CATERPILLAR®

SERT4052
June 2004

SERVICE TRAINING

TECHNICAL PRESENTATION

ACERT™ TECHNOLOGY FOR ON-HIGHWAY HEAVY DUTY ENGINES

ACERT TECHNOLOGY FOR ON-HIGHWAY HEAVY DUTY ENGINES

AUDIENCE

Level II–Service personnel who understand the principles of machine systems operation, diagnostic equipment, and procedures for testing and adjusting.

CONTENT

This presentation provides update information on the C11 through C15 ACERT On-highway Heavy Duty Truck Engines. This presentation may be used for self-paced and self-directed training.

OBJECTIVES

After learning the information in this presentation, the serviceman will be able to:

1. locate and identify the new mechanical components on the C11 through C15 ACERT Heavy Duty Truck Engines,
2. explain the operation of the new components in the systems; and
3. explain new procedures in testing and adjusting.

REFERENCES

Pure Power Caterpillar On-Highway Engines with ACERTTM Technology	LECT3965
C11 and C13 On-highway Engine KCA1-up, KCB1-up - Systems Operation, Testing and Adjusting	SENR9703
C15 On-highway Engine BXSS1-up, MXS1-up - Systems Operation, Testing and Adjusting	SENR9692

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Date: 6/04

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ACERT™ Technology for On-Highway Heavy Duty Engines

1

INTRODUCTION

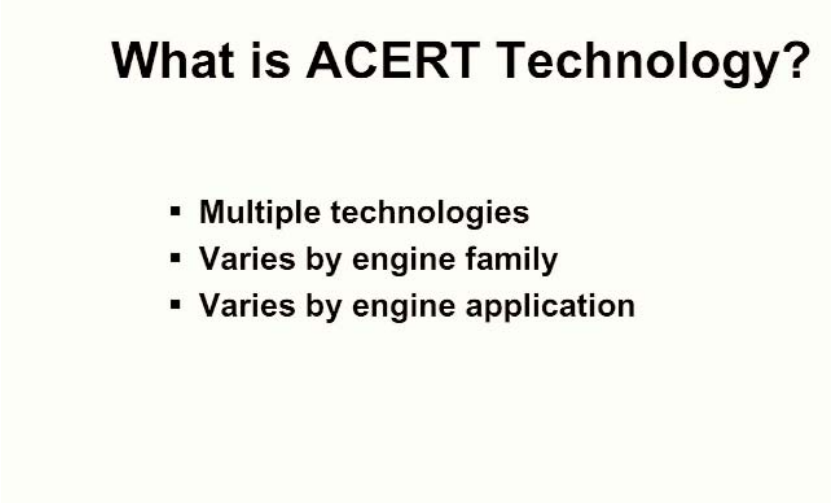
This presentation covers the mechanical changes for the 2003 C11 thru C15 on-highway heavy duty engines using ACERT technology.

2

This presentation will answer all of the questions above.

3

ACERT stands for Advanced Combustion Emissions Reduction Technology.



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ACERT technology is a series of evolutionary, incremental improvements that provide a breakthrough engine technology built on systems and components that have been developed by Cat with proven reliability.

5

ACERT Technology:

- Meets 2004 EPA emissions standards today while laying the goundwork for future emission standards

- Has maintenance intervals that are the same as previous Caterpillar HD truck engines.

- Uses the same oil type CH-4.

- Requires a smaller cooling system than liquid cooled EGR.

- Has lower maintenance costs than liquid cooled EGR.

6

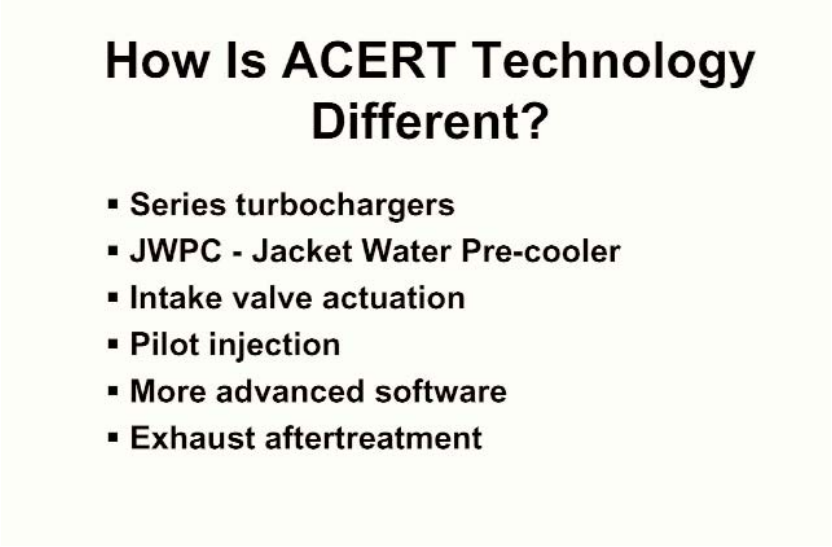
- The air quantity is controlled through series turbocharging and inlet air temperature control.

- Intake valve actuation controls cylinder pressure.

- Improved software manages the timing of the engine and the fuel quantity.

- A redesigned combustion chamber improves combustion efficiency.

- Catalytic Converter Muffler (CCM) is used as the exhaust aftertreatment.



7

- Two turbochargers are connected in series. The high pressure turbocharger uses a wastegate for controlling boost.

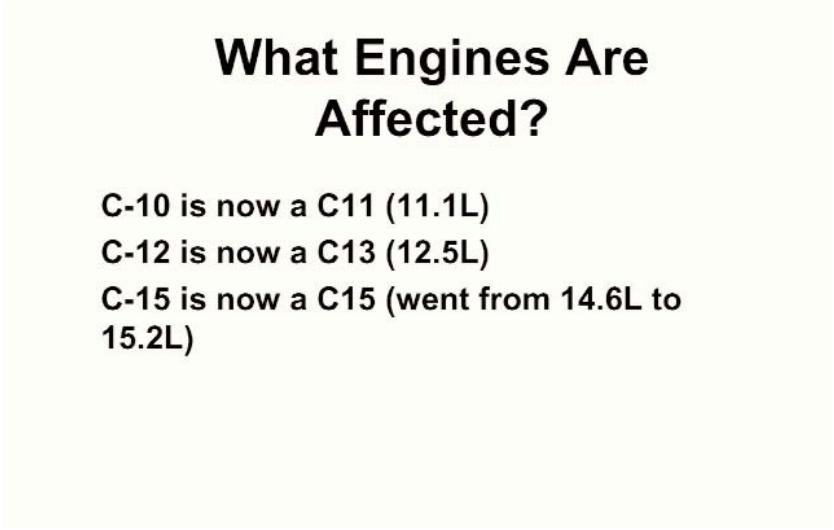
- A jacket water pre-cooler (JWPC) is used to cool the intake air from the turbochargers before it enters the air-to-air after cooler (ATAAC).

- A hydraulic/electric device holds the intake valves open 3 mm (0.118 in) during the compression stroke. The ECM determines when the intake valves will close.

- Pilot injection refers to a small amount of fuel that is injected into the combustion chamber in order to start the combustion process before the main injection takes place.

- The control software has been improved in order to take full advantage of the ACERT technology.

- A catalytic converter is used for exhaust aftertreatment in order to reduce the unburned hydrocarbons from the exhaust.



8

The current production engines listed will be phased out of off-highway applications and ACERT technology engines will be used across the Caterpillar line. ACERT technology engines can be identified by the lack of a hyphen in the model designation.

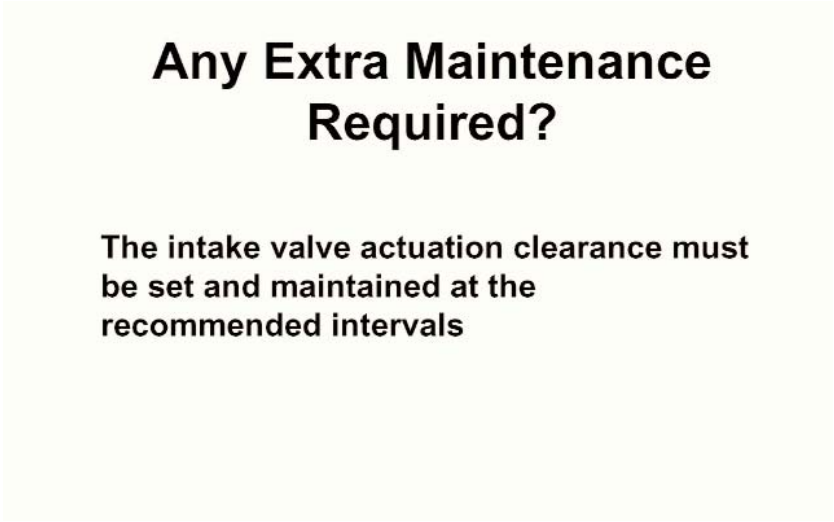
How Are They Different?

