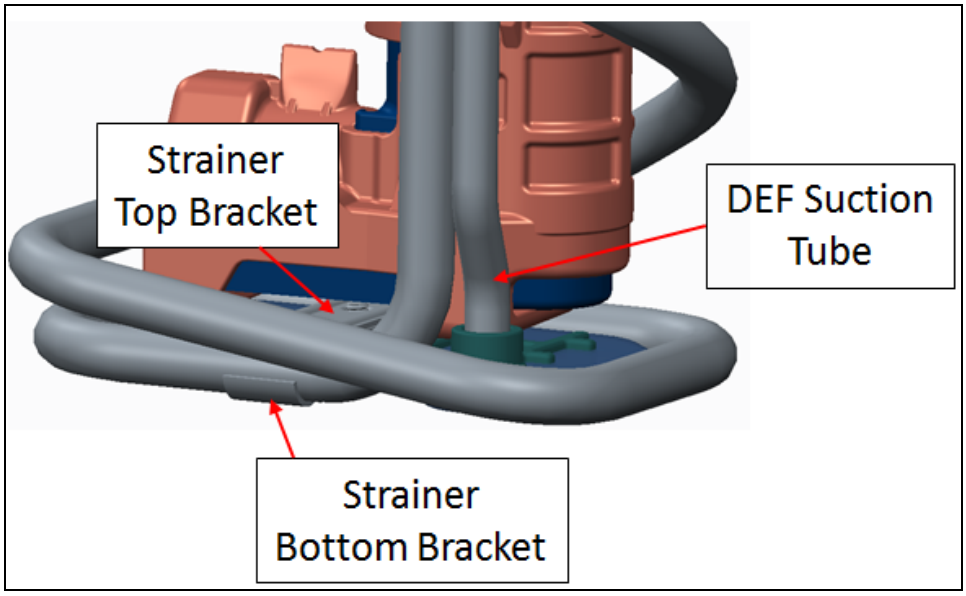


3.6 DEF SUCTION FILTER

This section demonstrates the proper steps for removing and installing the DM5 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 tank. For better visibility of the top and bottom strainer bracket locations, see the second image below. For instructions on how to remove the MFHU, please refer to Section 3.5A.



