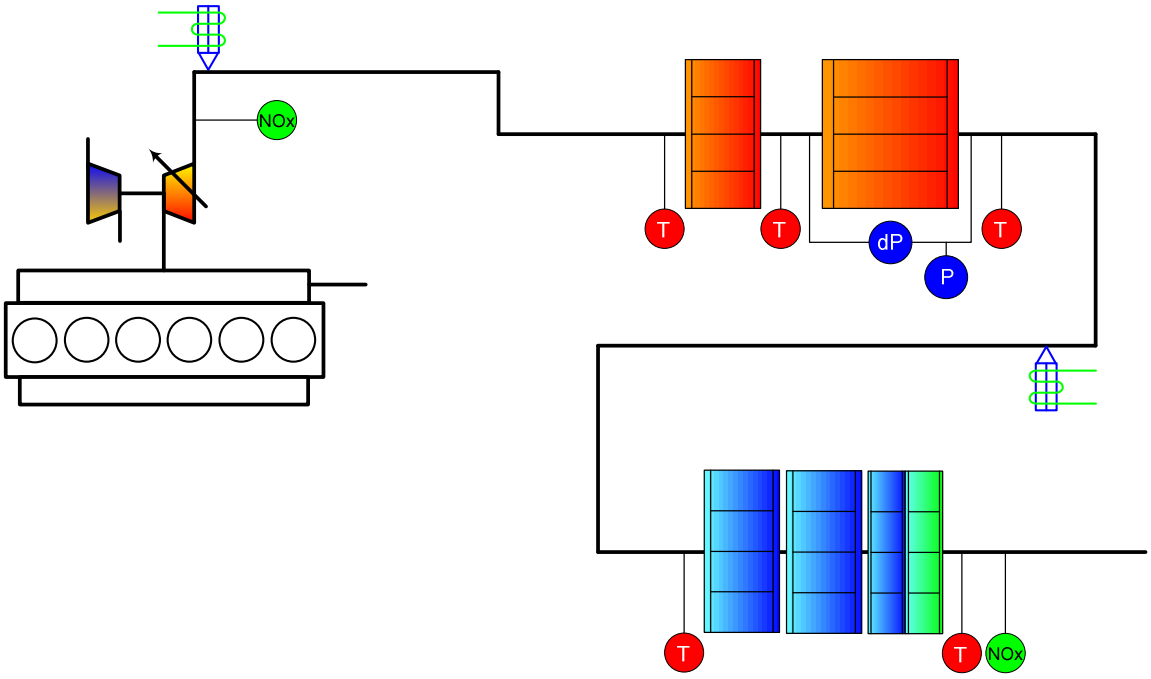
Monarch Aftertreatment Survival Guide For FP Systems

Rev 7e



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ATI

January 2010

Cummins Confidential

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Document Introduction

This document describes expected performance, limitations and special survival procedures specific to the 2010 Cummins Aftertreatment system including SCR.

This document covers both vehicle and test cell applications.

Hardware Introduction

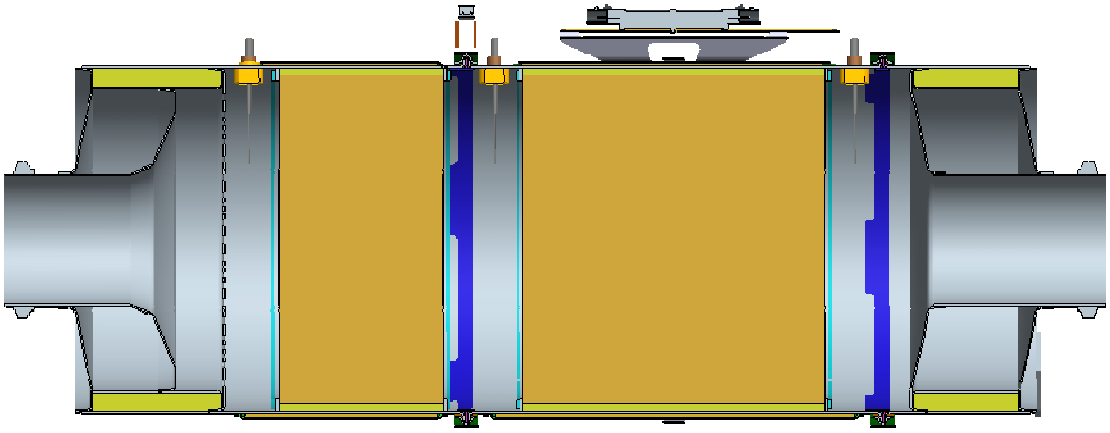
The Aftertreatment system is comprised of 3 specific off-engine components. The first component is the Hydrocarbon (HC) Doser and housing or manifold. The second is the Robust Particulate Filter (RPF) system. And, the third is the Selective Catalytic Reduction (SCR) system. Each of these off-engine components is detailed below.

The HC Doser manifold mates to the engine's turbocharger outlet flange. This manifold not only houses the HC Doser, but also the Engine Out NOx sensor. This NOx sensor is used as an input to the feed forward control for the Urea Dosing system.

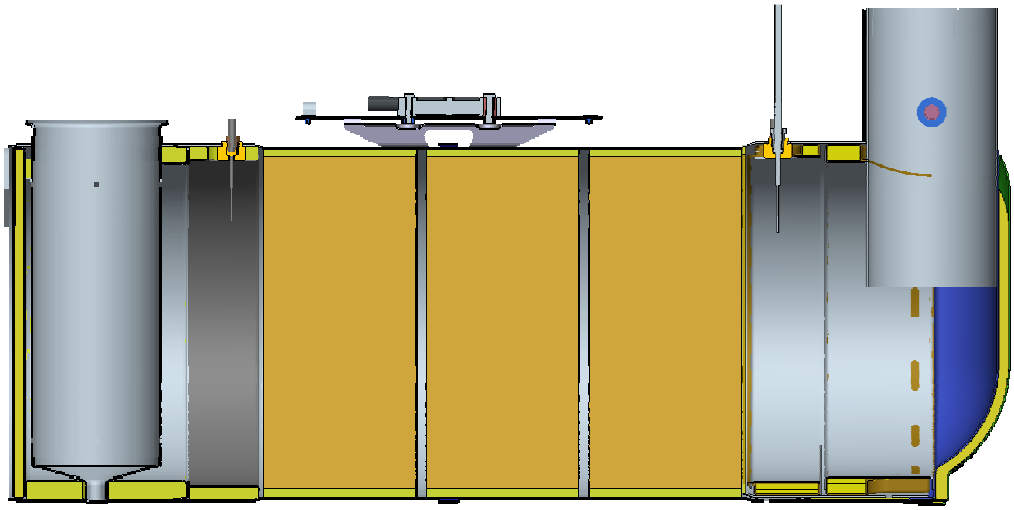
The RPF assembly (Graphic 1) consists of the following components: an integrated inlet and diesel oxidation catalyst (DOC), a diesel particulate filter (DPF), three temperature sensors (DOC In, DOC Out, & DPF Out), one combination DPF differential pressure and DPF Outlet gage pressure sensor, a sensor table, and exhaust silencing components assembled into a modular housing.

The SCR assembly includes the following components: a Decomposition Reactor (Graphic 3), an SCR Canister, two temperature sensors, a System Outlet NOx Sensor, a Bosch DCU, a Bosch Supply Module (Diesel Exhaust Fluid (DEF) Pump), a DEF Doser Module, a Wiring Harness, a DEF Supply Line, a DEF Pressure Line, and a DEF Return Line.

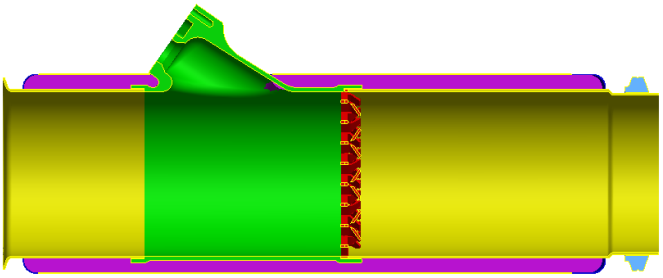
Inside the SCR Canister are three substrates (Graphic 2). The first 2 substrates are catalyzed with a Copper-Zeolite washcoat. This washcoat is the catalyst necessary to convert NOx to Nitrogen in the presence of Ammonia. The first 1/3 of the third substrate is the same Copper-Zeolite washcoat and the remaining 2/3 is Platinum-Iron-Zeolite. The final 2/3 of the third substrate is the Ammonia Oxidation catalyst (AMOX) and is used to oxidize any residual ammonia slipping past the SCR catalyst.



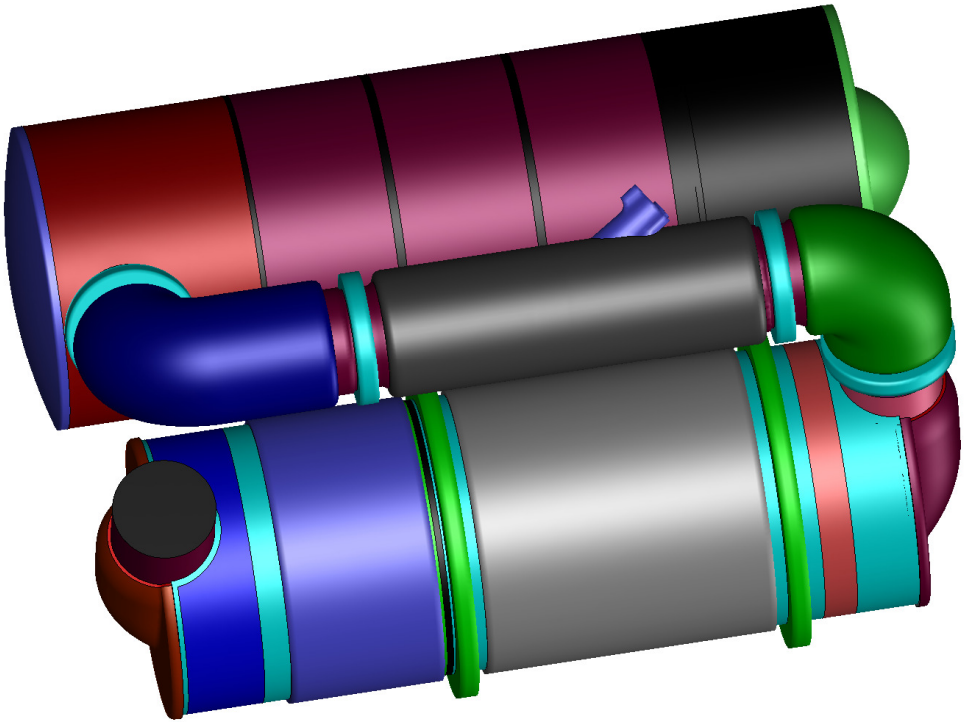
Graphic 1: RPF Cutaway



Graphic 2: SCR cut-away



Graphic 3: Decomposition Reactor



Graphic 4: RPF and SCR Switchback design

Performance Introduction

The Aftertreatment System is an integral part of Cummins 2010 EPA Emissions Compliant Engine system. The engine control system monitors the particulate filter to determine its operating status and controls thermal conditions for optimum regeneration. During normal operation, particulate matter is collected in the filter and oxidized as the exhaust conditions allow. Occasionally the engine control system will inject additional fuel into the exhaust to be oxidized by the DOC in front of the filter to increase the temperature of the exhaust through the filter. An In-Mission Regeneration may not be permitted if a failure has been detected by the ECM or the ECM is trimmed by the end-user such that an In-Mission Regeneration is not permitted under the specific duty cycle of operation. Under either of these circumstances, the DPF may not reach temperatures sufficient to regenerate completely or at all. If this situation continues, an Out-of-Mission Regeneration is required to oxidize soot collected in the filter before permanent damage occurs in the filter.

During an Out-of-Mission Regeneration of the particulate filter, the engine speed will increase to aid the regeneration process. Any auxiliary device that is dependant on engine speed for proper operation should be disengaged during an Out-of-Mission Regeneration. An Out-of-Mission Regeneration will stop when the regeneration is complete, the Service Brake / Clutch / Throttle are depressed, Vehicle Speed is detected, the transmission is placed in gear, or PTO is set.