	C-10	C11 ACERT	C-12	C13 ACERT	C-15	C15 ACERT
Bore	125 mm	130 mm	130 mm	130 mm	137 mm	137.2 mm
Stroke	140 mm	140 mm	150 mm	157 mm	165 mm	171.5 mm
Oil type	CH-4	CH-4	CH-4	CH-4	CH-4	CH-4
Oil change interval	500 hrs	500 hrs	500 hrs	500 hrs	500 hrs	600 hrs

9

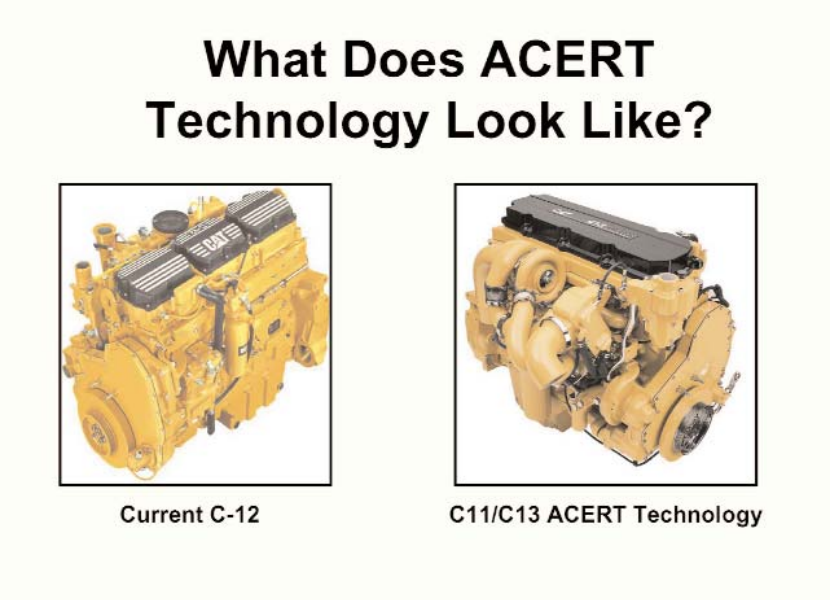
Oil change intervals and basic maintenance remains basically the same as current models. The oil change intervals should be based on Scheduled Oil Sampling (SOS) to determine individual requirements.

Engines can use the new CI-4 oil. CI-4 oil was developed for Exhaust Gas Recirculation (EGR) engines. The "-4" signifies 4 stroke diesel on-highway truck engines.



10

Unit injectors, valves, and compression brake settings must be performed first on the C15. Valve settings must be performed first on the C11/C13. If any settings are incorrect, damage to the engine valves, poor performance, and/or excessive emissions may result.



11

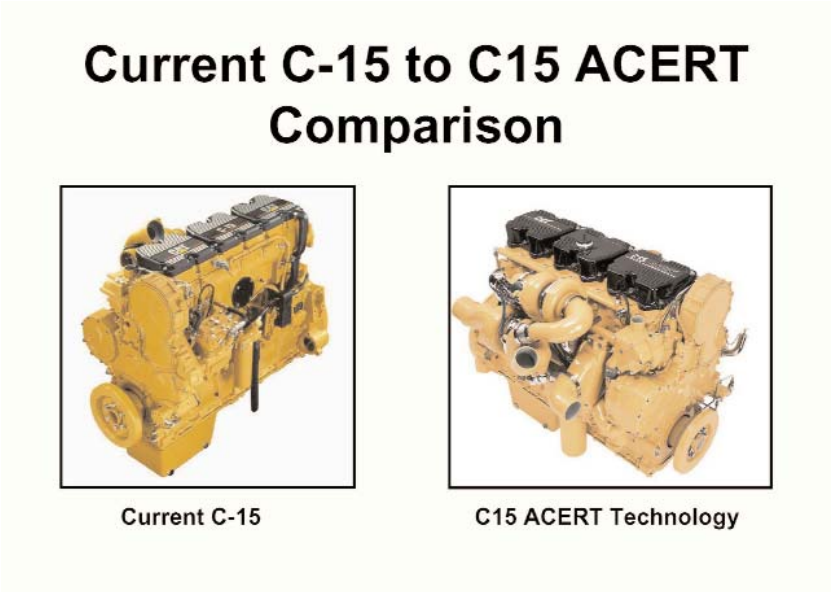
ACERT TECHNOLOGY FEATURES

The following illustrations will review the features of ACERT Technology for the ACERT C11 through C15 engines.

12

ACERT technology features are shown above.

The C11 and C13 have a common bore size and they share basic block/hardware design.



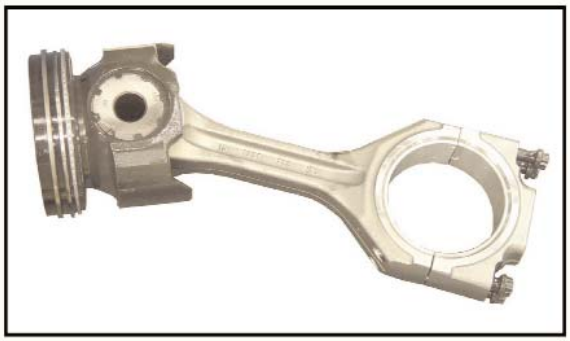
13

The C15 has the same basic modifications as the C11/C13 ACERT Technology engines.

14

The piston has a coating used to prevent scuffing of the cylinder liner.

C15 Piston Assembly



One piece steel piston

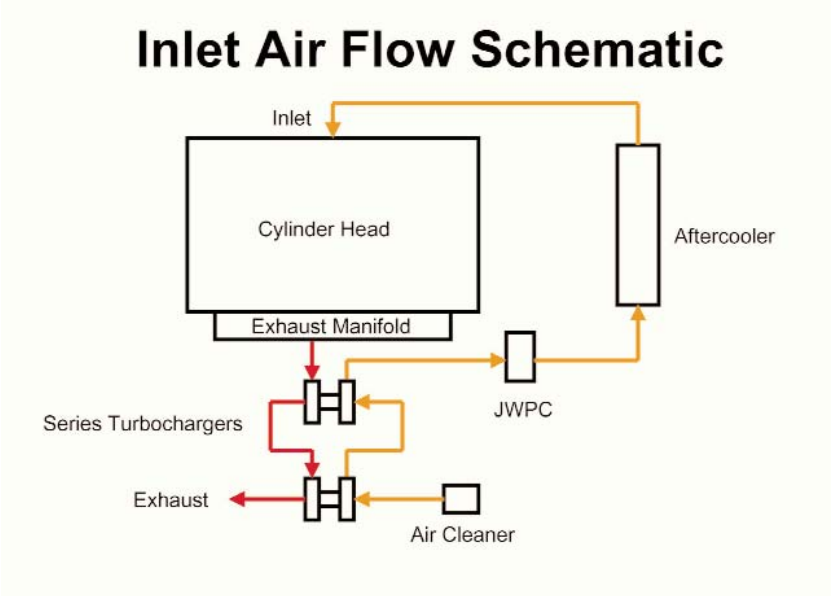
15

The C15 uses a one piece steel piston. An oil hole through the connecting rod I-beam is used to lubricate the wrist pin.

16

There are four bolts that hold the connecting rod cap to the connecting rod. Follow the correct tightening sequence in the specification manual.

The Specification manual has a special tightening procedure.

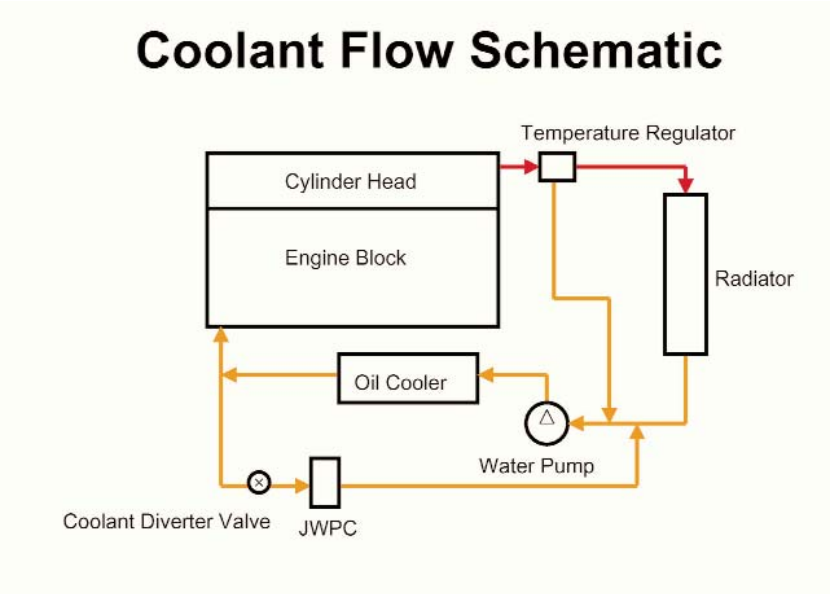


17

AIR FLOW AND COOLANT FLOW SYSTEMS

Air Flow Schematic

The twin, series turbochargers compress the intake air charge. Therefore, the temperature of the inlet air increases. A JWPC was installed in order to decrease the temperature of the inlet air before the inlet air enters the ATAAC.



18

Coolant Flow Schematic

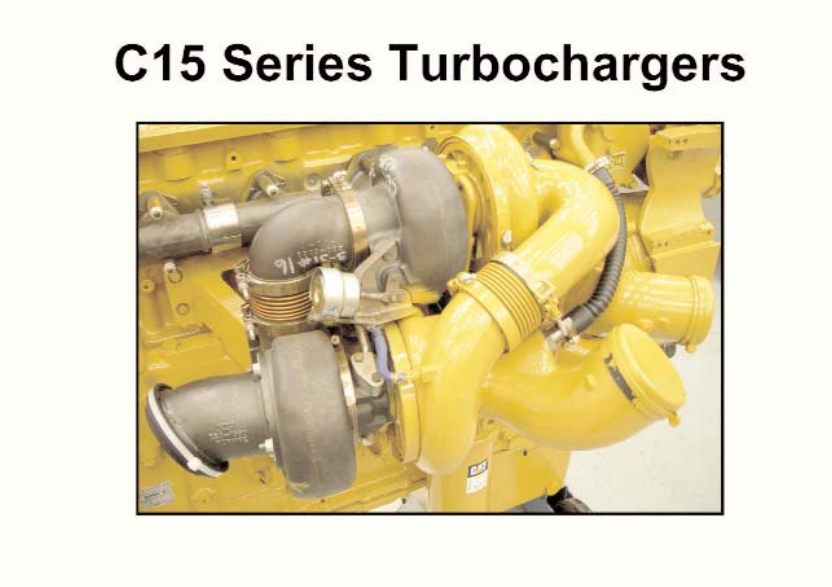
The coolant flow through the JWPC is controlled by the coolant diverter valve. The coolant diverter valve is normally open. The JWPC is not used at low idle or under low loads because the cooling system temperature could drop below normal operating temperature.