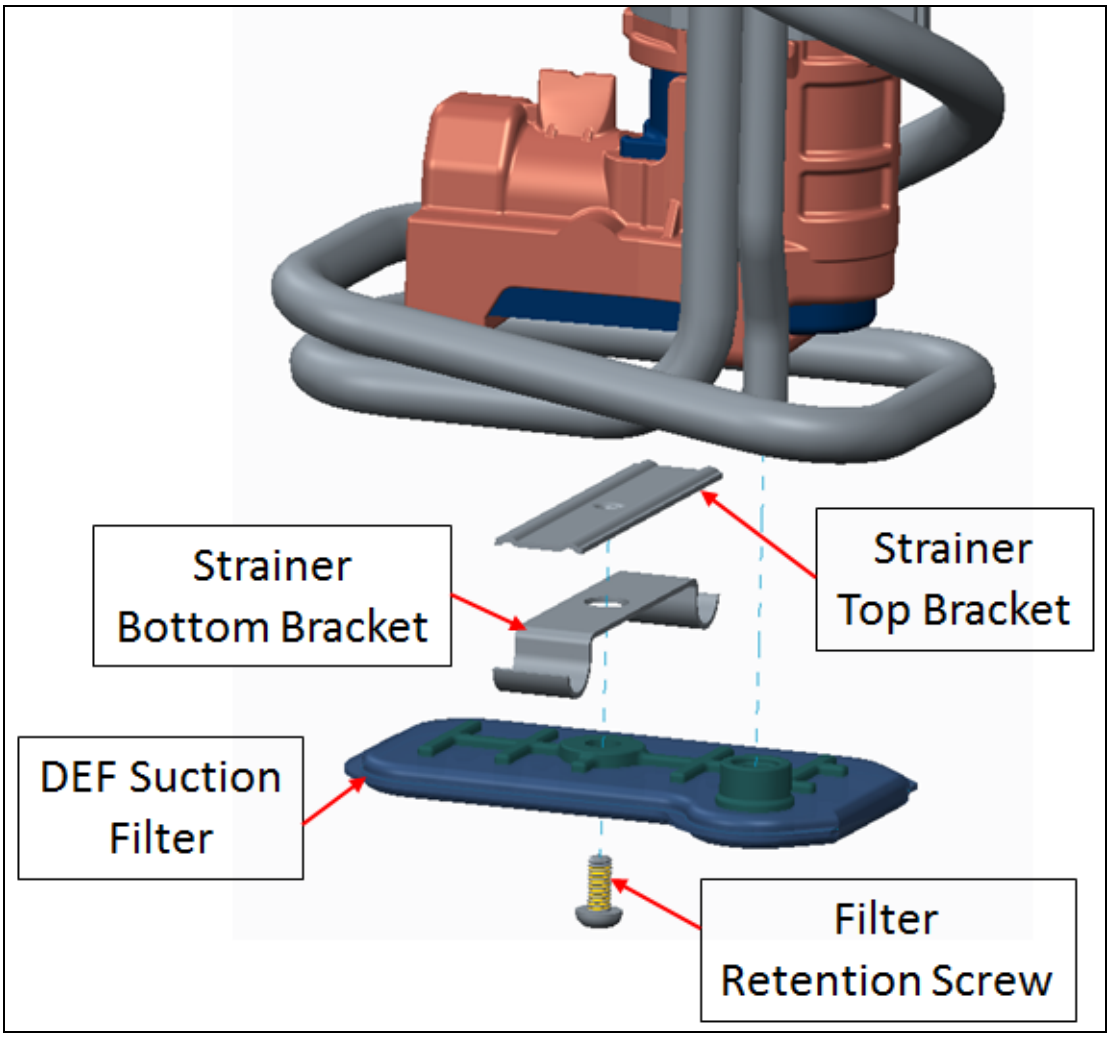




Suction Filter Removal Procedure:

NOTE: The following procedure begins after the MFHU has been removed from the DEF tank. For instructions on removing the MFHU, please refer to Section 3.5A.

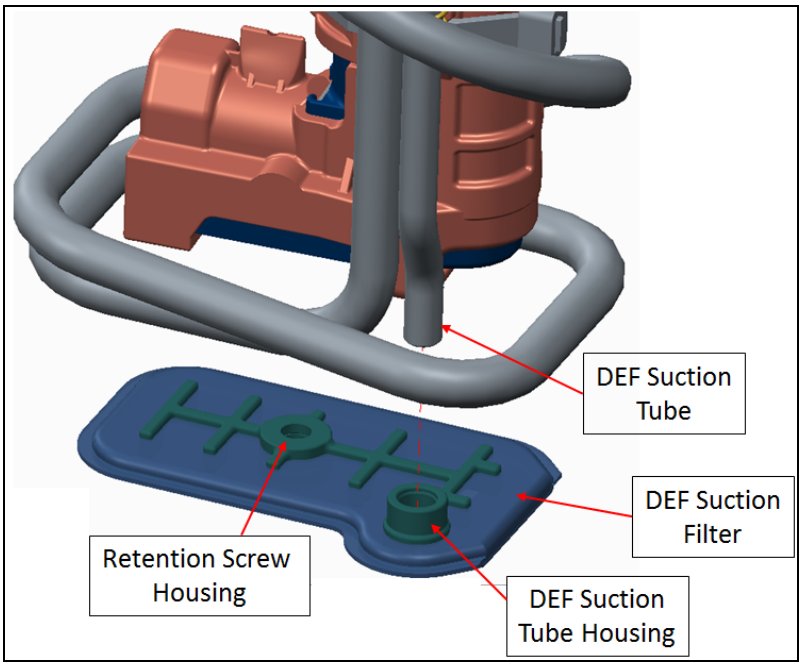
1) Locate the suction filter retention screw and remove using the #2 drive. Discard the screw.



2) Discard the strainer top and bottom brackets.

