



A NAVISTAR COMPANY

International[®] VT 365 2004 Engine Program I: Introduction

**Study Guide
TMT-120616**

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Table of Contents

Overview.....	2
----------------------	----------

Module I: Mechanical Features	4
--	----------

Module II: Engine Systems	10
--	-----------

Electronic Control System	10
ECM/IDM	10
ECM/IDM Communication	11
EGR Drive Module.....	12
Sensors	12
Air Management System	20
Turbocharger	20
Exhaust Gas Recirculation System	22
Fuel Management System.....	26
Fuel Supply	26
ICP System.....	29
Injectors	31
Base Management System.....	36
Cooling System	36
Lubrication System	38
Crankcase Ventilation.....	41

Module III: Unique Service Procedures VT 365.....	44
--	-----------

Oil Filter Replacement	45
Fuel Filter Replacement.....	46
High-Pressure Rail Removal	46
High-Pressure Rail Installation	46
Injector Removal.....	47
Cylinder Head Removal	49
Glow Plug Harness Removal and Installation	50
Glow Plug/Injector Sleeve Removal	50
Glow Plug Sleeve Installation	50
EGR Valve Removal	51
EGR Cooler Removal	51
Turbocharger Removal	54

Table of Contents

Intake Manifold.....	55
High Pressure Pump Cover Removal.....	55
Front Cover Removal.....	56
Conclusion	57

International® VT 365 Engine Training

Overview

“From a design standpoint, the 2004 International® VT 365 is much the same as the 2002 engine.”

From a design standpoint, the 2004 International® VT 365 is much the same as the 2002 engine. But now, the 2004 offers a series of product enhancements:

- Design improvements can be seen in the new EGR valve.
- Also, a new high-pressure manifold eliminates the need for high pressure hoses under the valve cover, which in turn simplifies service. The new manifold also reduces noise.
- Improvements have been made with a new cast iron, high-pressure oil pump.
- For more effective crankcase ventilation, the breather box size has been increased.

All of these product enhancements are a result of International Truck and Engine Corporation's pursuit of continuous improvement and customer satisfaction.

This DVD program and study guide provide a complete introduction to the 2004 VT 365.

If you are new to International[®], this program gives you a comprehensive overview of 2004 VT 365 technology. If you've already completed the 2002 VT 365 CBT and hands-on training, this program covers the design changes just mentioned and provides a complete program refresher.

This program is first in a series of DVDs on the International[®] VT 365. Program II covers complete step-by-step diagnostic procedures. Program III gives you an opportunity to apply what you learn in real VT 365 engine service situations. You'll take care of some basic repairs and some more challenging cases.

We'll even throw you some curves—the whole idea is to give you all the experience you need, so that once you face the real thing, you can get the job done right, within SRTs. With detailed practice and testing, Program III is also your opportunity to move a key step closer to certification by International[®] for 2004 VT 365 engine service.

Hopefully it's clear that this educational series is different. With DVD, you won't just sit back and watch. Be prepared to answer questions, offer advice, and even take control—in other words, be prepared to play a part in this DVD training series.

“If you are new to International[®], this program gives you a comprehensive overview of 2004 VT 365 technology.”

“With DVD, you won't just sit back and watch. Be prepared to answer questions, offer advice, and even take control—in other words, be prepared to play a part in this DVD training series.”

Module I Mechanical Features

Objectives:

- **Describe the mechanical configuration of the VT 365.**
- **Identify key components and new features for 2004.**

“The 2004 International® VT 365 is an eight cylinder, four stroke diesel engine with a displacement of 365 cubic inches.”

The 2004 International® VT 365 is an eight cylinder, four stroke diesel engine with a displacement of 365 cubic inches. The cylinders are arranged in a V pattern and are cast directly into the crankcase.

The camshaft is located in the crankcase and rides on five insert-type bushings.

The crankshaft is supported by five main bearings with the crankshaft thrust being controlled by the number four upper main bearing insert.

Individual main bearing caps have been replaced with a one-piece, cast iron lower crankcase, resulting in a more robust crankcase structure.

The rear-mounted gear train is used to drive the camshaft, the high-pressure pump, and the combination fuel pump and power steering pump, which is mounted to the lower right front side of the rear cover. The camshaft assembly is driven by the crankshaft gear that is located in front of the crankshaft primary flange.