19

Turbochargers

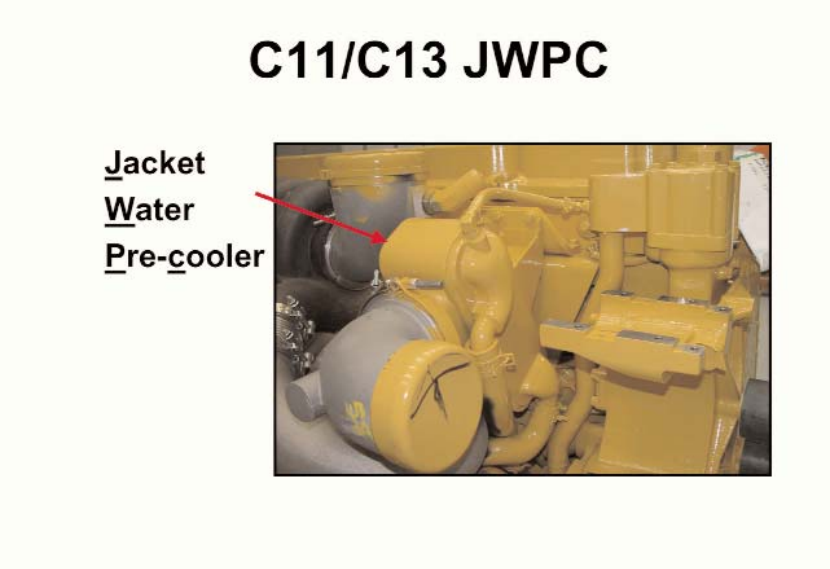
The C11 and C13 engines use a low pressure turbocharger, a high pressure turbocharger, and the JWPC.

The two turbocharges are in series. Working together in series, the turbos turn slower, resulting in increased turbo component life. This turbocharger arrangement improves engine response while lowering oxides of nitrogen and increasing fuel economy.



20

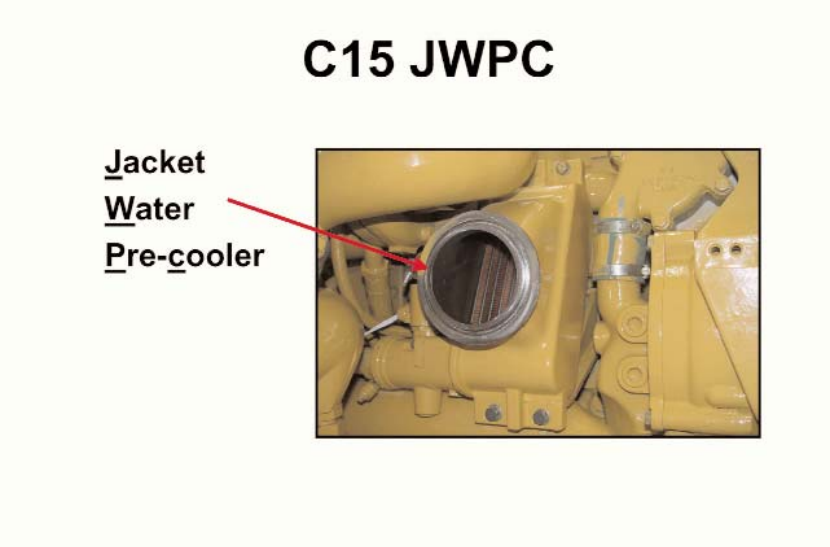
The C15 engine uses a low pressure turbocharger, a high pressure turbocharger, and the JWPC.



21

Jacket Water Pre-coolers

The JWPC is used to cool the air before it enters the ATAAC.



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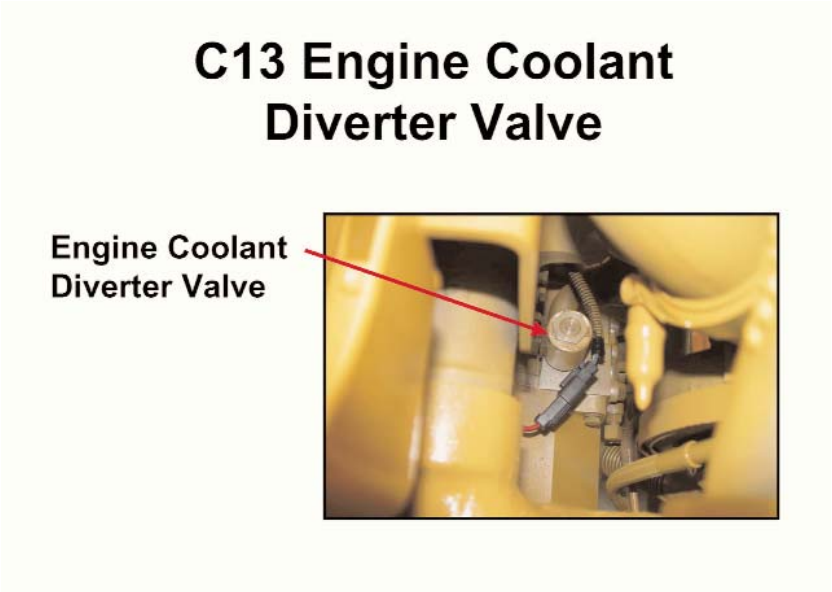
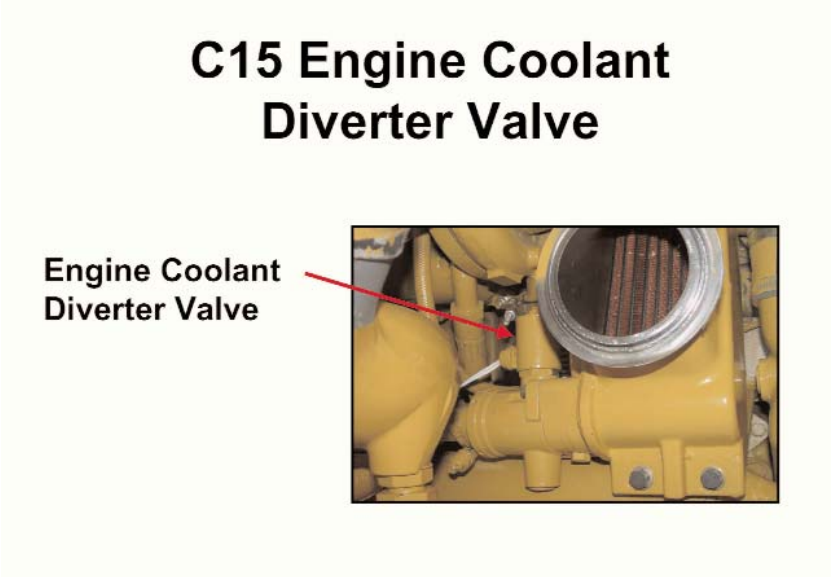
The JWPC is used to cool the air before it enters the ATAAC.



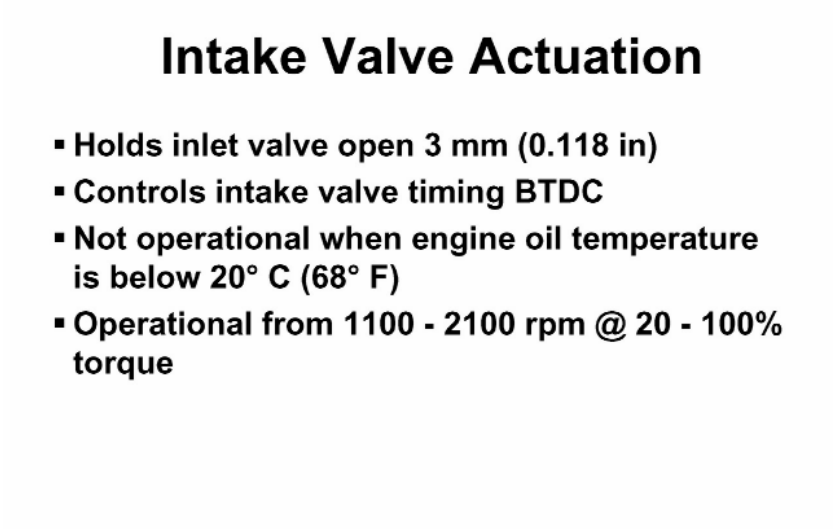
23

The engine coolant diverter valve stops coolant flow through the JWPC when the air temperature is cold or the engine is not up to operating temperature. The engine coolant diverter valve is located on the end of the engine oil cooler on the C11/C13.



24

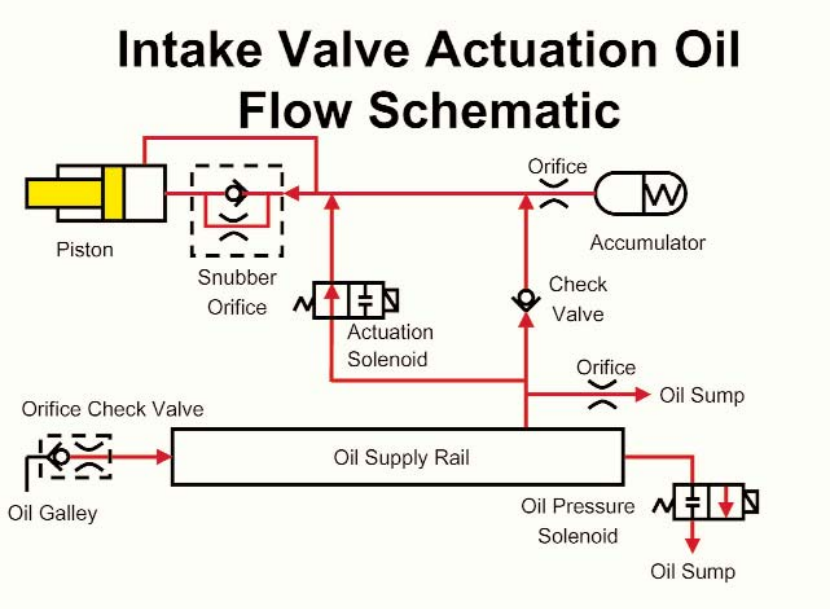
The engine coolant diverter valve stops coolant flow through the JWPC when the air temperature and the engine coolant is cold.