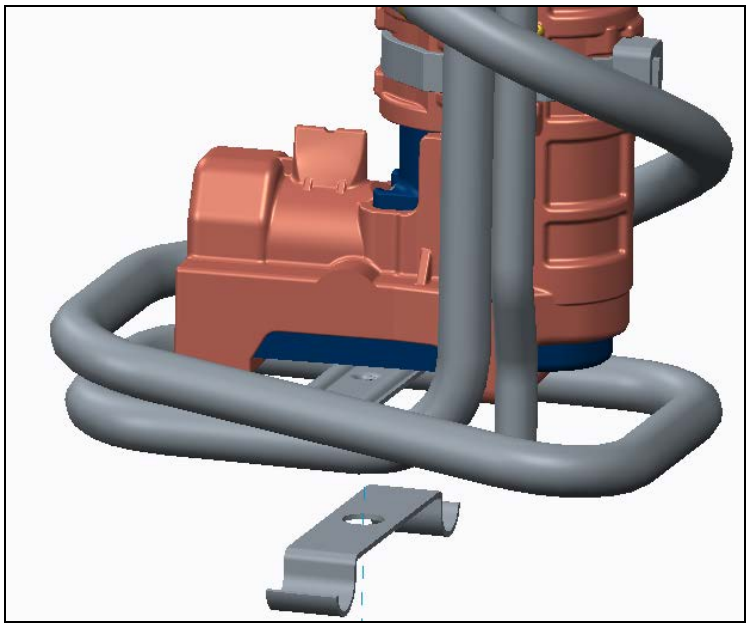
3) Pull the old suction filter off of the suction tube and discard.

Note: All the above described/labeled items are included in the suction filter replacement kit.

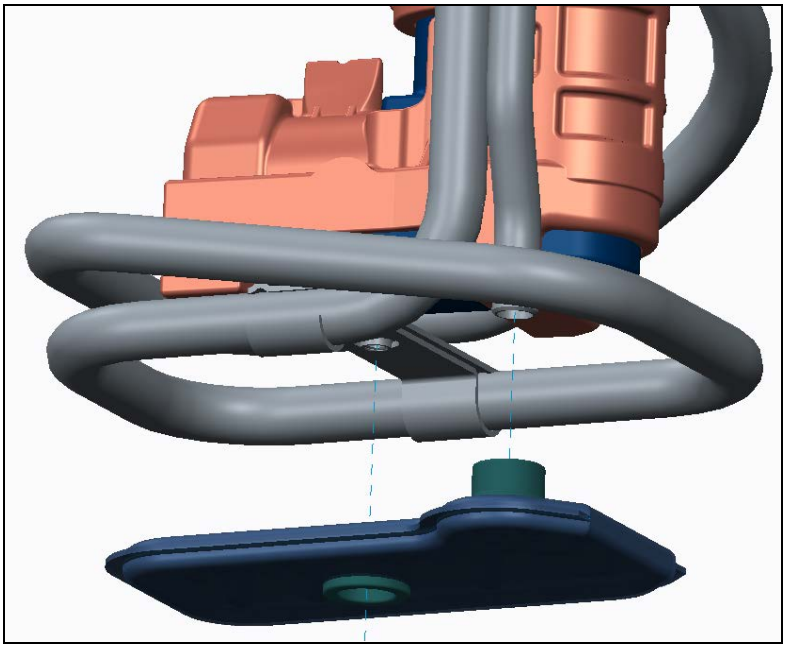


Suction Filter Installation Procedure:

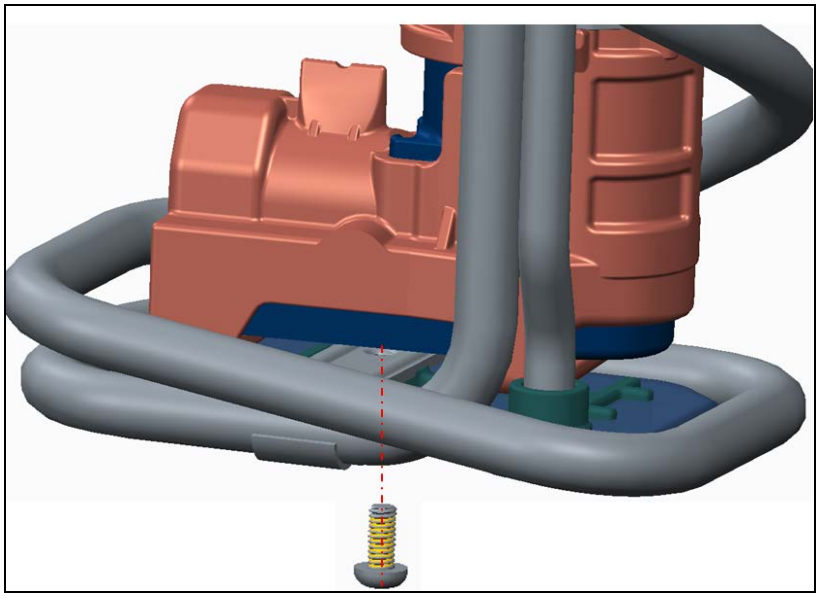
4) Insert the top strainer bracket through the gap between the heat exchanger coil and bottom of tri-function sensor. While the top bracket is sitting on the heat exchanger, position the bottom strainer bracket at the bottom of the heat exchanger coil and hold parallel to the top bracket.