The SCR system actively reduces NOx by injecting Diesel Exhaust Fluid (DEF) or Urea through the Doser Module into the Decomposition Reactor. The Urea decomposes inside the Decomposition Reactor into Ammonia and CO2. The ammonia then reacts with the NOx in the

presence of a catalyst to form N2 and H2O. In general, Urea is being injected continuously as long as exhaust flow and temperature thresholds are achieved.

Fuel Requirements for 2010

The engine must use Ultra Low Sulfur Diesel (ULSD) fuel (sulfur content less than 15 ppm), unless approved by the Field Test Coordinator or the Endurance Test Coordinator.

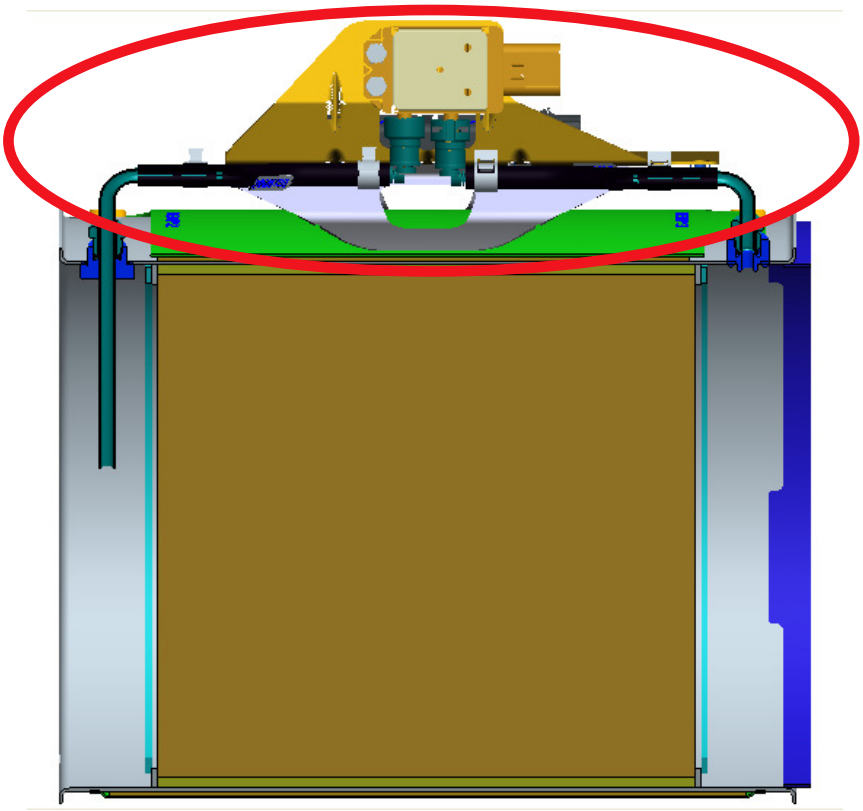
The DEF used for SCR systems is a eutectic solution that is 32.5% Urea by weight. DEF has a freezing point of -11 [deg_c]. Care must be taken to provide adequate thawing capability if an SCR system is to be used in ambient conditions that could freeze Urea. Application Engineering Bulletin 21.79 contains detailed information on proper installation of an SCR system.

Changes from 2007

2010 offers a chance for CES to commonize and simplify parts. One significant change for 2010 is that the DOC is now integrated with the Inlet section. As seen in Graphic 1 above, the DPF assembly is now 3 separate components (Inlet / DOC, DPF, Outlet) whereas the generic assembly for 2007 consisted of 4 separate components (Inlet, DOC, DPF, Outlet).

An additional gage pressure sensor has been added at the DPF Outlet to improve diagnostics for OBD requirements in 2010. With the addition of SCR and the increased backpressure, this gage pressure sensor provides a more accurate method to calculate volumetric flow rate through the system. The gage pressure sensor shares the same port and tube with the DPF delta P Lo Pressure port and tube.

The DPF for 2010 has also changed significantly from 2007. The DPF now houses both the DOC Out and DPF Out thermistors and both the DPF delta P Hi and Lo pressure ports and tubes. The DPF canister will also house the DPF dP / Out gage pressure sensor along with a sensor junction connection. The components listed above that are integral to the DPF are circled in Graphic 5 below.



Graphic 5: Components integral to DPF

Monarch engines will utilize an air purge in the fuel dosing system. The air purge will be plumbed in to either the truck service brake air supply or the test cell shop air supply. The air purge will purge the dosing fuel line of fuel after a regeneration event and is intended to improve HC doser reliability and reduce degradation over time.

The most obvious addition to the 2010 hardware recipe is SCR. SCR's main function is to reduce the system out NOx levels by injecting DEF in to the exhaust stream under most operating conditions.

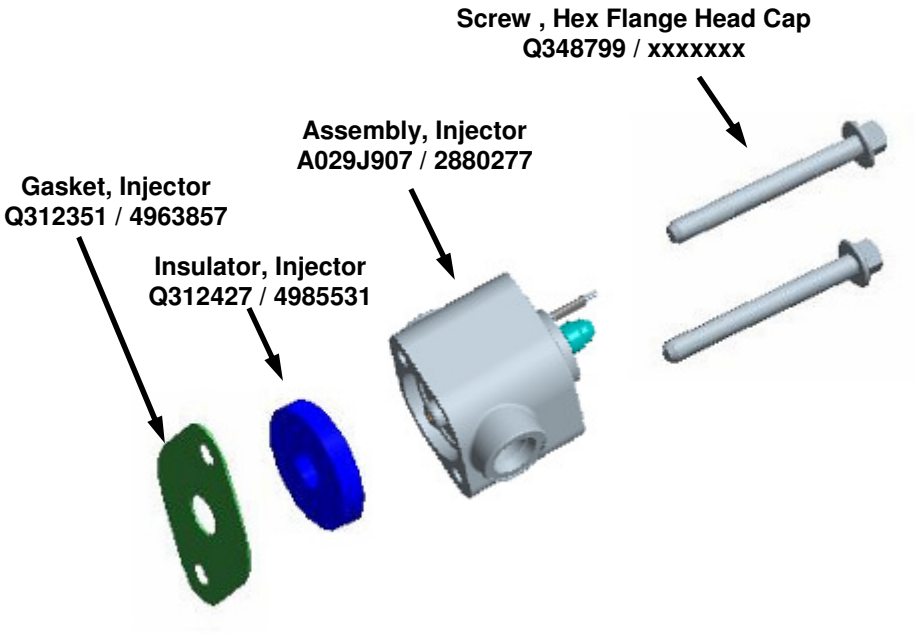
Major Component Part Number / Compatibility Information:

New 1.8 mH HC Doser Assembly:

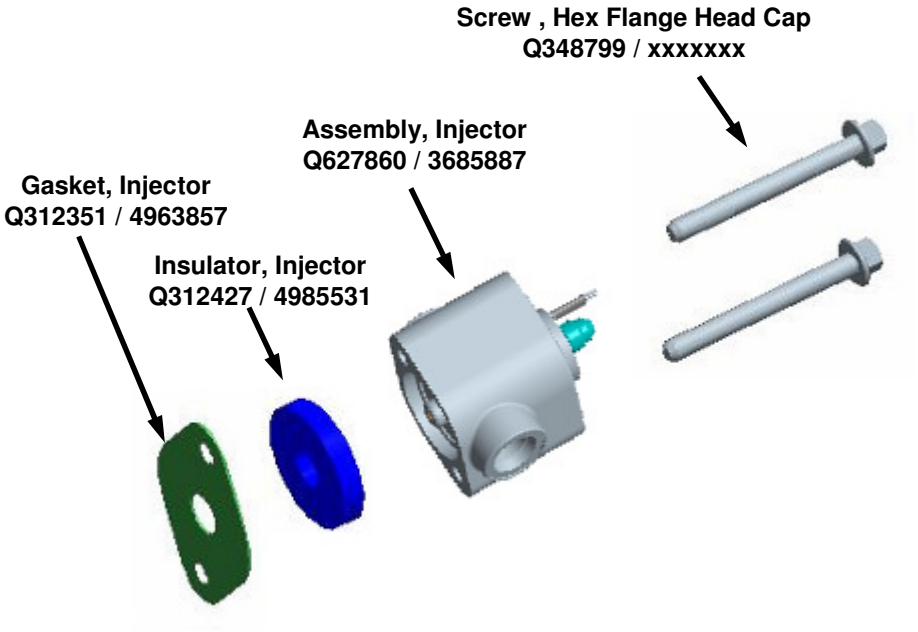
Assembly Part Number: CES A029J908 / Cummins 2880278

To be used on Monarch Red 6.14.0.03.r36 and higher (Ref Campaign MONA-34)

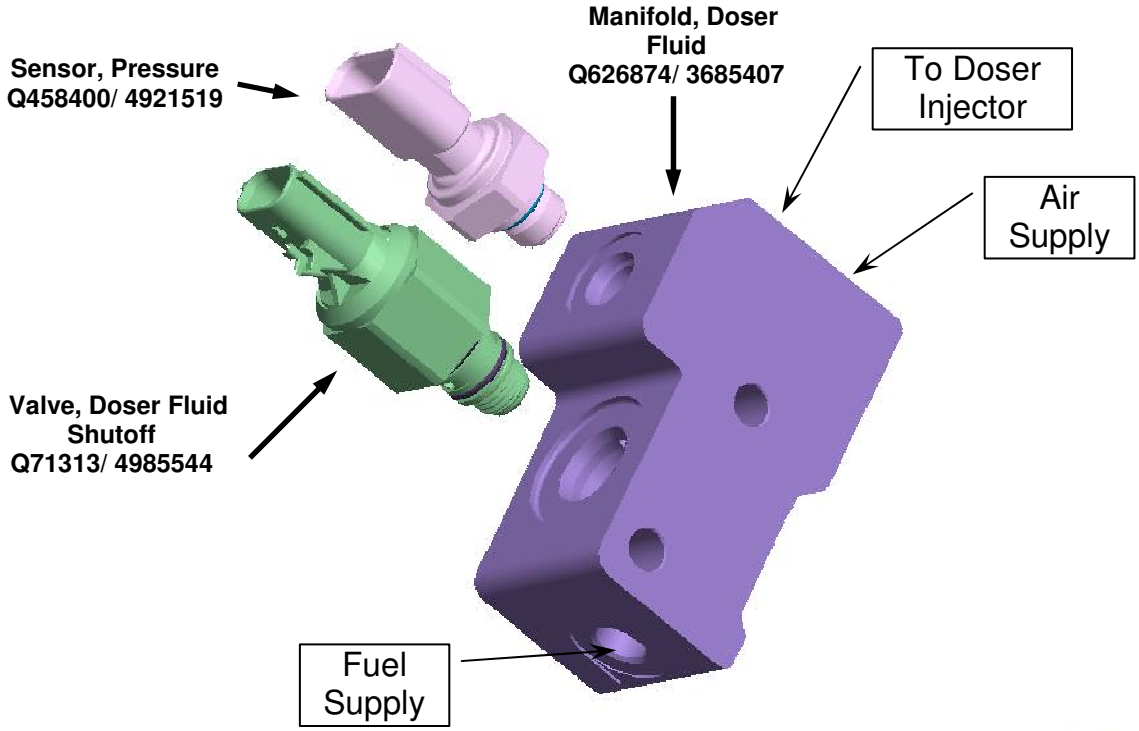
To be used on Monarch Black 6.14.0.08.r158 and higher (Ref Campaign MNBA-12)



Old 1.2 mH HC Doser Assembly:
Assembly Part Number: CES Q627859 / Cummins 2866313



Doser Fuel SOV Assembly :
Assembly Party Number: CES Q625388 / Cummins 3685406



Bosch DCU Software Color Coding:

Bosch DCU Software Version can only be read with INCA. Because INCA is not widely available, a color scheme was developed by CES to help identify the software contained inside the DCU. The following table defines the color associated with each software release and its intended association with the engine ECM software. This mark is always on the front face of the DCU.

Note: The color dot is meant only as a helpful guide. It is the responsibility of the test owner to document and understand the software contained within the DCU.