25

INTAKE VALVE ACTUATION

The intake valve actuator holds the intake valves open during the compression stroke until the ECM determines when to close the intake valves. The intake valves close BTDC. The result is a reduction in cylinder pressure during the compression stroke. The lower cylinder pressure results in reduced NOx.



26

In the normal (de-energized condition) the intake valve actuation system oil pressure solenoid is closed. The actuation solenoid is a normally open valve, which allows engine oil in to the piston assembly. The oil pressure will cause the piston to be fully extended. When the inlet rocker arm comes into contact with the piston, the force of the valve springs will push the piston back into its bore.

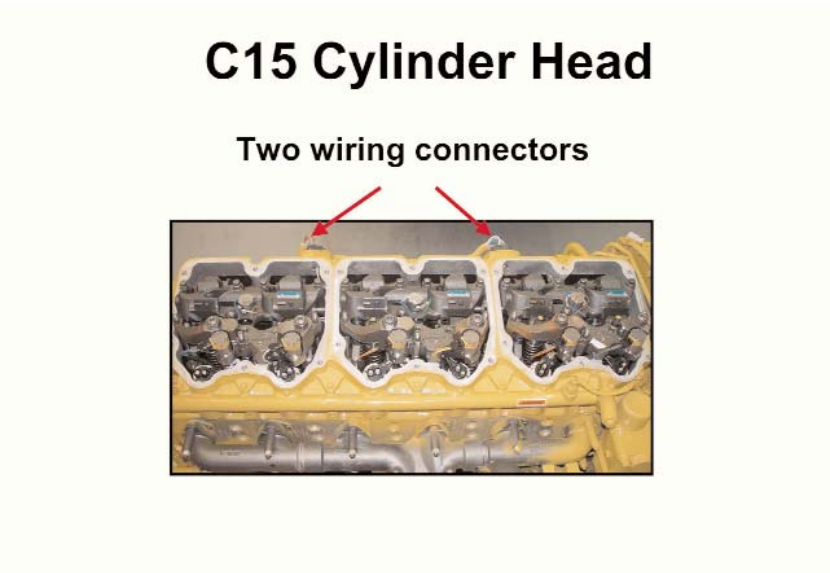
The path for the oil to escape is blocked when the actuation solenoid valve is energized. The piston remains fully extended when the inlet rocker arm comes into contact with the piston. The accumulator reduces valve bounce during the activation of the actuation solenoid.

The snubber controls the velocity at which the inlet valves close when the solenoid is de-energized.

The orifice that goes to the oil sump is used to purge air from the intake valve actuation housing.

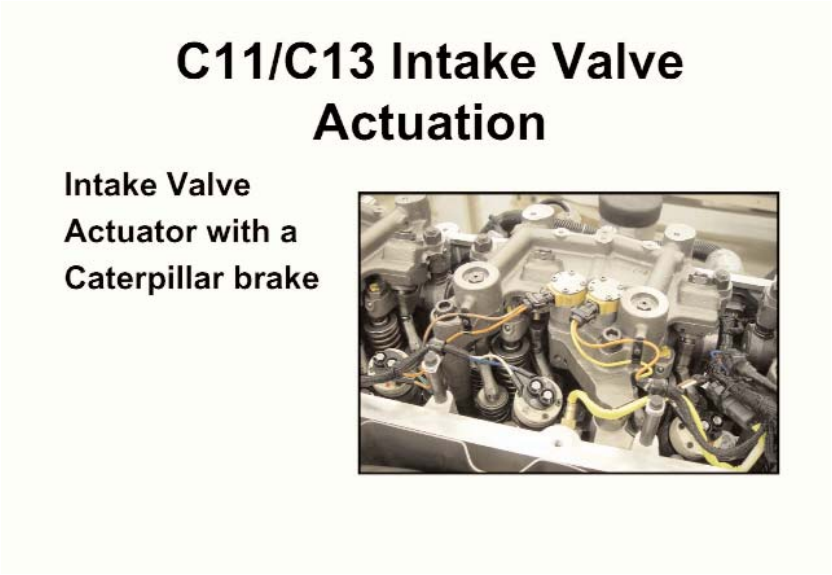
27

The C11/C13 engines use two electrical connectors for the overhead wiring. Intake valve actuation wiring and the injector and brake wiring pass through the same two connectors.



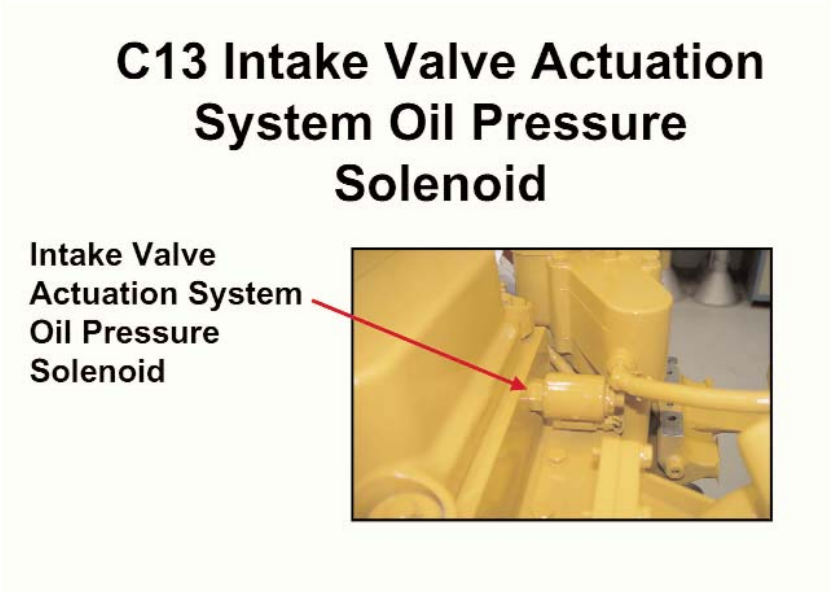
28

There are two electrical connectors for the overhead wiring. All of the overhead wiring runs through the connectors on the C15 engine.



29

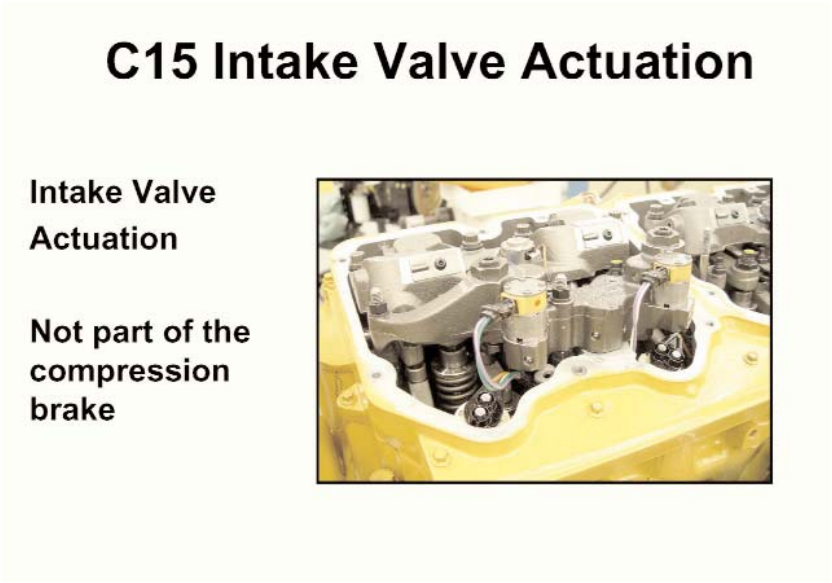
The intake valve actuator is a one piece unit on C11/C13 engines. The intake valve actuator is an engine brake and it controls inlet valve timing during the compression stroke.



30

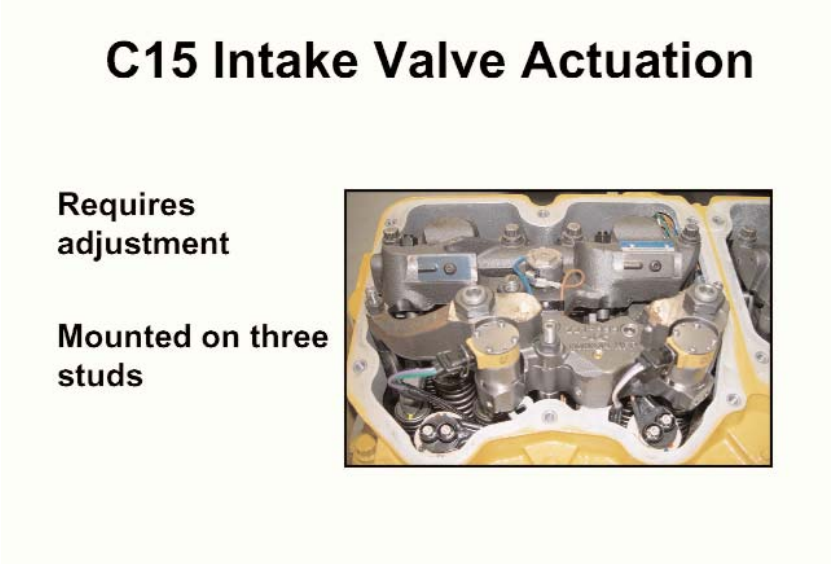
The solenoid controls the actuation pressure for the system. The intake valve actuation system oil pressure sensor and the engine oil temperature sensor send signals back to the ECM. The ECM controls intake valve actuation pressure through a intake valve actuation system oil pressure solenoid. The intake valve actuation system oil pressure solenoid is normally closed. When the oil pressure in the rail increases to a certain pressure, the ECM will open the intake valve actuation system oil pressure solenoid and relieve the excess oil back to oil sump.