The fuel injection system's high-pressure pump is mounted to the crankcase in the engine's valley and is driven by the camshaft gear.

The rear cover assembly is sealed to the crankcase with a push-in-place gasket. This assembly serves as both the rear cover to the crankcase gear area and the flywheel housing.

A secondary flange with an integral gear is pressed on the primary flange of the crankshaft. A ball bearing supported idler gear rides on an idler shaft and meshes with both the secondary flange and the power steering pump gear.

The rear oil seal carrier is bolted to the rear cover and the rear main seal is pressed into place.

Finally, the flywheel is attached with 10 bolts that extend through holes in the secondary flange to the primary flange.

The valves for each cylinder are operated by two roller-equipped hydraulic camfollowers held by a cam follower guide.

“The rear cover assembly is sealed to the crankcase with a push-in-place gasket.”

Each cast iron cylinder head is sealed to the crankcase with a multi-layered shim-type head gasket. Each cylinder has four valves.

The four valve-per-cylinder configuration allows for a centrally located injector and combustion chamber bowl.

The horseshoe-shaped intake manifold leaves the engine's valley open for the turbocharger and lubrication system components.

“Valve bridges are used to connect the operation of the intake and exhaust valve pairs for each cylinder.”

Valve bridges are used to connect the operation of the intake and exhaust valve pairs for each cylinder. The valve bridges allow a single rocker arm and pushrod to operate two valves.

The rocker arms are mounted on fulcrum plates that bolt to the aluminum rocker arm carrier.

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Module II Engine Systems

Objectives:

- **Identify individual functions and teamwork functions of the ECM and IDM.**
- **Determine how the ECM and IDM power up and how they operate.**
- **Identify the communication links between the ECM and IDM.**

“The Electronic Control System of the VT 365 is responsible for the operation of the engine.”

“The ECM and IDM work together to ensure the engine delivers the power the operator needs.”

Electronic Control System

The **Electronic Control System** of the VT 365 is responsible for the operation of the engine. The system controls the turbocharger, the exhaust gas recirculation system, the glow plug system, and the injection control pressure system.

The Electronic Control System works by gathering sensor information, processing that information in the electronic control modules, and then commanding the actuators that control the various systems.

ECM/IDM

The VT 365 uses both an **Electronic Control Module**, or **ECM**, and an **Injector Drive Module**, or **IDM**. The two modules are mounted together over the left bank valve cover except for vehicles based on the 1000 series stripped chassis. Stripped chassis vehicles will have the ECM and IDM mounted over the right bank valve cover.

The ECM and IDM work together to ensure the engine delivers the power the operator needs.

The ECM receives all engine sensor data, such as the accelerator position, engine temperature, and crankshaft and camshaft speed and position. Calculations then take place in the ECM in order to produce the signals for the injection pressure regulator, the turbocharger, the glow plug relay, and the EGR drive module.

Sensor information is also shared with the IDM to enable the IDM to determine the proper timing and duration of the fuel injection. The IDM will then send 48-volt signals to the injector coils in the correct sequence.

ECM/IDM Communication

The ECM communicates with the IDM over three separate communication links. They are the **CAN 2** link, the **Crankshaft Position Output**, or CKPO, circuit, and the **Camshaft Position Output**, or CMPO, circuit.

The CAN 2 link is a data line that allows the ECM to share with the IDM sensor values it collects. It also allows the IDM to share with the ECM injector faults it detects.

Both the CMPO and CKPO are single-wire links that allow the IDM to receive information relating to the camshaft and crankshaft positions.

“The ECM communicates with the IDM over three separate communication links.”

There is also a link between the ECM and the chassis **Electrical System Controller**, or ESC, or the **Multiplexed Signal Module**, or MSM. This link allows the ECM and the vehicle's ESC or MSM to communicate.

EGR Drive Module

“The EGR drive module is mounted on a vertical bracket in front of the ECM and IDM.”

The EGR drive module is mounted on a vertical bracket in front of the ECM and IDM.

The module communicates with the ECM over the CAN 2 link in order to receive ECM commands.

To share desired EGR position information with the EGR module, the ECM sends a signal to the drive module.

The module receives the signal and then sends voltage pulses to the EGR motor windings.

The sequence of voltage pulses causes the stepper motor to position the valve pintle.