5) Position the new filter's suction tube housing onto the bottom of the suction tube and press the filter flush towards the bottom of the tri-function sensor boot.



6) Align the filter, top and bottom brackets so that the filter retention screw can screw into the retention screw housing. Install the new retention screw using #2 drive. Recommended torque on screw is 14 - 18 in-lbs (1.58 – 2.03 N m).



7) Once the retention screw is installed, the MFHU will be ready to be installed into the tank. Refer to Section 3.5B for MFHU installation instructions.

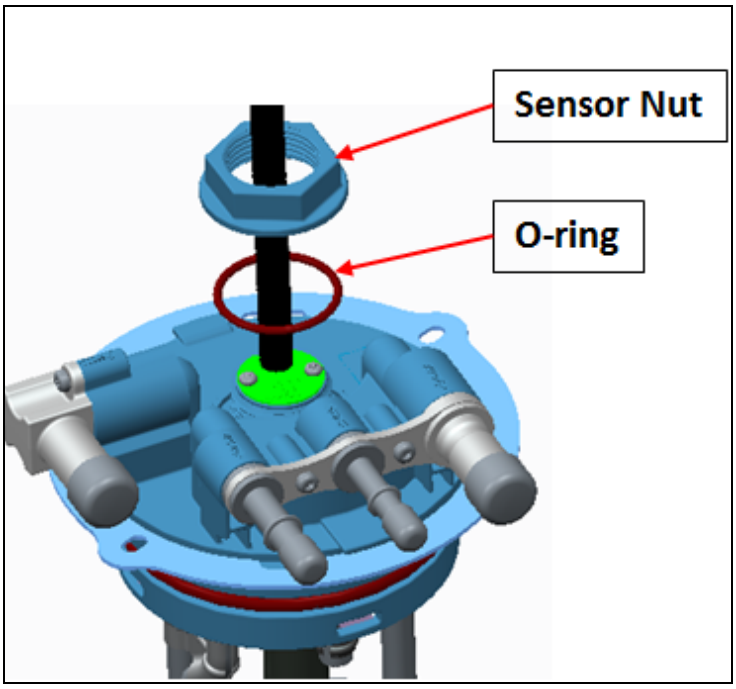
3.7 TRI-FUNCTION SENSOR

This section demonstrates how to properly remove and install the Tri-function sensor. It is crucial that these steps are followed to avoid performance issues with the DEF system.

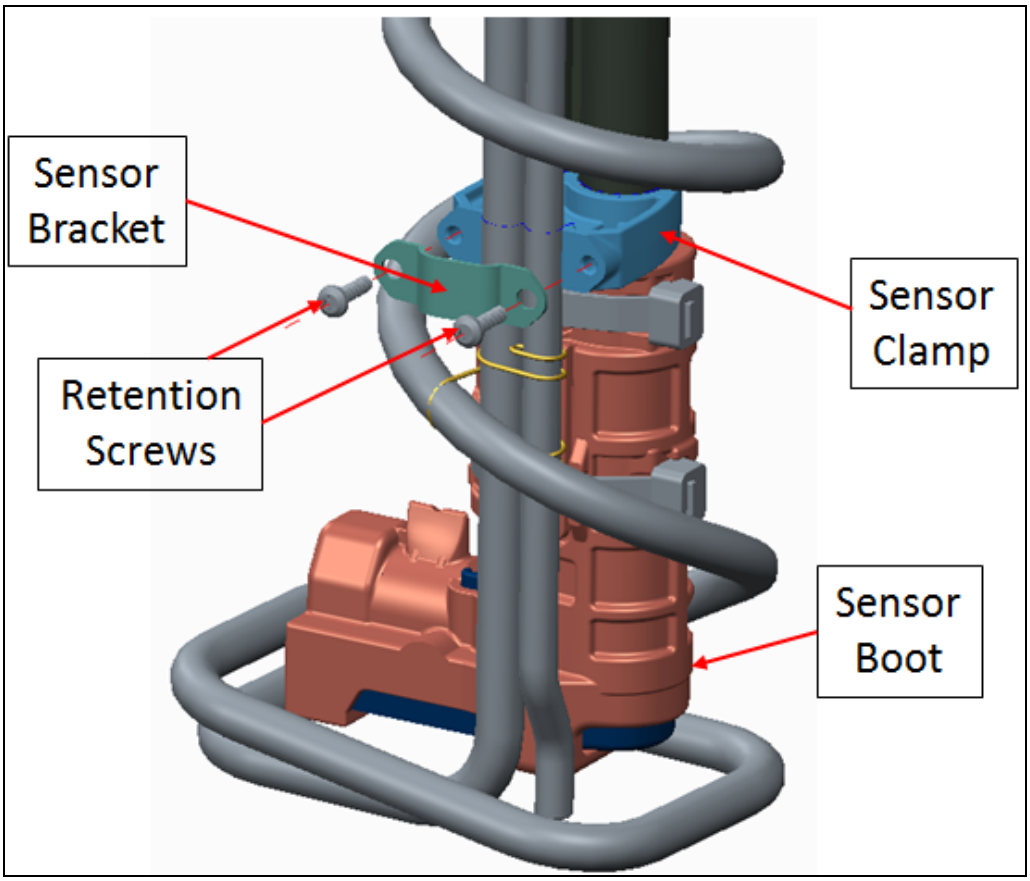
Tri-function Sensor Removal Procedure:

NOTE: The following procedure begins after the MFHU has been removed from the DEF tank. For instructions on removing the MFHU, please refer to Section 3.5A.

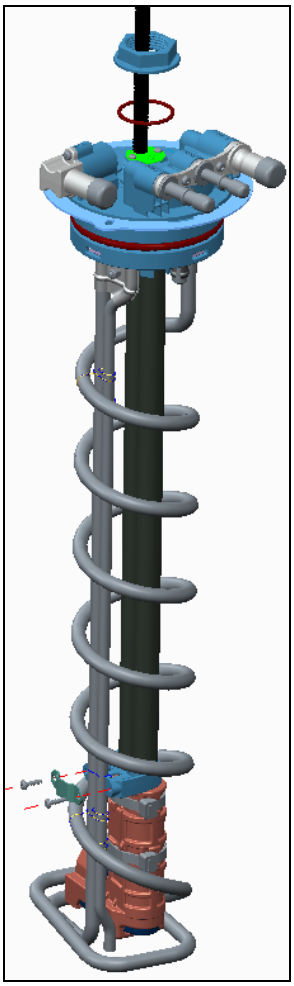
1) Loosen and remove the Tri-Function Sensor nut using a box wrench or pliers. Set the Sensor nut and the O-ring to the side.

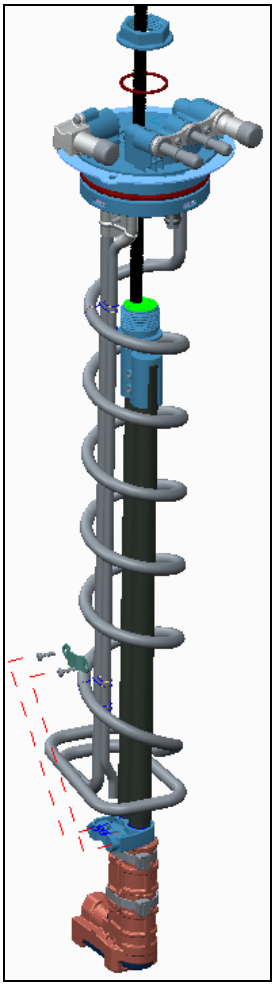


2) Remove the suction filter. Refer to section 3.6 for DEF suction filter removal instructions. Using a T15 Torx Driver, unscrew the retention screws that secure the sensor clamp to the MFHU tubes/Sensor Bracket.