The intake valve actuation system oil pressure solenoid is located in the front of the valve cover base, on the right side of the engine.



31

The intake valve actuator controls when the inlet valve closes. This is a separate component that is not part of the compression brake.



32

Before adjustment is made to the intake valve actuators on the C15, the overhead settings should be performed according to the service manual. Below is the summary for adjusting the intake valve actuators.

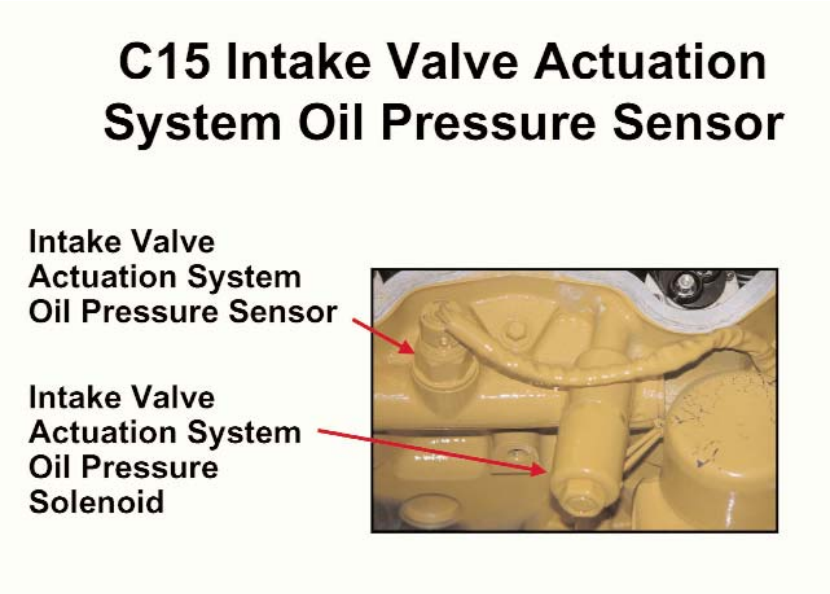
Loosen the jam nuts on top of the valve actuator assembly.

Follow the inlet valve adjustment procedure:

- Number 1 cylinder on TDC compression stroke
- Set intake valve actuators on cylinders 1, 2, and 4
- Rotate engine 360°
- Set intake valve actuators on cylinders 3, 5, and 6

Set intake valve actuator clearance.

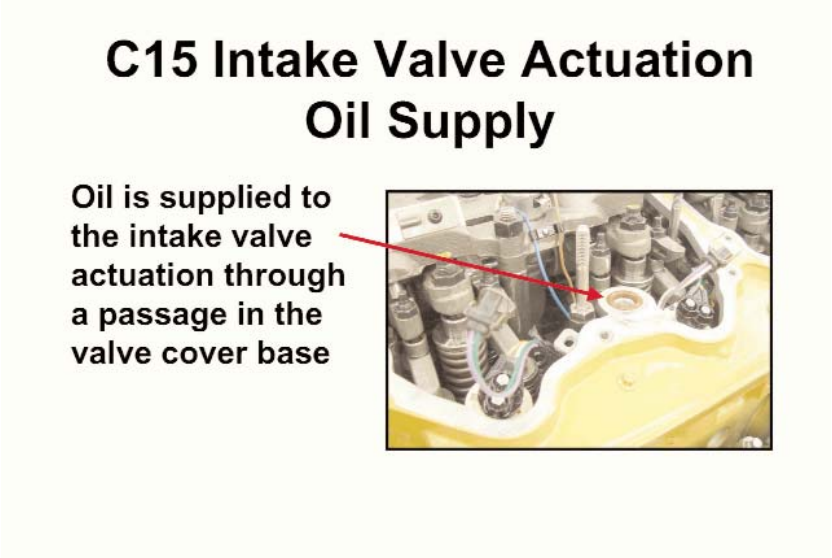
Tighten jam nuts.



33

The intake valve actuation system oil pressure sensor and the oil temperature sensor send signals back to the ECM. The ECM controls the intake valve actuation pressure through an intake valve actuation system oil pressure solenoid. The intake valve actuation system oil pressure solenoid allows pressure to be relieved by sending the oil back to the oil sump.

The intake valve actuation system oil pressure solenoid and the intake valve actuation system oil pressure sensor are located in the front of the valve cover base on the right side of the engine.

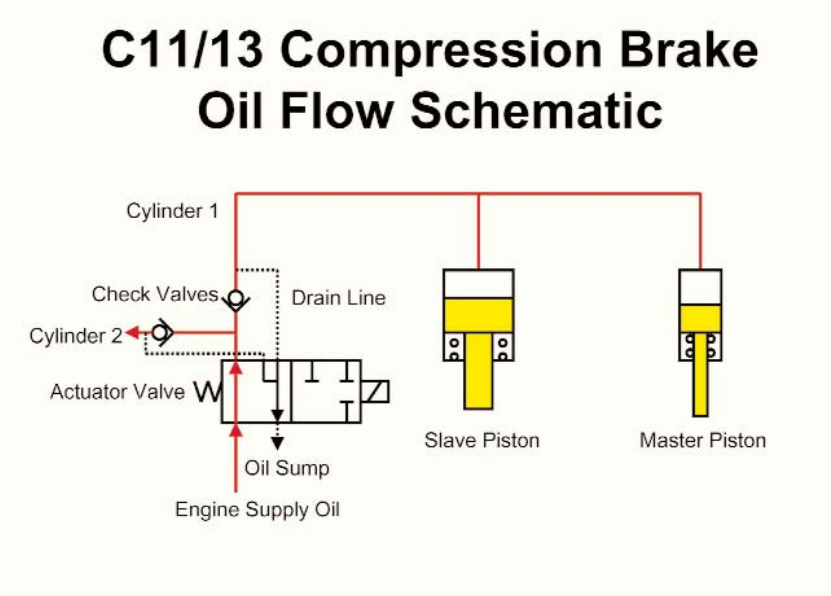


34

The actuation oil is supplied through a face-to-face o-ring seal in the valve cover base.

35

The intake valves are held open by the intake valve actuator assembly. The piston in the intake valve actuator assembly comes into contact with an extension on the intake valve rocker arm.



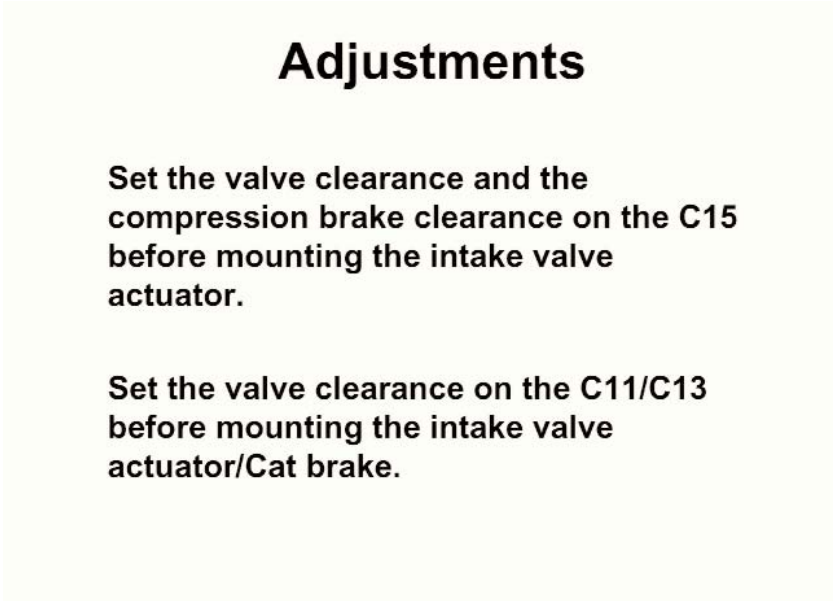
36

The actuator valve is a normally open valve.

Engine oil is directed to the piston assemblies at all times when the engine is running and the actuator valve is not activated.

The oil supply and the path for the oil to escape is blocked when the actuator valve is energized. As the camshaft rotates, the unit injector rocker arm pushes the master piston up into its cylinder. The displaced oil forces the slave piston down to extend against the rocker arm of the exhaust valves. The exhaust valves are forced open.

When the Engine Control Module (ECM) de-energizes the actuator valve, the oil pressure is relieved to the same pressure as the engine supply oil. The slave piston is returned to a normal position by spring force. The master piston is returned down to a normal position against the spring by the engine supply oil pressure.