SW	Color	ECM SW Association	Bosch HW Association
2.5.3	None	4.xx.x.xx	B1 DM/SM/DCU
3.5.1	Blue	5.12.0.1x	C0 DM/SM, C1 DCU
3.5.3	Black	6.13.0.10	C0 DM/SM, C1 DCU
3.5.4	Black with '3.5.4' written on DCU	6.13.0.10	C0 DM/SM, C1 DCU
3.6.4	Green	6.14.0.0x	C0 DM/SM, C1 DCU
3.7.1/3	Red	6.15.0.0x	C1 DM/SM, C2/D DCU
3.7.5/6	Red	7.10.0.0x	C1 DM/SM, C2/D DCU

Each DCU that has been recalibrated by ATI or CES has been properly marked with a permanent marker or paint pen. It is recommended that if a DCU is recalibrated in the field or test cell using the Download Utility, the proper color dot be painted on the front face of the DCU.

The Bosch Download Utility created by the Tools Group expired on 10/31/09 and can no longer be used to download software to the DCU. Insite has been updated to include software download capability for the Bosch DCU through the Engine ECM. INSITE 7.3 Feature Pack 2 is required for this new functionality.

Bosch Hardware Management:

Bosch Part Number associated with individual Sample Phase.

Part	Sample	Bosch Part Number	Sample	Part Number	Sample	Bosch (CEN) Part Number
12V SM	B	B444 606 134	C0	B444 606 202	C1	B444 606 402 (2871879) B444 606 425 (2871879)
24V SM			C0	B444 606 203	C1	B444 606 403 (2871880) B444 606 426 (2871880)
DM	B	B444 606 138	C0	B444 606 204 B444 606 220	C1	B444 606 408 (2871878) B444 606 427 (2871878)
DCU	B	0281B04596-02	C1	0281B05037-33 0281B100VA-33 0281B100VA-44	C2 / D	0281B1011U-04 (2871808) 0281B1011U-05 (2871808) 0281B1011U-07

Bosch Hardware / Software Compatibility:

The following chart shows the Bosch Hardware / Software Compatibility with the engine ECM Software. Refer to the feature matrix below to determine features associated with each DNOx Software Release.

DNOx SW	V2.5.3	C3.2	C3.5.5/4	C3.6.4	C3.7.1/3/5/6
SM	B1	B1/C0	B1/C0	B1/C0	B1/C0 C1
DM	B1	C0	C0	C0	C0 C1
DCU	B1	C1/C2	C1/C2	C1/C2	C1/C2
4.xx.x.xx	V2.5.3 Features	Not Compatible	Not Compatible	Not Compatible	Not Compatible
5.12.0.1x	Not Compatible	C3.2 Features	C3.2 Features	C3.2 Features	C3.2 Features
6.13.0.10	Not Compatible	C3.2 Features	C3.2 Features C3.4.3 Features	C3.2 Features C3.4.3 Features	C3.2 Features C3.4.3 Features
6.14.0.0x **6.15.0.0x**	Not Compatible	C3.2 Features	C3.2 Features C3.4.3 Features	C3.2 Features C3.4.3 Features C3.6.4 Features	C3.2 Features C3.4.3 Features C3.6.4 Features
6.15.0.0x	Not Compatible	C3.2 Features	C3.2 Features C3.4.3 Features	C3.2 Features C3.4.3 Features C3.6.4 Features	C3.2 Features C3.4.3 Features C3.6.4 Features C3.7.1 Features C3.7.3 Features C3.7.5 Features
7.10.0.0x	Not Compatible	C3.2 Features	C3.2 Features C3.4.3 Features	C3.2 Features C3.4.3 Features C3.6.4 Features	C3.2 Features C3.4.3 Features C3.6.4 Features C3.7.1 Features C3.7.3 Features C3.7.5 Features C3.7.6 Features

NOx Sensor Compatibility:
The following chart shows the Bosch Hardware / Software Compatibility with the engine ECM Software.

Part	Part Number	Compatibility	Defining Features
SAE 9 Inlet NOx Sensor	2872065	AlphaSCR, Beta, BetaFT, Cert	Bosch Black Connector (Can be used after removing key in connector)
SAE 9 Inlet NOx Sensor	2872027	AlphaSCR, Beta, BetaFT, Cert	Bosch Gray Connector
SAE 9 Outlet NOx Sensor	4984576	AlphaSCR, Beta, BetaFT, Cert	Bosch Black Connector
SAE 11 Inlet NOx Sensor	2872081 2872082 (24v)	LP / FP	Bosch Gray Connector
SAE 11 Outlet NOx Sensor	2871978 2871979 (24v)	LP / FP	Bosch Black Connector

Bosch Feature Matrix by Software Release:

V2.5.3 features	Doser automatically primes Doser transmits pump state, dosing rate Doser transmits DM1 messages
C3.2 features	ECM commands pump priming DCU transmits pump states, system ECM can override heaters ECM can override heaters DFCs transmitted via CAN Incomplete purge monitor
C3.5.3/4 features	Variant dataset selection Drive-cycle recognition Drive-cycle recognition Emergency shut off
C3.6.4 features	Bucket Heater Address Software id Source address request DM13 Reflash through service tool Cal id Actual variant dataset on datalink Pump pressure on datalink Cold soak detection by ECM DFC info for diagnostics run after key-off
C3.7.1/2 features	Tank Temp key-on Rationality Heater Service Test
C3.7.3 features	Bug Fixes for FC3651 after quick key cycle
C3.7.5 features	24V System Diag improvements (FC3566)
C3.7.6 features	DEF Tank In-Range Diag improvements

RPF and SCR Part Numbers:

Noun Name	Noun Name	CES Part Number	Cummins Part Number
EIEO Horiz Assembly	DEVICE, AFTERTREATMENT	205430A	2871543
	MODULE, INLET CATALYST	Q629457	2871577
	MODULE, PARTICULATE	Q629458	2871578
	MODULE, OUTLET	Q629459	2871579
EISO Horiz Assembly	DEVICE, AFTERTREATMENT	205431A	2871544
	MODULE, INLET CATALYST	Q629457	2871577
	MODULE, PARTICULATE	Q629458	2871578
	MODULE, OUTLET	Q629460	2871576
SIEO Horiz Assembly	DEVICE, AFTERTREATMENT	205433A	2871546
	MODULE, INLET CATALYST	Q629483	2871583
	MODULE, PARTICULATE	Q629484	2871584
	MODULE, OUTLET	Q629479	2871582
SISO Horiz Assembly	DEVICE, AFTERTREATMENT	205432A	2871545
	MODULE, INLET CATALYST	Q629476	2871580
	MODULE, PARTICULATE	Q629477	2871581
	MODULE, OUTLET	Q629479	2871582
SISO Vertical Assembly	DEVICE, AFTERTREATMENT	205434A	2871547
	MODULE, INLET CATALYST	Q629491	2871587
	MODULE, PARTICULATE	Q629458	2871578
	MODULE, OUTLET	Q629492	2871586
EISO Vertical Assembly	DEVICE, AFTERTREATMENT	205435A	2871548
	MODULE, INLET CATALYST	Q629493	2871585
	MODULE, PARTICULATE	Q629458	2871578
	MODULE, OUTLET	Q629492	2871586
EIEO Horiz SCR Assembly	DEVICE, SCR	205422A	2871573
EISO Horiz SCR Assembly	DEVICE, SCR	205423A	2871572
SISO Horiz SCR Assembly	DEVICE, SCR	205424A	2871549
SIEO Horiz SCR Assembly	DEVICE, SCR	205425A	2871552
EIEO Vert SCR Assembly	DEVICE, SCR	205417A	2871574
SIEO Vert SCR Assembly	DEVICE, SCR	205418A	2871575
Decomposition Reactor	Reactor, Decomposition	Q717302	2866291
Horizontal Delta P Subassy	BRACKET, Sensor Table +5	Q628787	2866343
Horizontal Delta P Subassy	BRACKET, Sensor Table -5	Q628790	2866344
Vertical Delta P Subassy	BRACKET, Sensor Table	Q629058	2866581
SCR Sensor Table Subassy	BRACKET, Sensor Table (SCR)	Q629141	N/A
Hi Pres Tube Assy - Horiz	TUBE, PRESSURE SENSING +5	Q628783	2866341

Low Pres Tube Assy - Horiz	TUBE, PRESSURE SENSING +5	Q628784	2866342
Hi Pres Tube Assy - Horiz	TUBE, PRESSURE SENSING -5	Q628796	2866348
Low Pres Tube Assy - Horiz	TUBE, PRESSURE SENSING -5	Q628797	2866349
Serviceable Parts	SENSOR, TEMPERATURE (DOC In)	Q229792	4984178
	SENOSR, TEMPERATURE (SCR Out)	Q229815	4984757
	SENSOR, TEMPERATURE (DOC Out, DPF Out, SCR In)	Q229793	4984179
	SENSOR, DPF DELTA PRESSURE and OUT P	Q229822	2871960
	GASKET, AFM DEVICE	Q312533	3684079
	CLAMP, T-BOLT (13” Clamp for Sensor Bracket)	Q187097	4965075
	CLAMP, V BAND (12” Clamp for DOC / DPF)	Q187111	4965098
	Gasket, RPF & SCR 5” Marmon	Q312516	2862575
	Clamp, RPF & SCR 5” Marmon	89503K	4965216
Instrumentation Parts	BOSS, dP Low	Q458440	
	BOSS, dP High	Q458458	
	BOSS, Thermistor	Q458496	
	BOSS, NOx Sensor	Q458534	

Test Cell Setup Guidelines:

All Mechanical Development Test Cells are expected to have DPF / SCR Assemblies installed. The only exceptions are the following:

ECCT: Critical to Monarch Program. AT is not required
OST: Motoring Test. AT is not required
Jacobs: Braking Test. AT is not required

All Mechanical Development Test Cells are required to have a complete HC dosing system installed. There are no exceptions.

If an engine does not have an active DPF, the following precautions need to be taken in order to prevent HC doser and HC Fuel Pressure sensor failure due to over-pressurization.

1. Remove the fuel supply line from the fuel filter head to the doser shut off valve manifold
2. Plug both the fuel filter head and the doser shut off valve manifold with the appropriate straight thread oring plugs

3. Remove the fuel supply line from the doser shut off valve manifold to the HC doser and drain the fuel from the line.
4. Reinstall the fuel supply line from the doser shut off valve manifold to the HC doser

Bill Simonton must be consulted on any deviation from the above requirements. CES Reliability is dependant on MD test cell hours to meet their reliability plan.

Test Cell Mounting:

The RPF muffler assembly can be installed horizontally or vertically. Horizontal installations should be cradle-mounted off the test cell floor.

Max DPF Assy weight	150 [lb]
Max package size (Horizontal)	13.5 [in] dia, 41 [in] len
Max package size (Vertical)	13.5 [in] dia, 55 [in] len
Max skin temperature, norm operation	325 [degC]
Max skin temperature, failure mode	375 [degC]

Likewise, SCR assemblies can also be installed horizontally or vertically. However, the Decomposition Reactor must be horizontal.

Max SCR Assy weight	150 [lb]
Max Decomp Reactor weight	25 [lb]
Max package size (Horizontal)	14 [in] dia, 43 [in] len
Max package size (Vertical)	14 [in] dia, 59 [in] len
Max skin temperature, norm operation	325 [degC]
Max skin temperature, failure mode	375 [degC]
Max exhaust gas temperature, normal	600 [degC]
Max exhaust gas temperature, fault condition	1000 [degC]

Truck and Test Cell Setup Guidelines:

All trucks and test cells are required to meet the following specifications, if applicable.

Refer to RPF Installation Requirements AEB 21.78, SCR Installation Requirements AEB 21.79, and Urea System Installation Rev1.pdf for proper installation guidelines.

Exhaust Tubing:

Material	409 Stainless Steel
Max length – Doser to DOC Inlet	guideline: 120 [in]
Min length – Doser to DOC Inlet	guideline: 40 [in]
Max heat loss (Insulation, double	See AEB 21.78

walled pipe, or smaller diameter pipe may be necessary to meet this spec).	
Diameter, Doser Tube out	typical: 4 [in] Mate to Full Marmon
Diameter, DOC inlet	typical: 5 [in] Mate to Full Marmon
Diameter, DPF outlet	typical: 5 [in] Mate to Full Marmon

Fuel supply:

Max sulfur content	15 [ppm]

Some trucks and test cells may be requested to run Bio-Diesel (B20) fuel. The CES Mechanical Development Leader must be contacted prior to using Bio-Diesel.