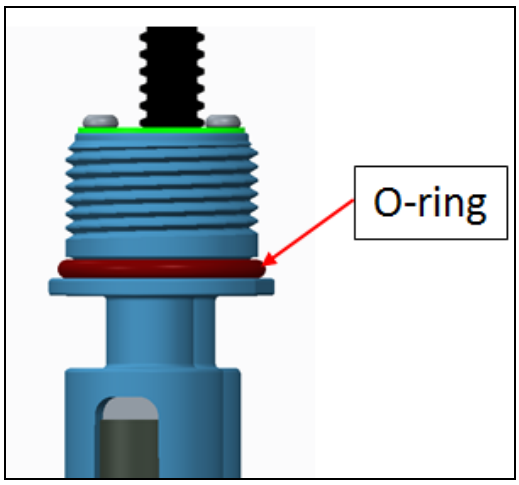


3) Remove the retention screws and the sensor bracket and slide the Tri-Function Sensor from the DEF head mounting base (Refer to image below). Do not damage the MFHU coil/suction tubes while removing the sensor.





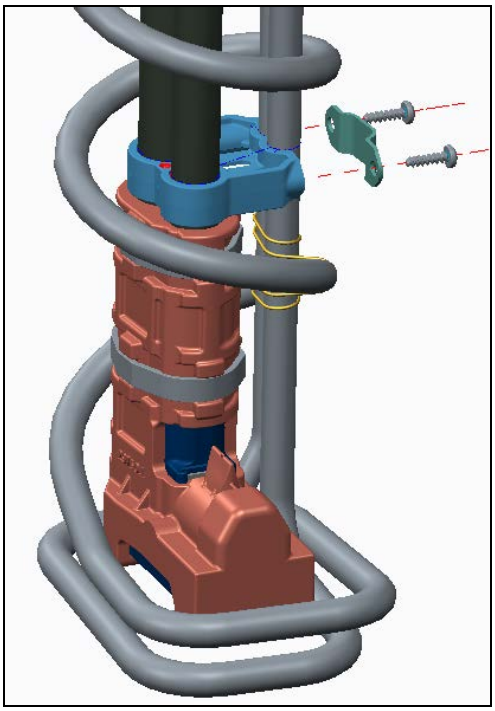
4) Inspect the Tri-Function Sensor for signs of damage. Verify an O-Ring is located below the threading at the top of the sensor (Refer to image below).

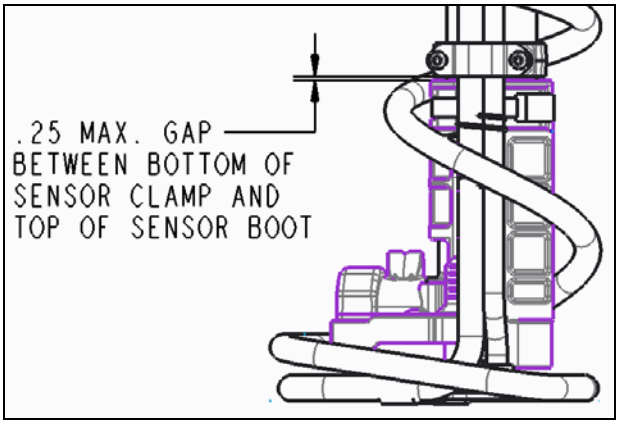


Tri-function Sensor Installation Procedure:

5) Make sure the new Tri-Function Sensor has an O-ring preinstalled on top as shown in the previous image.

6) Feed the new Tri-Function Sensor's cable into the bottom of the mounting base through the sensor opening. Press the Tri-Function Sensor clamp into the MFHU tubes to align with the sensor bracket and the foot of the sensor parallel with the heater Element. The gap between bottom of the sensor clamp and top of the sensor boot should not be more than 0.25 inch. Install the retention screws using T15 Torx Driver. Recommended torque on screws is 18 - 24 in-lbs (2.03 – 2.71 N m) (Refer to image below).