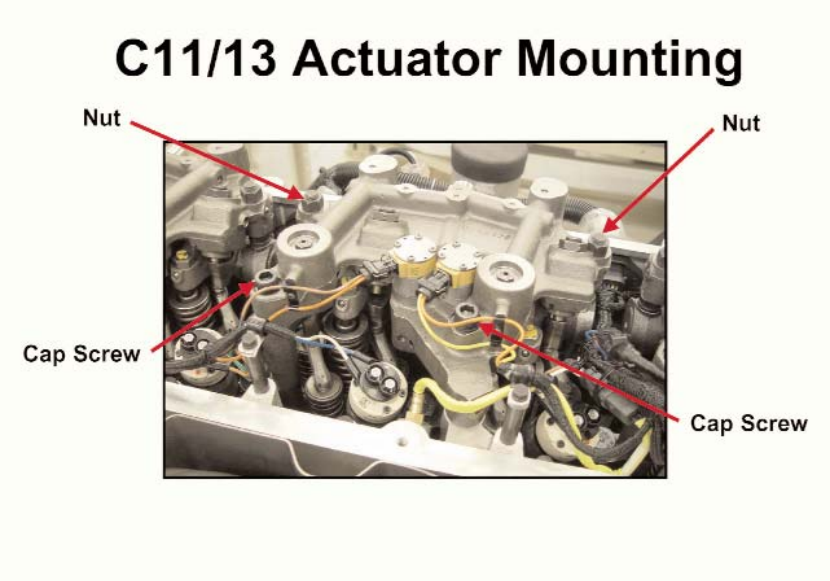


37

Adjustments

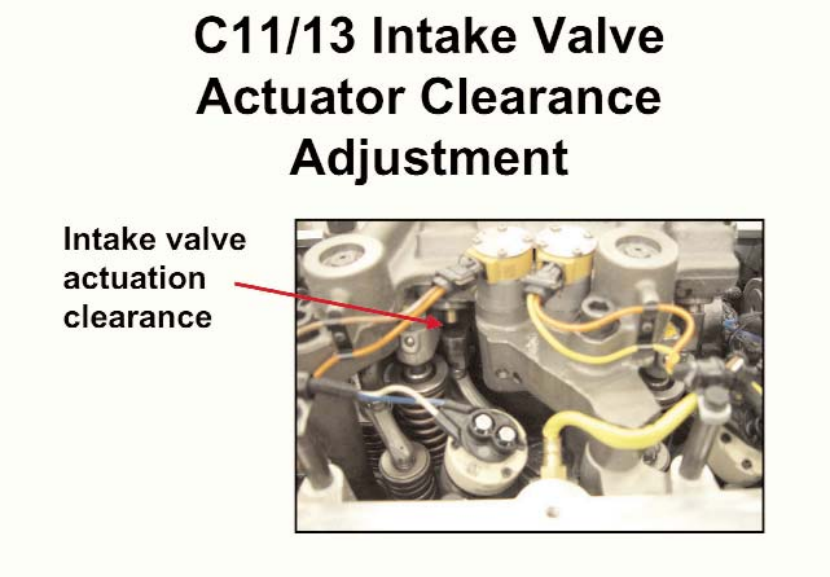
Follow the engine overhead setting procedures before mounting the intake valve actuator on the C15 engine. The valve adjustment screws cannot be accessed once the intake valve actuator is mounted onto the C15.

Set the valve clearance and the unit injector height on the C11/C13 engines before mounting the intake valve actuator/Cat brake assembly. Once installed, the intake valve actuator/Cat brake assembly limits access to the engine valves and the unit injectors for their adjustment.



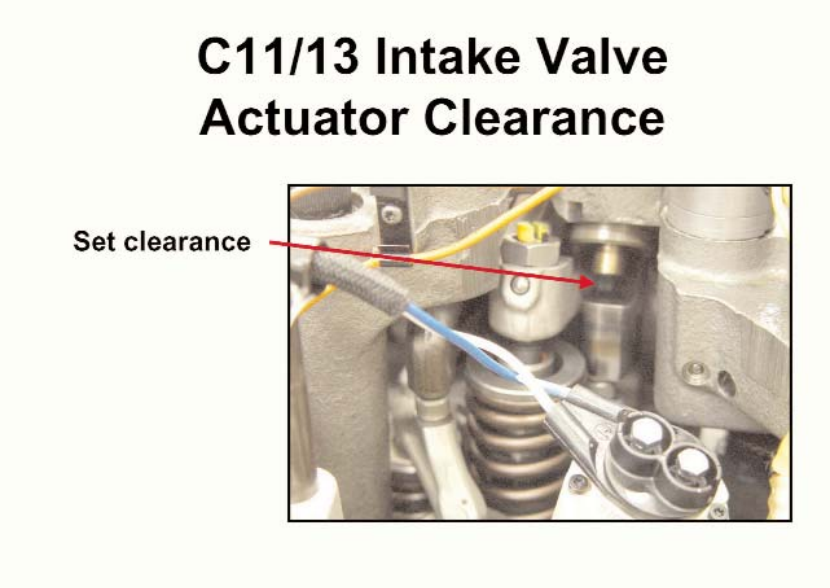
38

Tighten the mounting bolts for the actuator.



39

Loosen the jam nuts on top of intake valve actuator, then turn the adjusting screws counter clockwise. The intake rocker arm must be on its base circle of the camshaft.

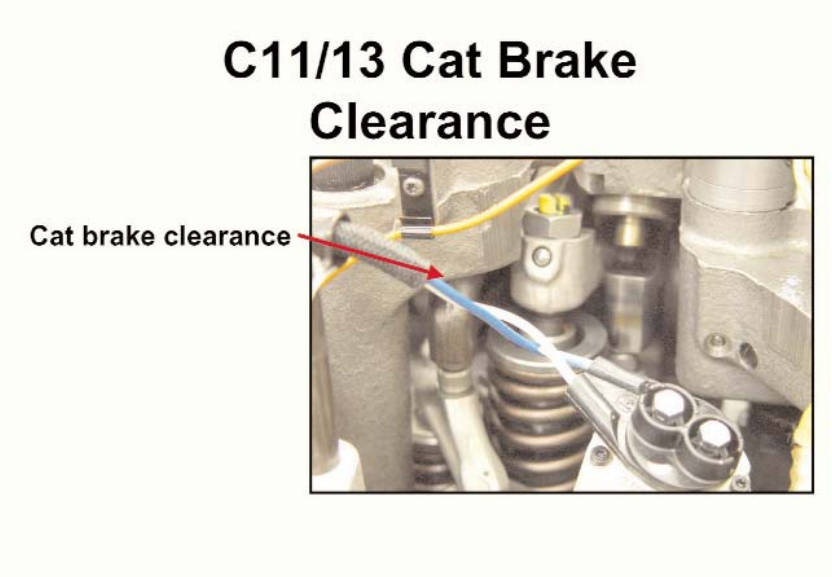


40

Use a feeler gauge to measure the distance between the rocker arm and the actuation piston.

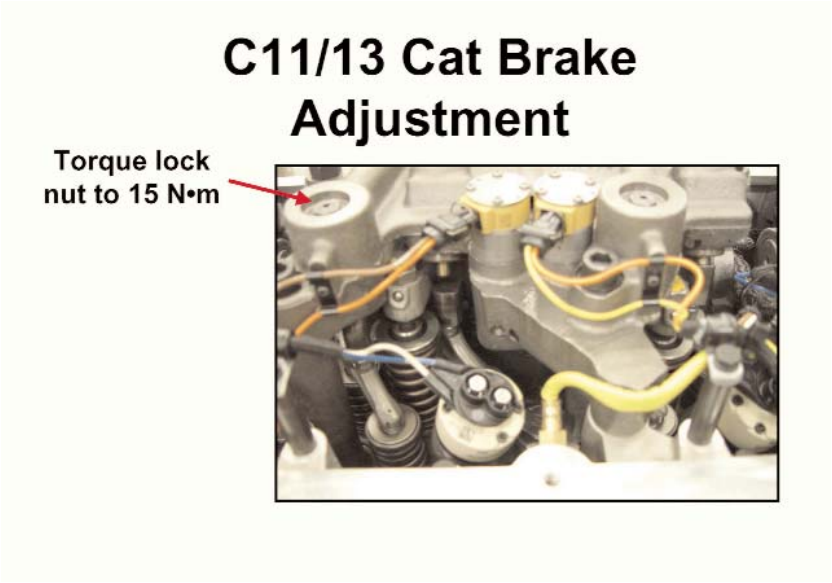
Follow the inlet valve adjustment procedure:

- Number 1 cylinder on TDC compression stroke
- Set intake valve actuator on cylinders 1, 2, and 4
- Rotate engine 360°
- Set intake valve actuator on cylinders 3, 5, and 6



41

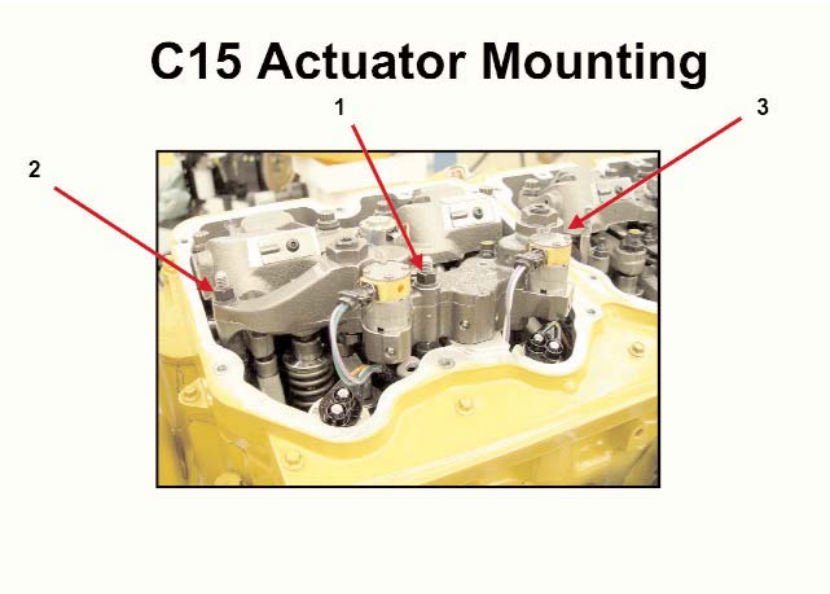
Use a feeler gauge to measure the distance between the rocker arm and the actuation piston in order to set the clearance on the Cat brake.