DEF supply:

The Supply Module and Doser Module utilize specific fittings for the urea line connection. These connections for the Supply Module and Doser Module must meet SAE J2004. The Suction and Throttle Lines are 3/8" Diameter and the Pressure line is 5/16" diameter.

The urea line connection fittings in the Supply Module should not be removed. They are not serviceable and can be easily damaged upon removal.

The throttle line connection in the Supply Module utilizes an orifice to control the proper amount of backflow. This orifice is required for proper operation.

Urea Concentration	32.5 [%]

Air supply to dosing system:

Air supply pressure (only for engines equipped with air purge dosing system)	80-120 [psi]

Post-SCR Instrumentation Considerations:

Under specific operating conditions, Ammonia can slip past the SCR and AMOX system. Deposits left behind by Ammonia can degrade the instrumentation used to measure exhaust constituents. Continuous monitoring of instrumentation is recommended to ensure data integrity

Pre-DOC Instrumentation Considerations:

Instrumentation placed before the DOC will be subject to up to 20,000 ppm HC under regeneration conditions.

Urea Heating Controls :

If Urea Heater Control faults exist and are undesired or prevent urea dosing, 10 Ohm resistors can be installed in the 3 Urea line Heater circuits across each of the 2 pin connectors and the Urea Tank Heater Control valve across pins 1 and 4.

Likewise, if no heating controls are desired, trim T_UIM_FT_SCR_Heating_Type to 4. This assumes that C_UIM_VarDatasetSel_Tbl = [1, 2, 3, **4**, 5]. Selection 4 is used to indicate NO Heating Control.

Urea Tank Temp and Level :

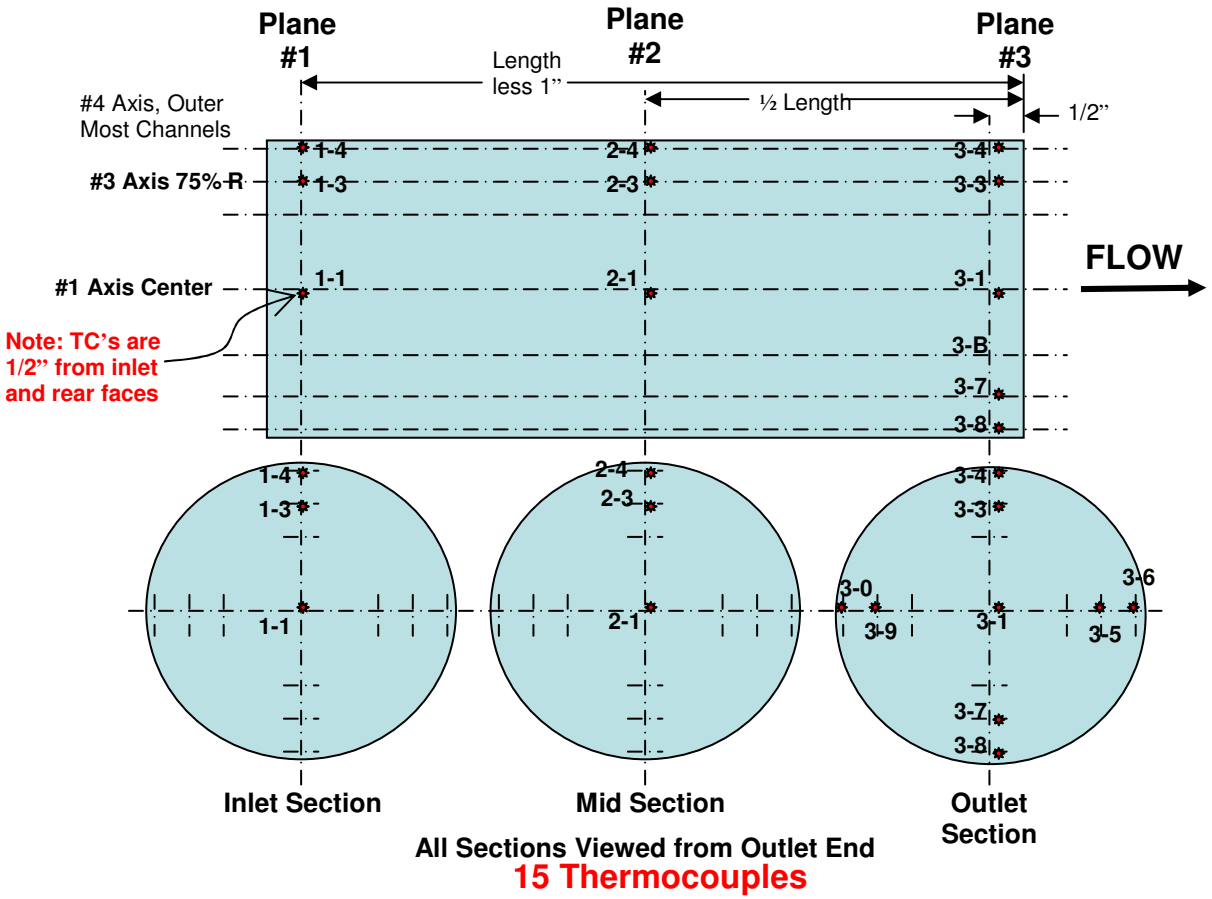
Resistors can be installed in the Urea Tank Temperature and Level Circuits to mimic realistic Temperature and Levels required for fault free operation.

In the round connector marked Tank Level / Temp:
Tie 1 and 2 together with 120 Ohm resistor (Pin 1 - Level Signal, Pin 2 - Level Return)
Tie 3 and 4 together with 390 Ohm resistor (Pin 3 - Temp Signal, Pin 4 - Temp Return)

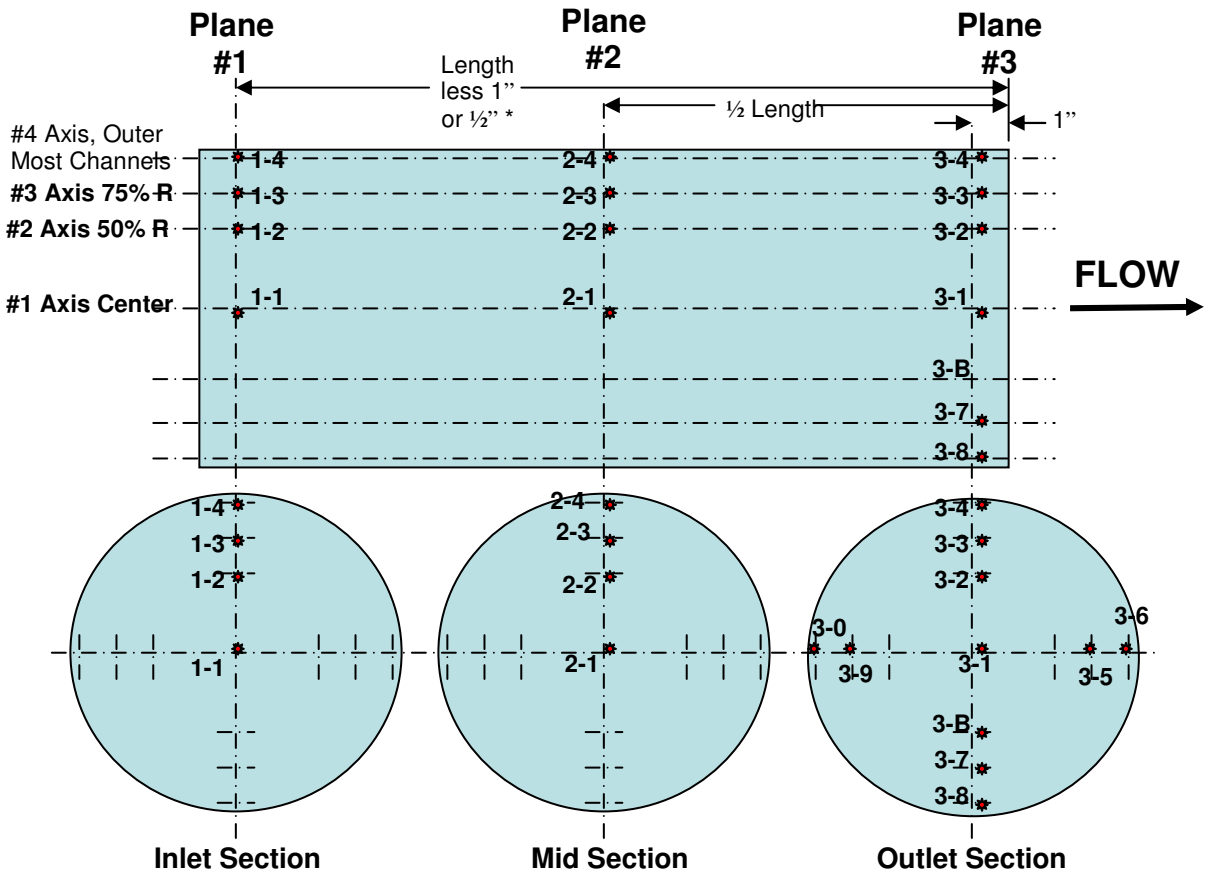
Thermocouple Installation:

Some Mechanical Development Tests may require internally instrumented components. If a DPF or DOC is required to be internally instrumented, follow the below guidelines.

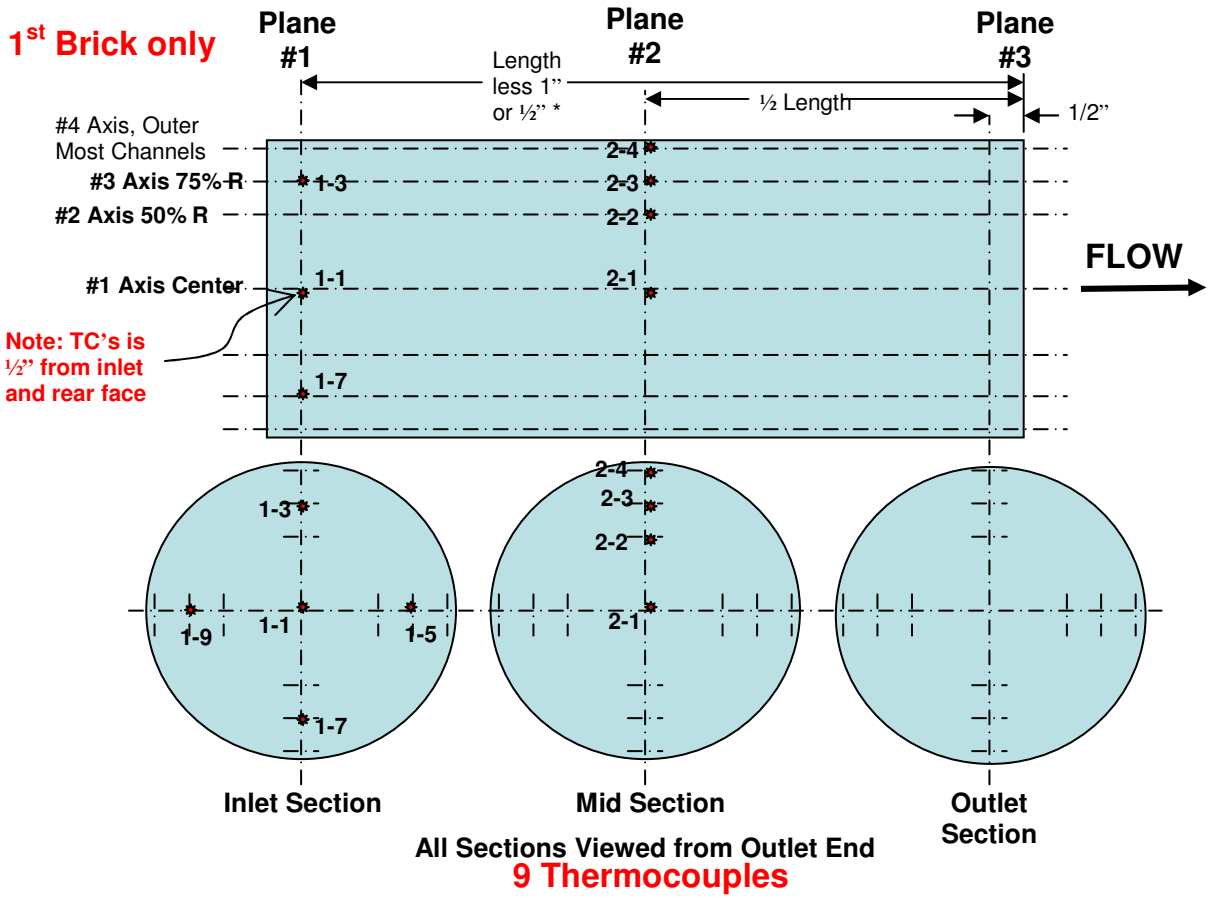
DOC Bed:


Plane #1
Plane #2
Plane #3
Length less 1"
½ Length
1/2"
#4 Axis, Outer Most Channels
#3 Axis 75%-R
#1 Axis Center
Note: TC's are 1/2" from inlet and rear faces
FLOW
1-4
1-3
1-1
2-4
2-3
2-1
3-4
3-3
3-1
3-B
3-7
3-8
3-0
3-9
3-6
3-5
Inlet Section
Mid Section
Outlet Section
All Sections Viewed from Outlet End
15 Thermocouples

DPF Bed:

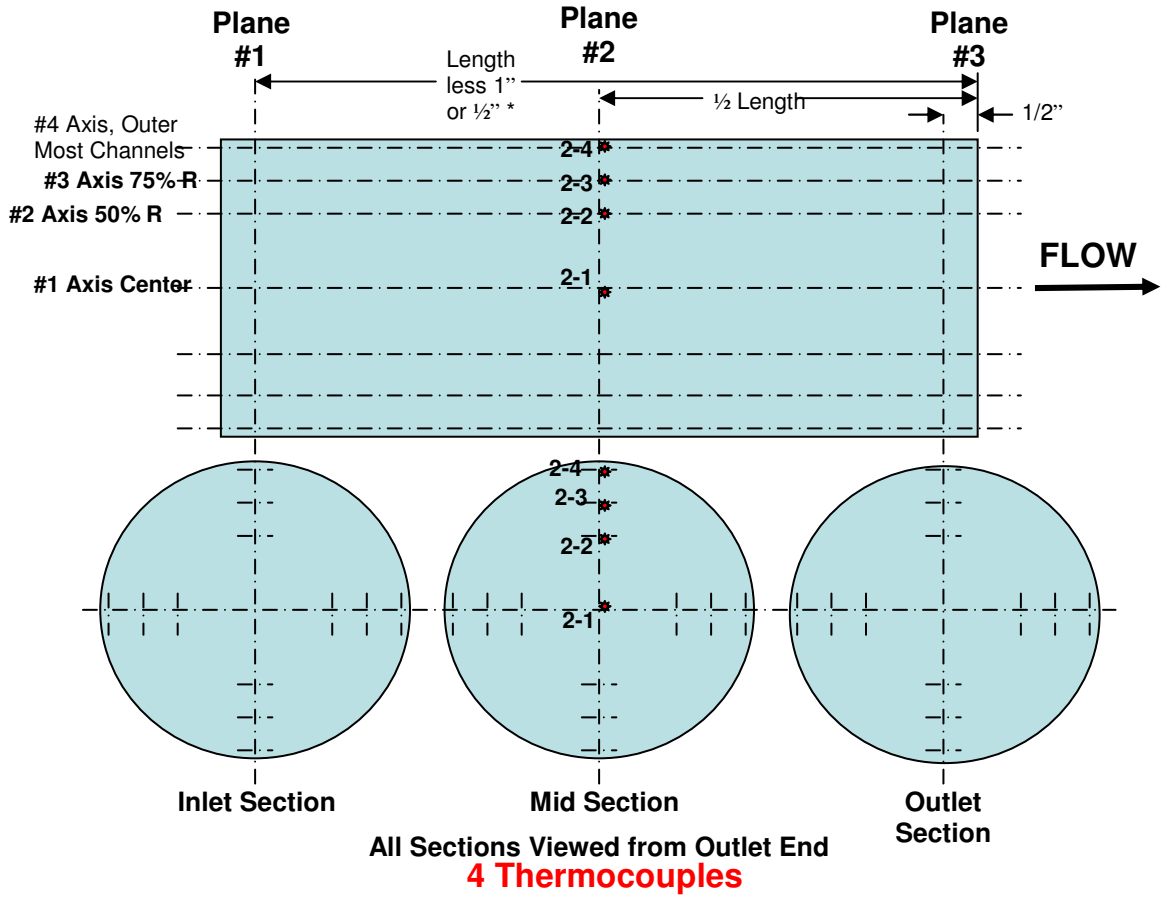

Plane #1
Plane #2
Plane #3
Length less 1" or ½" *
½ Length
1"
#4 Axis, Outer Most Channels
#3 Axis 75% R
#2 Axis 50% R
#1 Axis Center
1-4
1-3
1-2
1-1
2-4
2-3
2-2
2-1
3-4
3-3
3-2
3-1
3-B
3-7
3-8
FLOW
3-0
3-9
3-6
3-5
Inlet Section
Mid Section
Outlet Section
All Sections Viewed from Outlet End
19 Thermocouples

SCR Bed:



Note: Thermocouples are in First Brick Only

AMOX Bed:



Performance Limits:

Engine backpressure, max flow, clean filter (min)	25.7 [kPa]
Engine backpressure, max flow, clean filter (max)	35.7 [kPa]
Engine backpressure, max flow, full filter (soot) (max)	46.2 [kPa]
Engine backpressure, max flow, full filter (soot and ash) (max)	56.2 [kPa]
Max engine out PM rate, NTE zone	8 [g/hr]
Max engine out PM rate, any cruise point (14-1600 RPM)	4 [g/hr]
Max engine out transient smoke, opacity	20 [%]
Max engine out UHC, steady state, warm engine	300 [ppm]
Max turbine outlet temperature	600 [degC]

Abuse Test Limitations:

It is expected that Mechanical Development tests often run with special calibrations to generate abuse conditions. When setting up these calibrations, relaxed limitations are still imposed to

protect the aftertreatment system. The limitations described in the Tech Profile still apply, unless modified below.

Max engine out smoke	2.0 [AVL, FSN]
Periodic Regenerations	at least 1 every 36 hours
System Diagnostics	disabled if needed
Test Cell Fault Accommodation	see list below

The test cell must be setup to monitor for the following conditions. When one of these conditions exist, the test cell should shut down after a short cool down period (1 minute at 1500 [rpm] at no load).

V_ATP_trc_DOC_Out	> 700 [degC]
V_ATP_trc_DPF_Out	> 800 [degC]
V_SFP_gpl_Soot_Load_Comb	> 6.38 [g/L]
V_SFP_mg_Soot_Load_Comb	> 130 [g]
V_SFP_gpl_Soot_Load_DP	> 6.87 [g/L]
V_SFP_mg_Soot_Load_DP	> 140 [g]

It is expected that system level data is regularly collected to aid in the prevention and diagnosing of progressive damage failures. Periodic fuel readings (~1 per hour) and flogger data (~1 per minute) are required data.

Aftertreatment Protection

Numerous system failures can lead to progressive damage in the aftertreatment system. In an attempt to protect the aftertreatment system until service can be rendered, the system will take steps to protect itself. In most cases this will involve changing engine operating conditions. In some case this will include severe power derates. See the latest Design Review material for a complete list of faults and expected responses.

Regeneration Tactics

The Regeneration Tactic is a set of parameters that control the regeneration process. Tactics include start and end of regeneration soot levels, target temperatures, dwell times and ramp rates. Useful variables to aid the diagnostic process include:

V_HIM_bs_Status
V_HIM_bs_DiagStatus
H_OCL_bs_HC_CtrlLimits
V_ATD_bs_PFS_SysIO_Errs
V_ATD_bs_PFS_SysPerf1_Errs
V_ATD_bs_PFS_SysPerf2_Errs

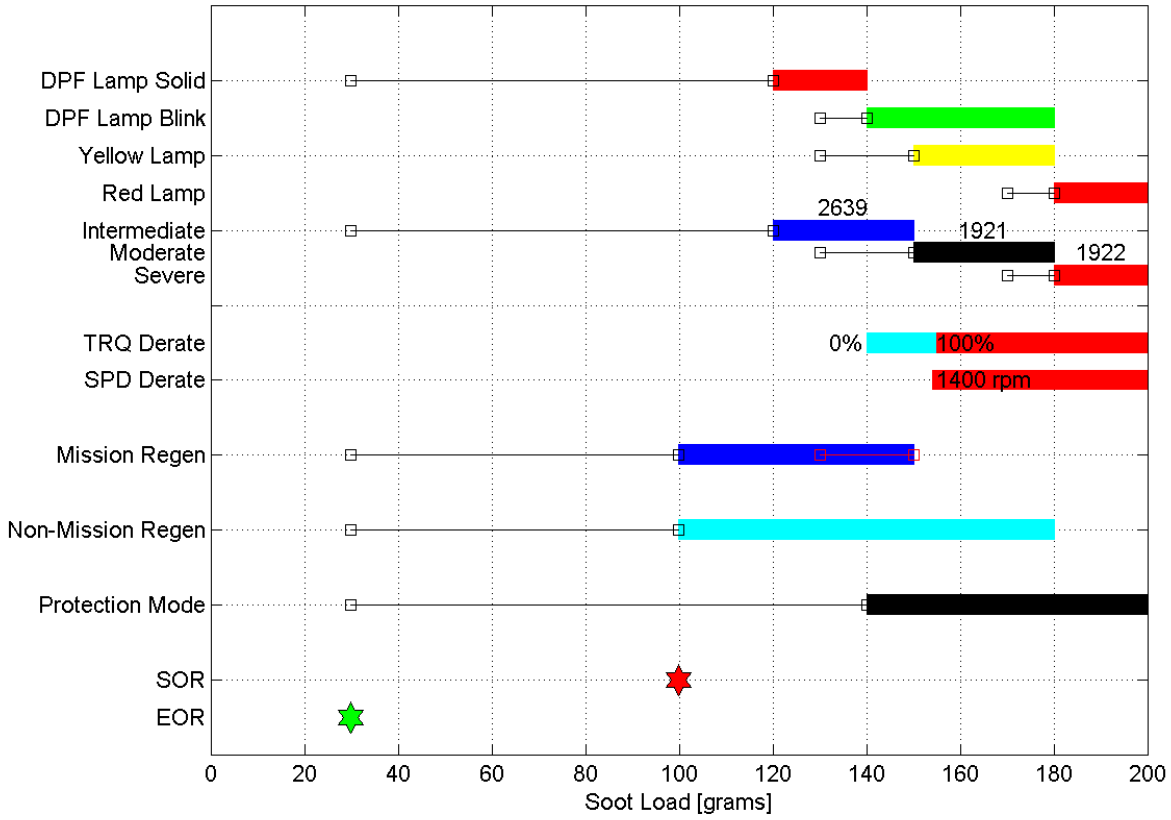
V_ATM_Oper_Mode
V_ATM_Soot_Stage
EXM_ATM_Oper_Mode_Rqst
V_SFR_Regen_Stage
V_SFP_gpl_Soot_Load_Comb
V_SFP_mg_Soot_Load_Comb
V_SFP_gpl_Soot_Load_DP
V_SFP_mg_Soot_Load_DP
P_SFR_Regen_Trigger_State

Operator Interface

The Operator Interface includes the use of three lamps along with the standard amber warning and red stop lamps. Basic soot load condition and requested operator interactions are communicated through the use of two of these lamps, specifically the DPF and HEST Lamp. A graphical depiction of the fault and lamp accommodations is shown below in Graphic 6.