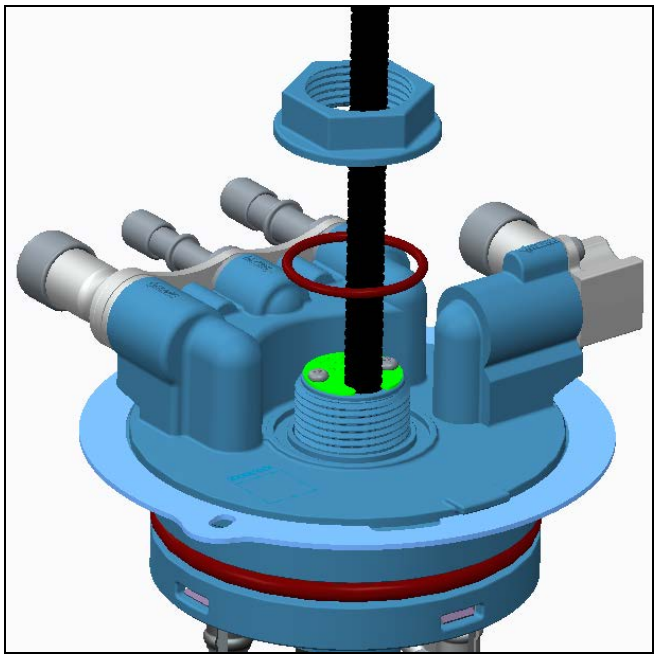




7) Position the top of the sensor through the mounting base such that the upper threaded portion of the sensor is seen. Ensure the top surface of the header is cleaned.

8) Install the Sensor O-ring on the top through the upper threaded portion of the sensor by feeding the cable through the O-ring. The O-ring should sit in the MFHU mounting base groove. Do not apply O-ring lube on this O-ring.

9) Install the Tri-Function Sensor nut on the top by feeding the cable through the sensor nut and screwing down the nut on the sensor down to the mounting base. Tighten nut to 40 - 44 in. lbs (4.5 - 4.97 N m).



10) Install the DEF suction filter. Refer to section 3.6 for DEF suction filter installation instructions.

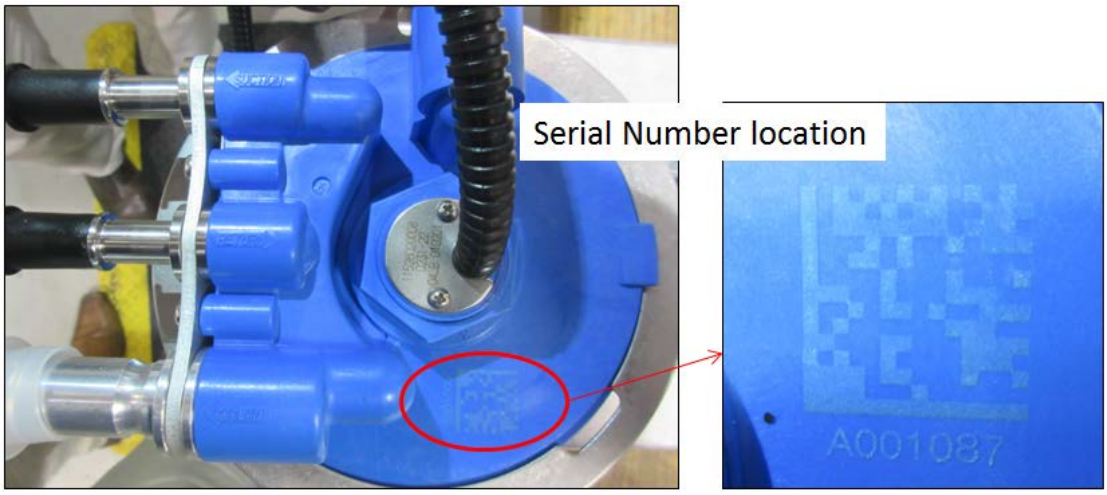
11) Once the DEF suction filter is installed, the MFHU is ready to be installed into the tank assembly. Refer to section 3.5B for MFHU installation instructions.

4.0 FREQUENTLY ASKED QUESTIONS (FAQ's)

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

✓ Providing the following information will help in expediting the troubleshooting process.

1. All Fault Codes related to the incident
2. DEF tank assembly part number
3. MFHU serial number (reference image below for location)



4. Location of failure (City, State, Territory)
5. Failure Date

➢ How can I troubleshoot the Tri-Function Sensor?

✓ Request for Shaw's DEF gauge tool kit. The Part Number for this kit is **960-0231-01-KIT**. This kit consists of the following items:

QTY.	PART NUMBER	DESCRIPTION
1	TB-2989	TECHNICAL BULLETIN
1	960-0232-02	DEF GAUGE VEHICLE HARNESS
1	960-0232-01	DEF GAUGE

Shaw's DEF gauge is capable of displaying all the DEF Tri-Function sensor outputs and their associated Failure Mode Indicators (FMI). This gauge plugs in between the J1939 connector on the Shaw's DEF SCR system and the Vehicle's Harness. Technical Bulletin **TB-2989** is a quick start guide that describes the diagnostics process.

➢ Can I orient the Multi-Function Head Unit?

✓ Refer to page 48 for the header orientation options.