42

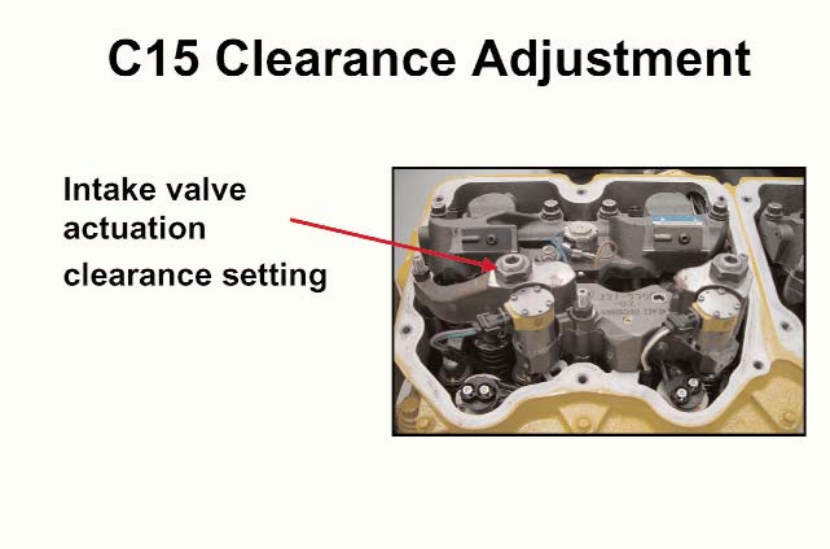
Use a feeler gauge to measure the distance between the rocker arm and the actuation piston.

Torque the jam nut to 15 +/- 3 Nm.



43

Tighten the three mounting nuts starting with the center nut (1).



44

Loosen jam nuts on top of intake valve actuation. Then turn the adjusting screws counter clockwise. The intake rocker arm must be on its base circle of the camshaft.

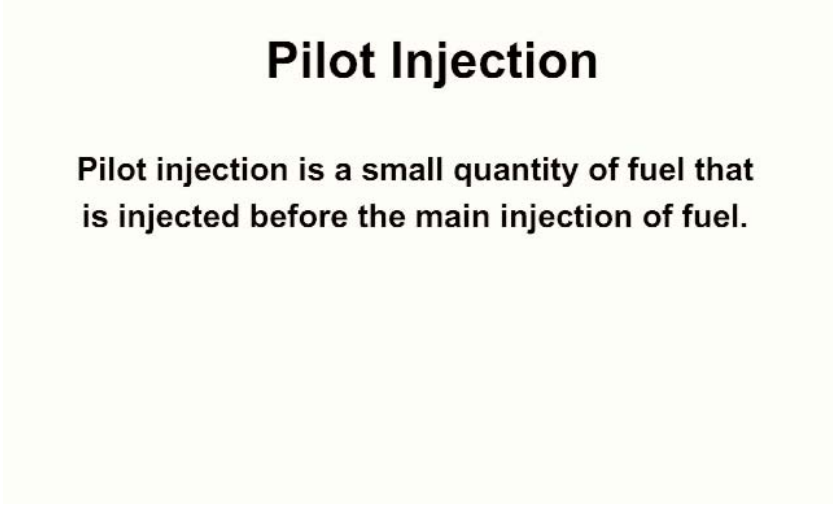
45

Use a feeler gauge to measure the distance between the rocker arm and the actuation piston.

Torque the jam nut.

Follow the inlet valve adjustment procedure:

- Number 1 cylinder on TDC compression stroke
- Set intake valve actuation clearance on cylinders 1, 2, and 4
- Rotate engine 360°
- Set intake valve actuation clearance on cylinders 3, 5, and 6



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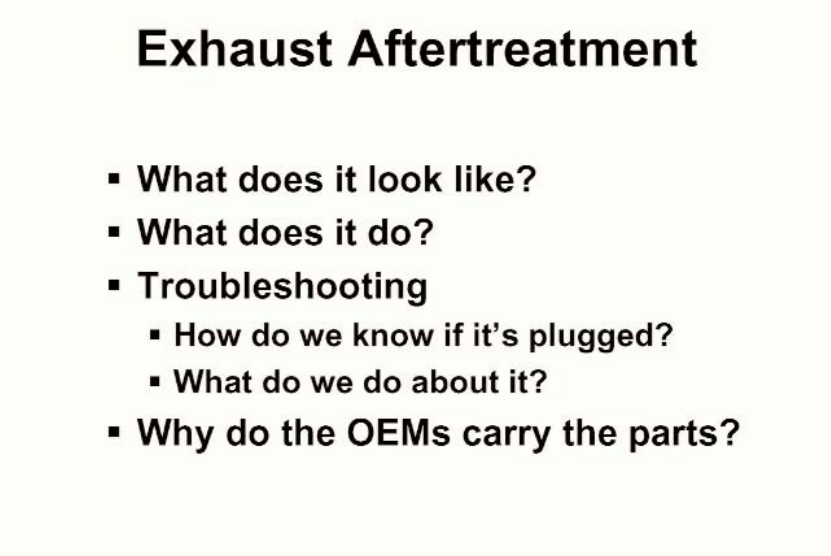
PILOT INJECTION

Pilot injection is a small quantity of fuel that is injected into the combustion chamber before the main injection of fuel. Pilot injection helps to reduce exhaust emissions and combustion noise.



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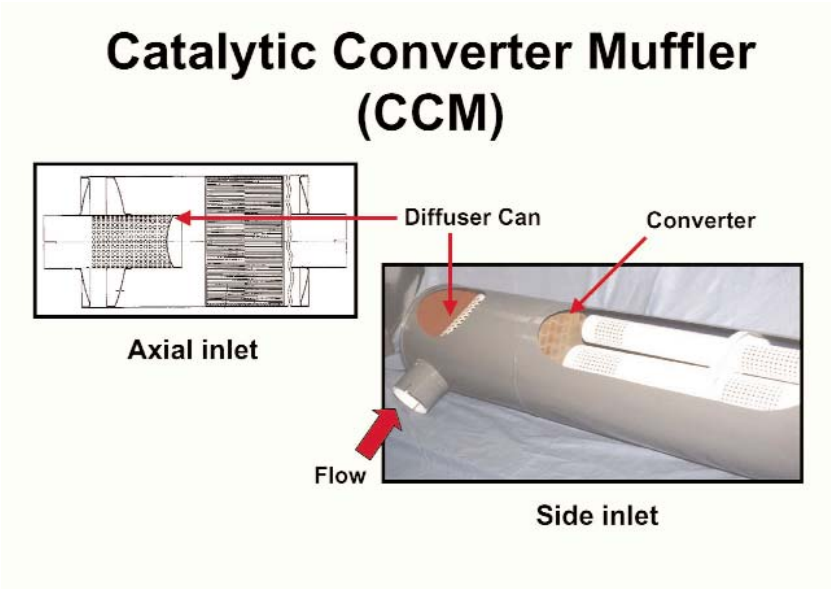
EXHAUST AFTERTREATMENT

These questions will be answered on the following pages.

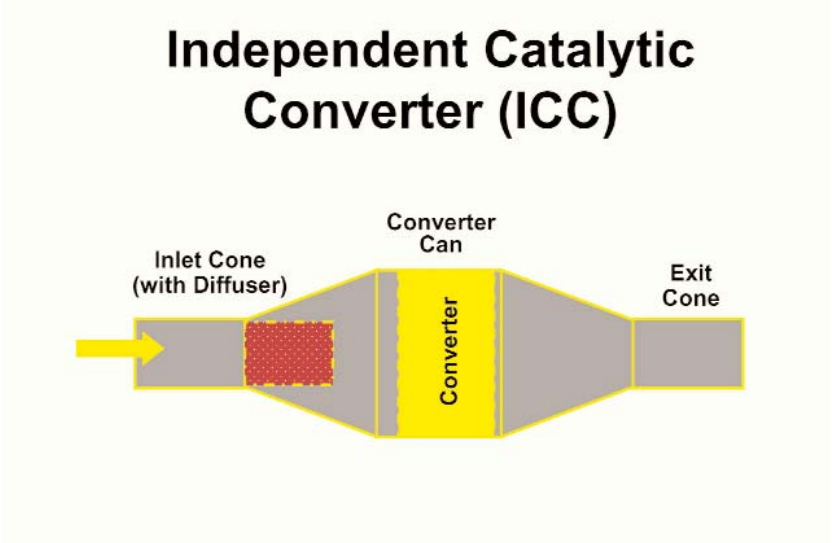
48

The exhaust aftertreatment can be combined with a muffler and used as a stack or under the chassis.



49

A catalytic converter muffler (CCM) has the catalytic converter inside the muffler. The design is simple and requires less modification for installation on a truck.



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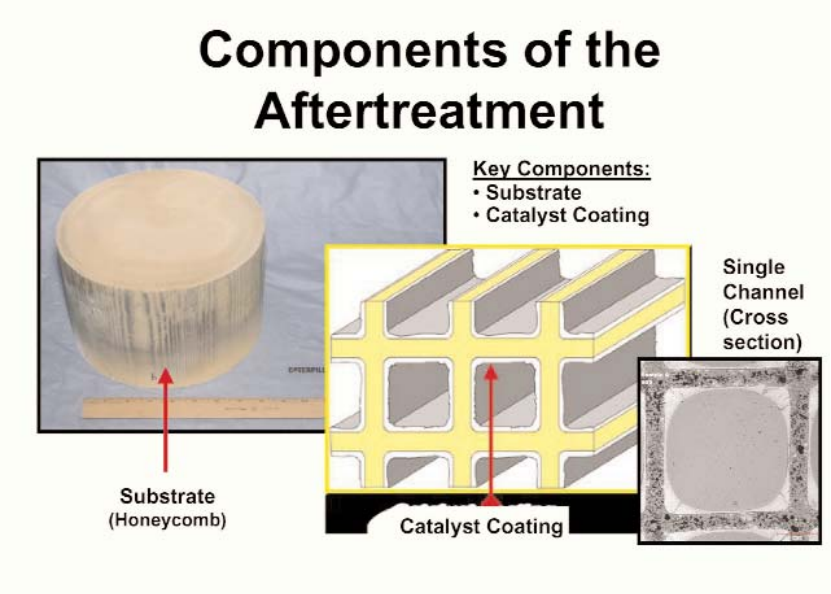
An independent catalytic converter (ICC) is separate from the muffler. An ICC requires the truck OEM to engineer where the ICC will fit in the exhaust system. The ICC requires heat shields around it in order to protect the rest of the truck and any service personnel from the high operating temperatures.