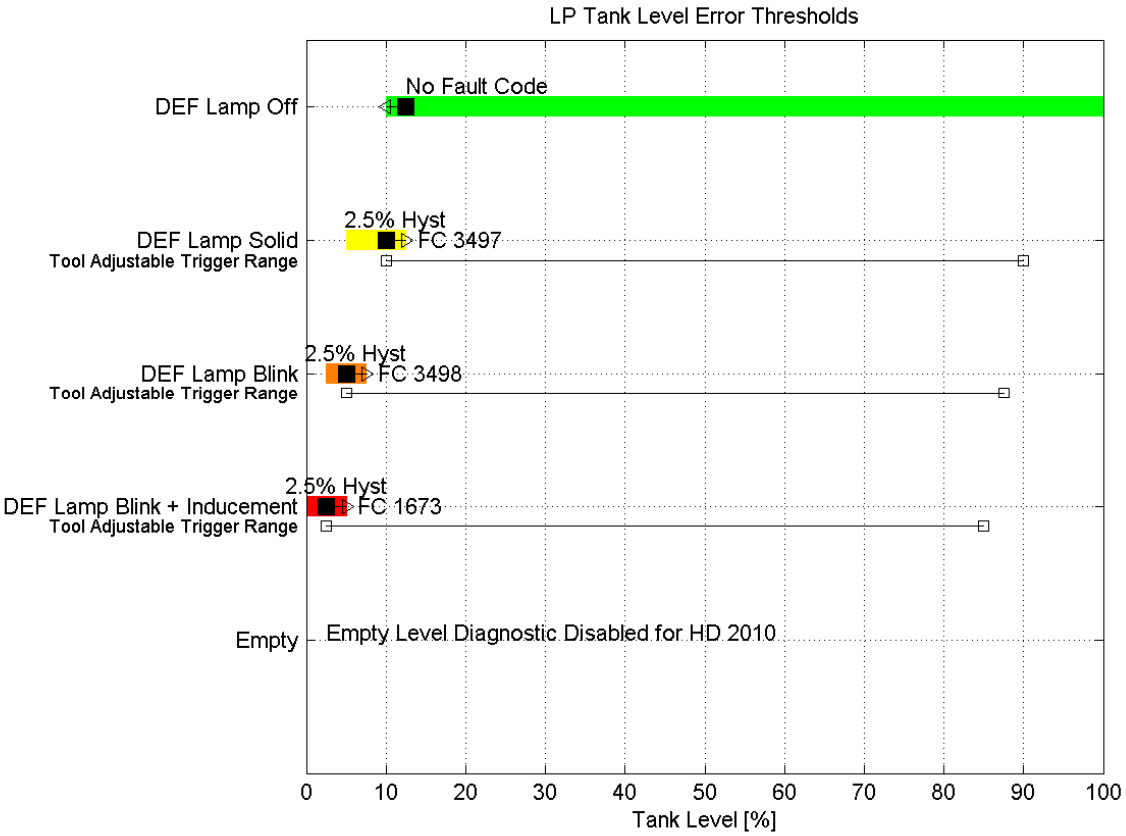
FC	Lamps	Trigger (CSLE)	Expectations	Required Actions
none	none	100 [g]	In-Mission and Out-of-Mission regeneration available. No change in operation noticeable	None required
FC2639	Solid DPF	120 [g]	In-Mission and Out-of-Mission regeneration available.	Increase duty cycle to exhaust heat or initiate an Out-of-Mission regen
FC2639	Flashing DPF	140 [g]	In-Mission and Out-of-Mission regeneration available. -EGR Off	Increase duty cycle to exhaust heat or initiate an Out-of-Mission regen
FC1921	Flashing DPF Solid Yellow	150 [g]	In-Mission regeneration no longer available. Out-of-Mission regeneration available. -Torque Derate begins (Severity Based) -EGR Off	Stop and initiate an Out-of-Mission regen

FC1921	Flashing DPF Solid Yellow	155 [g]	In-Mission regeneration no longer available. Out-of-Mission regeneration available. -Speed Derate (Max 1400 RPM) -Torque Derate Max (1000 ftlbs) -EGR Off	Stop and initiate an Out-of-Mission regen
FC1922	Solid Red	180 [g]	In-Mission and Out-of-Mission regeneration no longer available -Speed Derate (Max 1400 RPM) -Torque Derate Max (1000 ftlbs) -EGR Off	Remove and replace filter



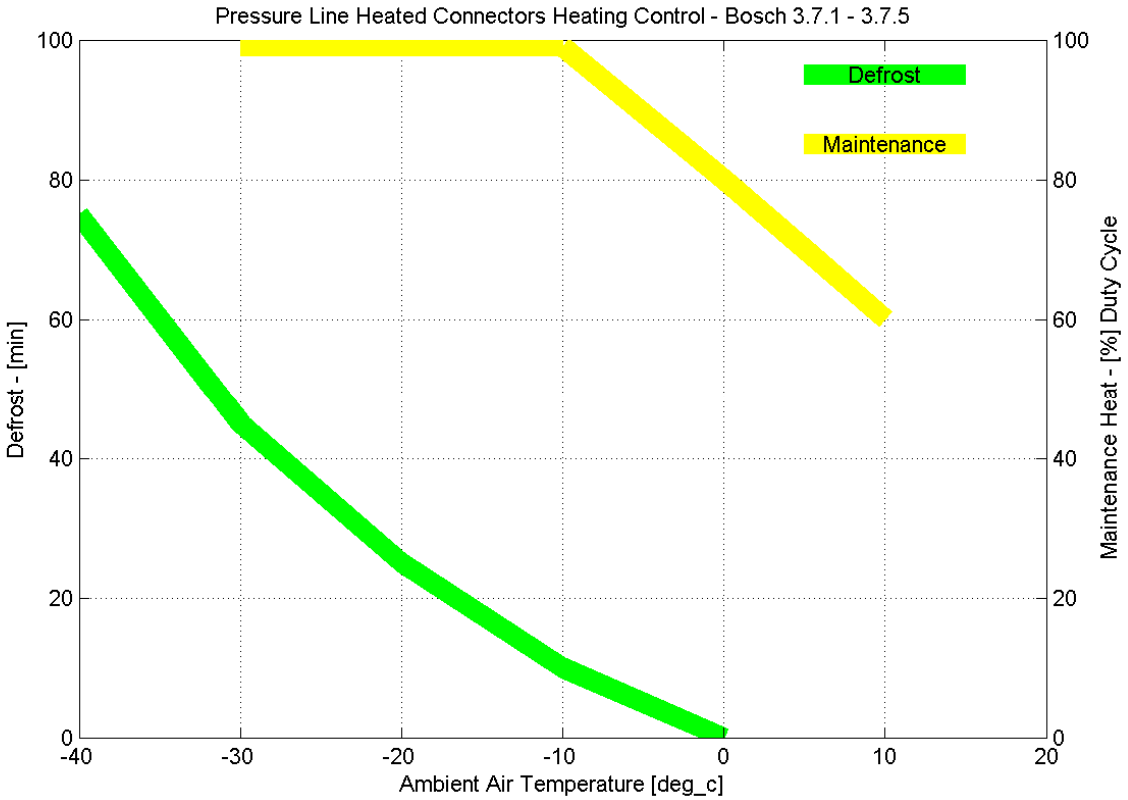
Graphic 6: DPF Tactics

The Operator Interface also includes a DEF lamp. The DEF lamp combined with the amber warning lamp work together to notify the driver of low DEF Tank level. A graphical depiction of the DEF and Amber Warning lamp operation based on DEF Tank level are shown below in Graphic 7.

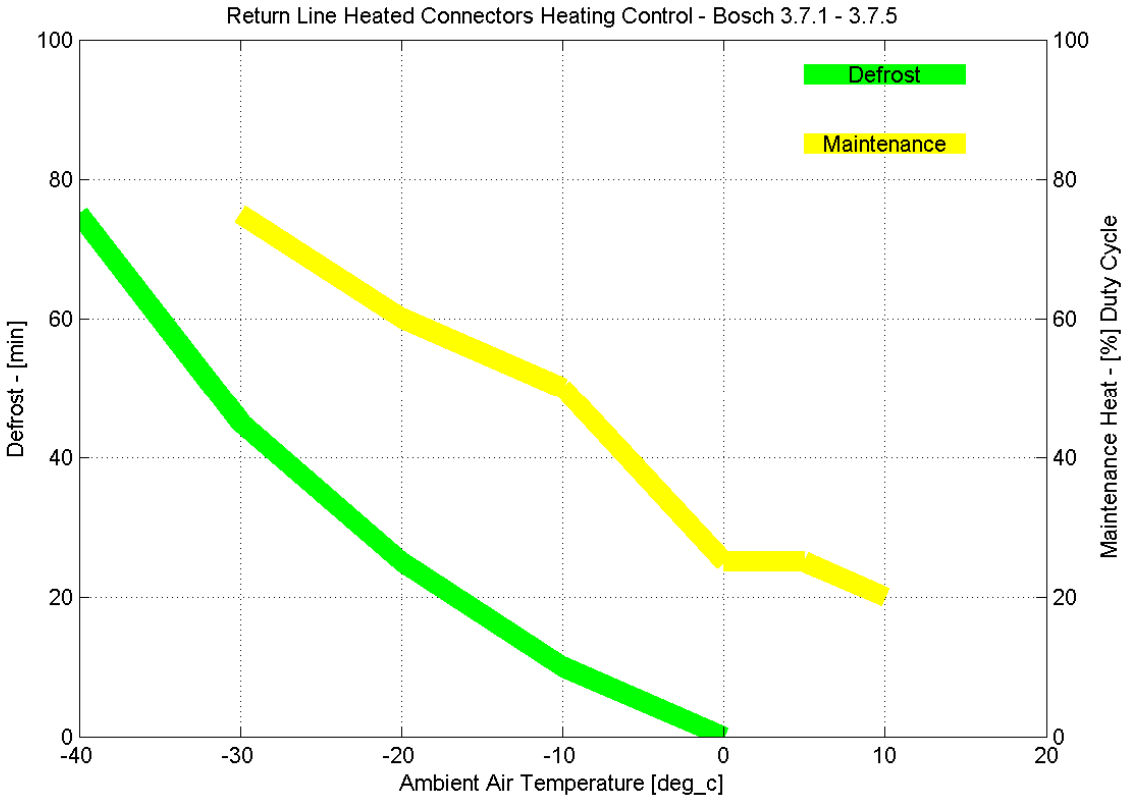


Graphic 7: DEF Tank Level Tactics

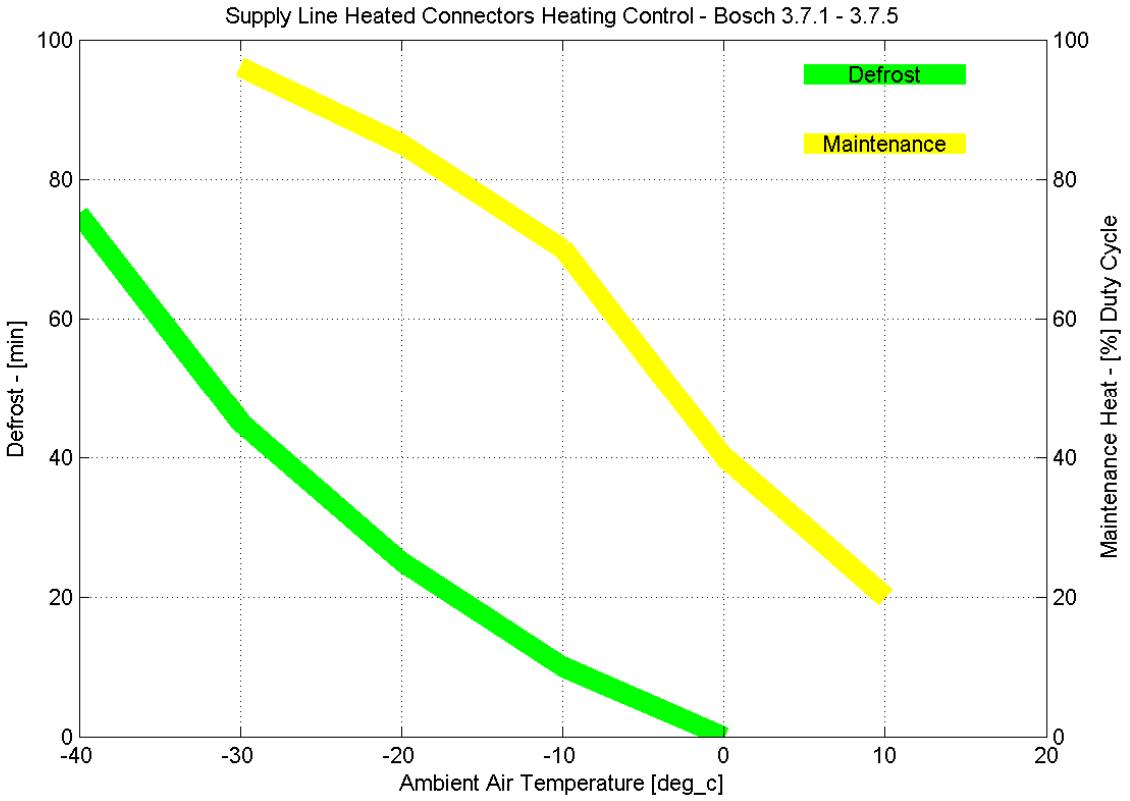
DEF Heating Control Thresholds (Heated DEF Lines / Module)