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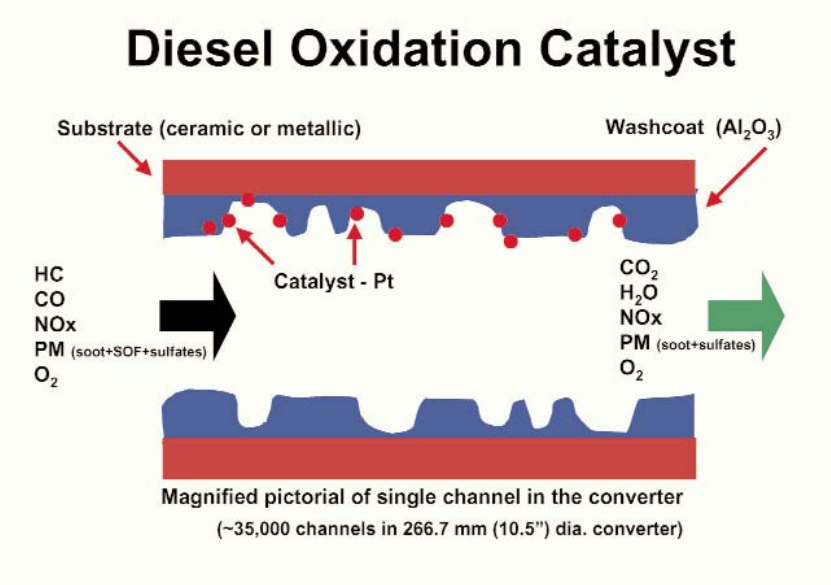
The catalytic element is a porous ceramic substrate with a precious metal catalyst coating. Flow passes through the honeycomb design channels.

The cross sections here show the ceramic substrate (yellow) which is "wash coated" (white) with an aluminum oxide catalyst. As exhaust gases flow past the coating, a reaction occurs that changes the chemical compounds in the exhaust gases.



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Chemicals from the engines exhaust that enter the converter:

HC = Hydrocarbon
CO = Carbon Monoxide
NOx = Nitrogen Oxide or Oxides of Nitrogen
PM (soot+SOF+sulfates)
O_2 = Oxygen

Chemicals that exit the converter:

CO_2 = Carbon Dioxide
H_2O = Water
NOx = Nitrogen Oxide or Oxides of Nitrogen
PM (soot+sulfates)
O_2 = Oxygen

Catalyst:

(Al_2O_3) = Aluminum Oxide

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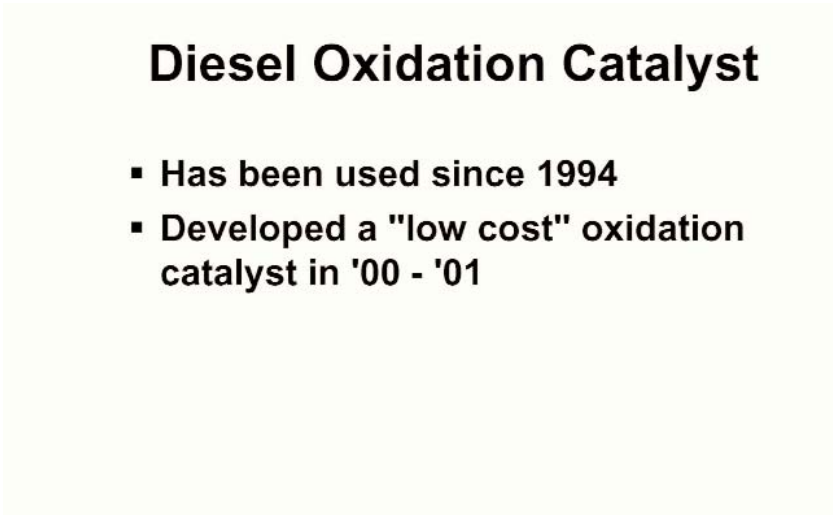
The Diesel Oxidation Catalyst (DOC) operates at a lower temperature than an ICC for gasoline engines. A diesel engine has a leaner A/F ratio and a lower exhaust temperature than a gasoline engine.

Caterpillar has been using a DOC since 1994 on the 3126B.



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Oxidation Catalyst History at Caterpillar

Oxidation catalyst has been in production since 1994.

- Over 50,000 units

Cat developed a “low cost” Oxicat in 2000 - 2001

- 3126E application
- Over 40,000 units

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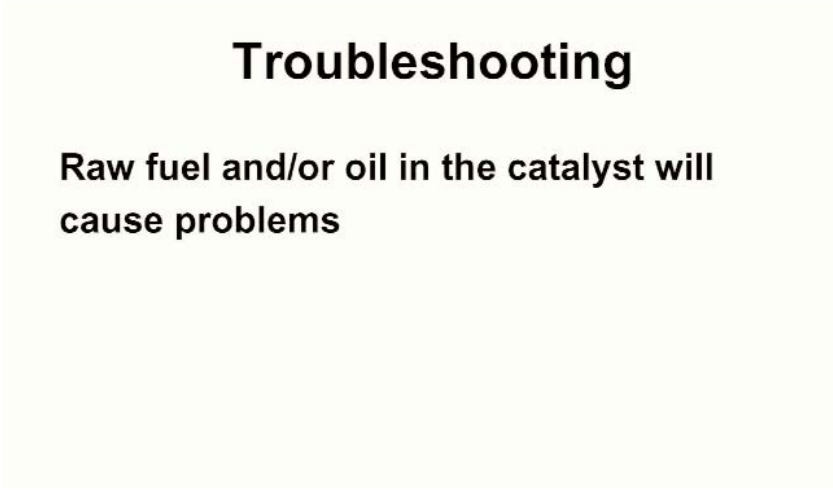
ACERT technology aftertreatment is essentially the same as on the current 3126E, a low cost oxidation catalyst.

Differences:

- Larger cell channels are used: 300 cells/in^2 instead of 400 cells/in^2.

- Most trucks use dual exhaust stacks.

- Also some independent catalytic converters may be used.



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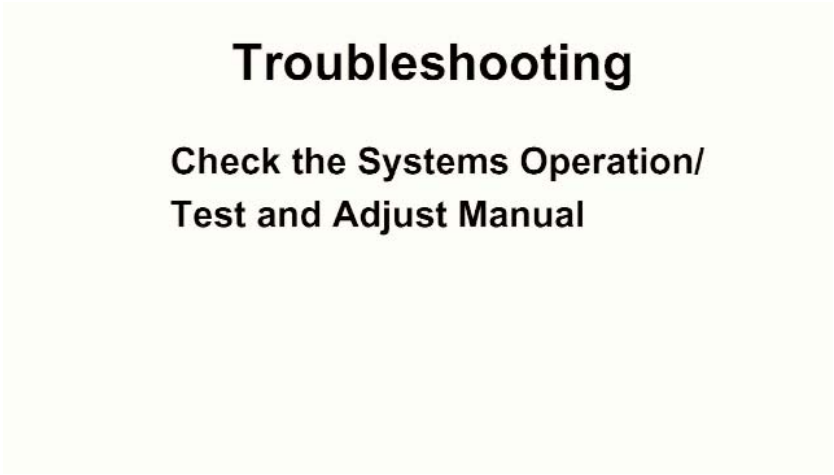
Troubleshooting

Problems caused by raw fuel and or oil in the catalyst.

- Increased back pressure
- Increased exhaust temperature
- Deteriorated catalytic action



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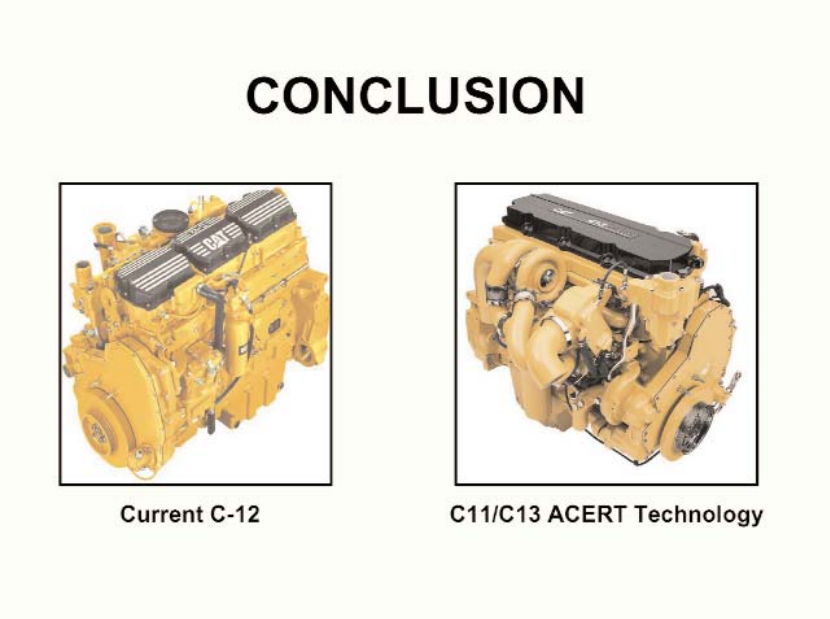
If the problem could be higher nominal back pressure:

- Check Systems Operation/Test and Adjust (SOTA) for the maximum allowable back pressure
- To assess possible problem:
  - Measure high idle back pressure – with no load on the engine
  - Multiply by 1.8
  - Compare to maximum back pressure specifications in SOTA



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CONCLUSION

This concludes the presentation on the mechanical changes for the 2003 C11 thru C15 on-highway heavy duty engines using ACERT technology.