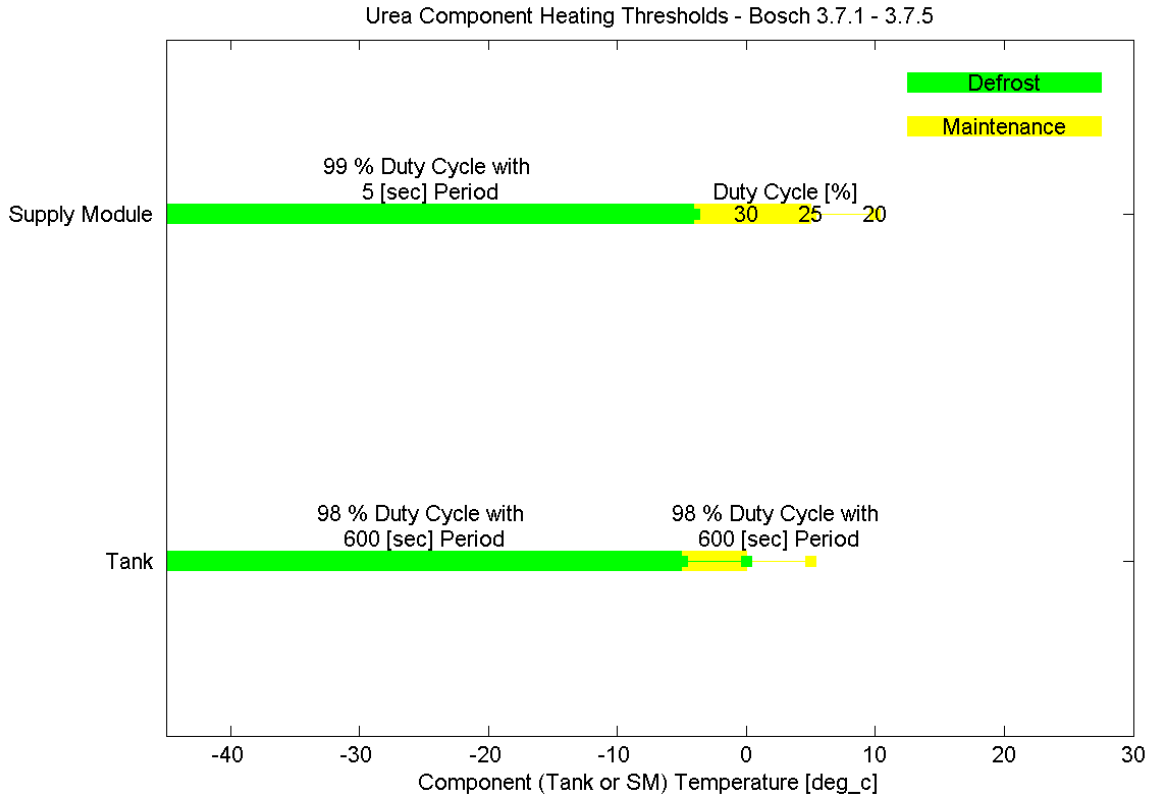
Graphic 8: DEF Pressure Line (Line #1) Heating Control Logic



Graphic 9: DEF Return Line (Line #3) Heating Control Logic

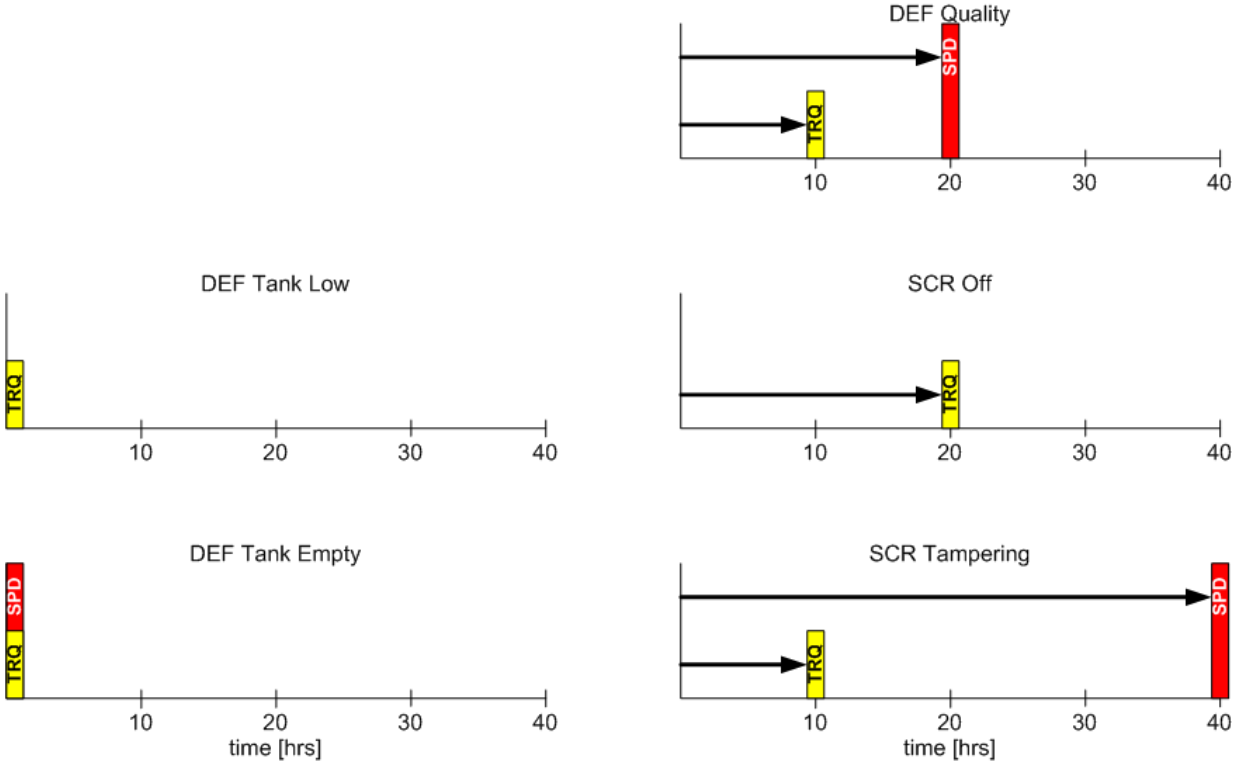


Graphic 10: DEF Supply Line (Line #2) Heating Control Logic



Graphic 11: Supply Module and Tank Heating Control Logic

Inducement Control Logic



Understanding Bosch DCU Software Version

With the release of Bosch 3.7.3, Bosch broadcasts its DCU Software Version. In order to decipher the version, monitor the following parameters:

J39_SCR_Soft_ID (ex. 303**3** HEX)
J39_SCR_Soft_ID_Minor_Rev (ex. 303**7** HEX)
J39_SCR_Soft_ID_Bug_Fix (ex. 303**3** HEX)

In the above example, the DCU SW Version is 3.7.3

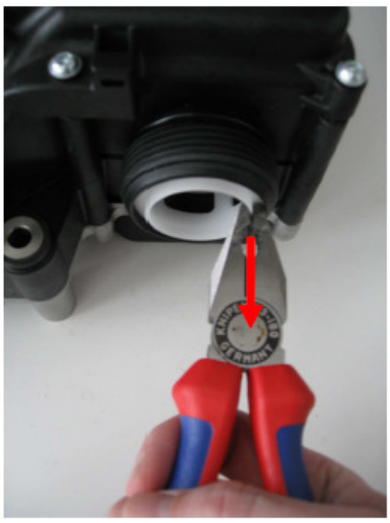
Bosch Supply Module Filter R&I

The Supply Module filter has a maintenance interval of 200,000 miles or 4500 Hours. It may also need to be replaced due to fault codes related to DEF Supply Module Pressure, etc. This filter is a 10 micron filter and can be serviced through the following steps.

Removal Procedure:

1. Unscrew the diesel exhaust fluid filter cap.
2. Remove the aftertreatment diesel exhaust fluid filter equalizing element.
3. Remove the old aftertreatment diesel exhaust fluid dosing unit filter element.





Installation Procedure:

Note: Lubrication of the DEF filter o-rings is not required.

1. Slide the DEF filter equalizing element into the DEF filter cartridge.
2. Insert the assembly into the aftertreatement DEF dosing unit.
3. Install and tighten the cap.

Torque Value: 20 N•m [177 in-lb]



Out-of-Mission Regeneration Initiation

An Out-of-Mission Regeneration requires operator intervention to trigger. This is described below.

Preparation:

1. Park vehicle in safe location, away from other vehicles
2. Verify stack outlet is not directed at heat sensitive objects
3. Verify transmission is in Neutral (Out Of Gear)
4. Verify Parking Brake is set
5. Verify Regen is being requested (Use override if necessary)
   O_SFR_Regen_Trigger_On = 1

Procedure:

1. Start engine
2. Toggle the Initiate Regeneration switch. In some cases this will be the existing diagnostic switch. (See below if no Initiate Regeneration switch exists)

Expectations:

1. Engine speed will elevate to roughly 900 RPM (Red), 1000 RPM (Black)
2. Exhaust temperatures will elevate
3. Regeneration duration will vary between 20 and 40 minutes depending on selected tactics (Or until O_SFR_Regen_Trigger_On is set back to 0)
4. Engine speed will return to low idle when the regeneration is complete

Aborting Procedure:

1. The Out-of-Mission regeneration will abort if the throttle, brake or clutch pedal is depressed, an in-gear condition is encountered, or vehicle speed is greater than 0 kph.

Engineering Overrides:

Test Cells may require the following parameters to be set before an Out-of-Mission regeneration can be triggered. This assumes all enable criteria are met (switches, soot loads, etc…)

C_EXM_MRegen_VehSpdThd_Select = 1
T_EXM_MobileRegenVehSpdDisThd = 0

An Out-of-Mission regeneration will not begin if the soot load is not above the start of regeneration threshold or the maximum time between regenerations threshold has not been reached. For special engineering tests, soot load can be overridden to a value that is greater than the trigger threshold using the following procedure. XX is the user-desired soot load (in grams per liter) that the system will be reset to.

O_SFP_gpl_Soot_Load_User_Reset_Val XX [g/L]
-Divide the desired soot load in [g] by 20.39 [L] to get [g/L]
O_SFP_gpl_Soot_Load_User_Reset_En 1

O_SFP_Soot_Load_Reset	1
O_SFP_Soot_Load_Reset	0
O_SFP_gpl_Soot_Load_User_Reset_En	0

For engineering trucks that do not have an Initiate Regeneration switch, an Out-of-Mission regeneration can be triggered using the following procedure. This assumes all enable criteria for an Out-of-Mission regeneration are met (switches, soot loads, etc…)

T_AIM_FT_NMRegenSwitchEnbl	1
O_AIM_NMRegen_Sw_Val	1
O_AIM_NMRegen_Sw_Enbl	1

To override the system such that dosing occurs regardless of a regeneration request, the following override can be set. When this override is set, the system will still only regenerate when allowed by the system (i.e. temperatures, flows, and other enable criteria are met).

O_SFR_Regen_Trigger_On	1

Out-of-Mission Regeneration Limitations

Out-of-Mission Regenerations should not be attempted under certain conditions. This is described below.

1. Do not attempt an Out-of-Mission regeneration if any aftertreatment hardware failure exists.
2. Do not attempt an Out-of-Mission regeneration if any engine hardware failure exists.
3. Do not attempt an Out-of-Mission regeneration if any auxiliary device that is dependant on engine speed for proper operation is engaged.

Keep in mind that an In-Mission or Out-of-Mission Regeneration will not begin if a regeneration is not being requested by the ECM. See the above overrides if a regeneration is desired but the system is not asking for one.

Out-of-Mission Regeneration at High Soot Loads

When extremely high soot loads are encountered, the DPF is considered unrecoverable. Attempting an Out-of-Mission regeneration under high soot loads may result in the catastrophic failure of the DPF. If more than 180 grams of soot (according to V_SFP_mg_Soot_Load_Comb) is encountered, the DPF must be replaced.

Out-of-Mission Regeneration Reporting

The Aftertreatment Integration group wants to know when Out-of-Mission regenerations are required. This information will be used to better understand duty cycle and system deterioration.

Please record Out-of-Mission regenerations through McParts. Please include the following information:

Truck number
Date
Time
Calibration name
Operator comments

Troubleshooting Contacts:

The following is a list of names to contact in the event of trouble.

CES Mech Dev Lead	Bill Simonton	7-5355
CES Performance Lead	Joe Brault	7-6577
Engine Thermal Management	CPE	
Packaging (RPF joints)	Eric Reeck	7-6744
General Field Test Troubleshooting	Ryan Edgecomb	7-3145
General Engineering Truck T/S	Javier Franco	7-6470
General Test Cell Troubleshooting	Ryan or Javier	

Useful Override Procedures

To override the soot load estimate:

O_SFP_gpl_Soot_Load_Reset_Val = XX [g/L]
Grams = 20.39 * g/L
O_SFP_gpl_Soot_Load_ Reset_En = 1
O_SFP_Soot_Load_Reset = 1
O_SFP_Soot_Load_Reset = 0
O_SFP_gpl_Soot_Load_ Reset_En = 0

To override the Regen Stage:

O_SFR_RegenStage_Val = X
O_SFR_RegenStage_Enbl = 1

To override the regeneration target temp:

O_SFR_trc_RegenTrgt_Val = XXX [degC]
O_SFR_trc_RegenTrgt_Enbl = 1

To override the DPF dP value:

C_AIM_pr_DPF_DeltaP_Default = XX [kPa]
O_AIM_pr_DPF_DeltaP_Enable = 1

To force an Out-of-Mission regeneration request:

O_ATR_NMRegen_Val = 1
O_ATR_NMRegen_Enbl = 1

To force an Out-of-Mission regeneration:

O_SFR_Regen_Trigger_On = 1
O_AIM_NMRegen_Sw_Val = 1
O_AIM_NMRegen_Sw_Enbl = 1

To override Urea Dosing (assumes flow and temp are sufficient):

O_UIM_flm_UreaInjCmd_Enbl= 1
O_UIM_flm_UreaInjCmd_Val= XX [ml/sec]

To Disable Urea Tank Manager (if Urea Tank does not have level or temperature sensing):

T_UTM_Enable = 0

Useful Variable Names List:

Accelerator_Pedal_Position
Actual_Gear_Ratio
Altitude
Ambient_Air_Press
Ambient_Air_Tmptr
APC_hp_Cmd
APC_hp_Fdbk
Battery_Voltage
CAC_Outlet_Tmptr_Est
CBM_FdbkTorqueFuel
CBM_PM_Out_Rate
CBP_Air_Fuel_Ratio
CBR_Alpha
CBR_Alpha_WT_Factor
CBR_Base_Chi_WT_Factor
Exhaust_Press_Est
Exhaust_Press_Sensor
Exhaust_Tmptr
EXM_ATM_Oper_Mode_Rqst
EXM_Oper_Mode_Permitted
EXM_TMMode
Fan_Drive_State
Filtered_Turbo_Speed
Fresh_Air_Flow
Friction_Torque
H_HIM_fg_Dosing_Cmd
H_HIM_fn_DosingCmdComp
H_HIM_fn_EffComp
H_OCL_bs_HC_CtrlLimits
H_OCM_fg_NO2_In
V_ATD_bs_PFS_SysIO_Errs
V_ATD_bs_PFS_SysPerf1_Errs
V_ATD_bs_PFS_SysPerf2_Errs
V_ATD_bs_SCR_SysIO1_Errs
V_ATD_bs_SCR_SysPerf_Errs
V_ATD_DPF_Lamp_State
V_ATD_HET_Lamp_State
V_ATM_fg_HC_Fdbk_Total
V_ATP_Allow_Regen_State
V_ATP_fg_Turbo_Out
V_ATP_fg_Turbo_Out_NOx
V_ATP_fv_DPFOutP
V_ATR_DoserAirPurgeRqst
V_HIM_bs_DiagStatus
V_HIM_DFSOV_Cmd

CBR_Chi_Mode_Status
CBR_Chi_Table_Mask
CBR_Cold_Amb_Ref_Status
CBR_FCLR_WT_Factor
CBR_Main_Fueling
CBR_Main_SOI
CBR_Main_SOI_ColdAmbFactor
CBR_Pilot2_Fuel_Quantity_Final
CBR_Pilot2_SOI
CBR_Post1_Fuel_Quantity_Final
CBR_Post1_SOI
CBR_Post2_Fuel_Quantity_Final
CBR_Post2_SOI
CBR_Prot_WT_Factor
CBR_TM1_WT_Factor
CBR_TM2_WT_Factor
Charge_Flow
Charge_Flow_Command_State
Charge_Press
Charge_Press_Est
Charge_Press_Sensor
Charge_Tmptr
Charge_Tmptr_Est
Charge_Tmptr_Sensor
CHL_EGR_Frac_Cmd
CHL_MCF_Cmd
CHP_HDR_EGR_Flow
CHP_Pumping_Torque
Combustion_Control_Path_Owner
Compressor_Inlet_Tmptr
Compressor_Outlet_Tmptr
Coolant_Temperature
Crankcase_Press
Crankcase_Pressure
EAC_EGR_Valve_Cmd
ECM_Run_Time
EGA_PWM_Abs_Duty_Cycle
EGR_Delta_Press
EGR_DeltaP_Est
EGR_Flow
EGR_Fraction
EGR_Fraction_Command_State
EGR_Orif_Press
EGR_Orif_Press_Est
EGR_Orif_Press_IR_Enable
EGR_Orifice_Delta_Press
EGR_Orifice_Tmptr
EGR_Position
EMM_AECD_State
EMM_Protection_State_1
H_OCM_fg_NOx_In
H_OCM_fg_O2_In
H_PRD_q_MeanFueling
H_PRD_r_CorrelationSqrd
H_PRD_r_Slope
H_PRD_r_VarianceSlope
H_SFP_DPTrust_Fctr_Adjusted
H_SFP_gph_Noxid_Rate
H_SFP_gph_Oxid_Rate
InternalTmptr_Sensor
J39_AFT_Intake_NOx
J39_AFT_Outlet_NOx
J39_VGT_Actuator_Position
J39_VGT_Actuator_Status
J39_VGT_Motor_Effort
J39_VGT_Temperature
MME_Vehicle_Mass
Net_Engine_Torque
OFC_Equiv_Ratio_Limit
Oil_Pressure
Oil_Temperature
P_APC_ct_TotalMdvPeakCounts
P_HIM_DFM_Eff_Avg
P_HIM_DFM_Eff_Regen
P_OCD_ct_UsedUp_Diag
P_OCD_fn_CompEff
P_OCD_fn_Dosing_NmlEff
P_SFD_tmh_TimeSinceLastRegen
P_SFP_DPSLE_DPF_TrustCond
P_SFR_ct_Ineff_Regen_Occr
P_SFR_Regen_Trigger_State
P_SFR_tm_Ineff_Dosing
PTO_Status
Stop_Fault_Lamp
TAHR_EGR_Flow_Cmd
TAHR_EGR_Valve_Fdbk_Cmd
TAHR_EMP_Cmd_Final
TAHR_IMP_Cmd
TGC_VT_Cmd
Total_Fueling
Turbine_Out_Tmptr
Turbo_Speed_Est
V_AIM_pr_DPF_DeltaP
V_AIM_pr_HC_DoserP
V_AIM_prg_DPF_OutP
V_AIM_trc_CCC_In
V_AIM_trc_CCC_Out
V_AIM_trc_DOC_In
V_AIM_trc_DOC_Out
V_AIM_trc_DPF_Out
V_HIM_DFSOV2_Cmd
V_HIM_DIAG_Pressure_Test_State
V_HIM_fg_HC_Final_Limit
V_HIM_pr_DFS_dP
V_HIM_pr_DFS_Off
V_OCD_tm_UsedUp_Diag
V_OCL_ppm_CCC_HC_Inlet_Hi_Rqst
V_OCM_fg_HC_In
V_OCM_ppm_CCC_HC_Out_HiCmd
V_OCM_ppm_DOC_HC_Out_HiCmd
V_OCR_fg_HC_Cmd
V_OCR_fg_HC_Corr
V_OCR_fg_HC_Der_Cntrl
V_OCR_fg_HC_Int_Cntrl
V_OCR_fg_HC_Nominal
V_OCR_fg_HC_Prp_Cntrl
V_SCR_ANR_Val
V_SCR_FdfwdCmd_Limited_Flag
V_SCR_fn_DeNOxEff_Max
V_SCR_mol_dt_NH3_Fdfwd_Calc
V_SCR_mol_dt_NH3_FdfwdCmd
V_SCR_mol_dt_NOx_In
V_SCR_mol_dt_TailpipeNOxTrgt
V_SFD_DPFEff_FRmean
V_SFD_DPFEff_Intercept
V_SFD_DPFEff_Slope
V_SFD_tmh_DutyCycle_RegenHr
V_SFP_fv_DPF
V_SFP_gph_NetSootAccumRate
V_SFP_mg_Soot_Load_Comb
V_SFP_mg_Soot_Load_DP
V_SFR_Regen_Stage
V_SFR_Regen_Trigger
V_SFR_trc_Cmd
V_UID_bs_DosingSysFaultStat_1
V_UID_bs_DosingSysFaultStat_2
V_UID_bs_DosingSysFaultStat_3
V_UID_bs_DosingSysFaultStat_4
V_UID_bs_DosingSysFaultStat_5
V_UIM_ECM_DoserState
V_UIM_flm_InjRateCmd
V_UIM_flm_EstUreaInjRate
V_UIM_PL_Heater_StateMachine
V_UIM_RL_Heater_StateMachine
V_UIM_SL_Heater_StateMachine
V_UIM_SM_Heater_StateMachine
V_UIM_Tank_Heater_StateMachine
V_UIM_UreaPumpState
V_UTD_DEFLamp_State
V_UTM_pc_Urea_TankLvl

EMM_Protection_State_2
Engine_Speed
Exhaust_Metal_Tmptr
Exhaust_Press
V_AIM_trc_SCR_In
V_AIM_trc_SCR_Out
V_ATD_bs_PFS_EngOut_Status
V_ATD_bs_PFS_Sensor_Status
V_UTM_trc_Urea_TankT
Vehicle_Speed
Warning_Fault_Lamp

Data Presentation Conventions

In an effort to facilitate efficient communication, please make every attempt to use the following conventions when presenting data:

All temperatures in [degC]
All pressures in [kPa]
Vehicle speed in [km/hr]
Dosing fuel rate in [g/sec]
DOC In Temp shown in red
DOC Out Temp shown in green
DPF Out Temp shown in blue
SCR In Temp shown in cyan
SCR Out Temp shown in black
DOC Out Regeneration Temp Control shown in magenta
Dosing fuel shown in red
Data units on all plots, with units in square braces (ie: [g] or [degC])

Reference Material for 2010

AEB 21.78 and 21.79 describe vehicle installation requirements for the RPF and SCR aftertreatment systems. Sam Penrice owns these documents and should be contacted if either is required for an installation. The current publicly available AEBs can be obtained from the Global Customer Engineering Website at www.gce.cummins.com. The published AEBs available at the time of the creation of this document are also available in the same location where this document was posted (H:\Monarch\SPI\ATI\Documentation\Survival Guide\AlphaSCR and the Monarch Database under Ryan Edgecomb).

For further helpful Urea Dosing System Installation requirements, refer to Urea System Installation Rev1.pdf which is also available in the same location where this document was posted (H:\Monarch\SPI\ATI\Documentation\Survival Guide\AlphaSCR and the Monarch Database under Ryan Edgecomb).

The Common Approach to Control System Diagnostics lists all phase-specific fault codes, defines individual features, graphically depicts certain AECD and Engine Protection activity, and contains suggested datasets for logging specific issues as defined by poor performance or indicated by fault codes. This document can be found at H:\Monarch\Cals\Common Approach