Objectives:

- **Locate the sensors on the engine.**
- **Identify “new” sensors and their functions.**
- **Match each sensor with its purpose.**

Sensors

The ECM must receive information from a variety of sensors for proper operation. These sensors allow the ECM to calculate the position of a component, the rotational speed of a

shaft, the temperature of a fluid, or the pressure in a system.

The four temperature sensors are: intake air, manifold air, engine oil, and engine coolant.

The **Engine Coolant Temperature sensor**, or ECT, is located in the coolant outlet area of the front cover. The ECM uses the ECT sensor information for the instrument cluster gauge, the optional engine warning and shutdown system, and the coolant temperature compensation system.

Coolant temperature compensation cuts back the delivery of fuel to match the performance of the cooling system if the engine coolant temperature exceeds a given temperature. The optional engine warning and shutdown system can be enabled to warn the operator of high coolant temperature with the red engine lamp. The system can also be programmed to shut the engine down if critical temperatures occur.

The **Engine Oil Temperature sensor**, or EOT, is mounted on the oil filter base. The sensor provides information used to calculate injection-timing changes required due to changes in oil viscosity.

“The four temperature sensors are: intake air, manifold air, engine oil, and engine coolant.”

“The Engine Oil Temperature sensor is mounted on the oil filter base.”

The **Manifold Air Temperature sensor**, or MAT, is mounted on the intake manifold near its connection to the charge air cooler. The MAT sensor provides information used to calculate the proper degree of EGR valve opening.

The **Engine Oil Pressure sensor**, or EOP, is located on the oil filter base. The ECM uses the EOP sensor information for the instrument cluster gauge and for the optional engine warning and shutdown system. The optional engine warning and shutdown system can be enabled to warn the operator of low oil pressure with the red engine lamp or to shut the engine down when low oil pressure is encountered.

The **Manifold Absolute Pressure sensor**, or MAP, is mounted on the right bank of the intake manifold. The MAP sensor provides information used to calculate the proper vane position in the turbocharger and the valve opening in the EGR valve.

“The Injection Control Pressure sensor is mounted on the right bank high-pressure rail.”

The **Injection Control Pressure sensor**, or ICP, is mounted on the right bank high-pressure rail. Although the rail is mounted under the valve cover, the sensor protrudes through an opening in the valve cover, allowing service of the sensor without valve cover removal.

The ICP sensor is used as a feedback signal into the closed loop operation of the IPR valve and for detection of injection control pressure system faults.

The **Exhaust Back Pressure sensor**, or EBP, is mounted to a tube on the left bank of the engine. The EBP tube connects to the left bank exhaust manifold and allows exhaust back-pressure to reach the sensor.

The **Camshaft Position sensor**, or CMP, is located on the left front side of the crankcase. The sensor is a magnetic pick-up type sensor that reacts to a single peg pressed into the camshaft. Each time the peg passes the sensor, an AC voltage signal is sent to the ECM. Knowing the position of the camshaft allows the ECM to determine the position or stroke of each piston within its four-stroke cycle at any point in time.

“Knowing the position of the camshaft allows the ECM to determine the position or stroke of each piston within its four-stroke cycle at any point in time.”

The **Crankshaft Position sensor**, or CKP, is located on the right front side of the lower crankcase half. Like the camshaft position sensor, the crankshaft position sensor is a magnetic pick-up type. However, the CKP sensor reacts to a 58-tooth trigger wheel affixed to the front of the crankshaft.

“The trigger wheel teeth are arranged in a 60-tooth pattern with two of the teeth missing.”

The trigger wheel teeth are arranged in a 60-tooth pattern with two of the teeth missing. This pattern allows the ECM to calculate engine speed and the position of each piston in the engine.

There are also chassis-mounted sensors that are input into the ECM. They are the **Accelerator Position Sensor**, or APS, the **Idle Validation Switch**, or IVS, the **Barometric Pressure sensor**, or BAP, and the **Intake Air Temperature sensor**, or IAT.

The APS and the IVS are mounted on the accelerator pedal assembly.

The APS/IVS converts a reference voltage to a variable signal that communicates the pedal position to the ECM.

The BAP sensor is mounted under the instrument panel of the truck. The BAP sensor allows the ECM to read the altitude. Altitude information is used to control the turbocharger vane position, fuel injection quantity, fuel injection timing, and glow plug on-time.

“The IAT sensor is mounted in the air filter housing duct.”

The IAT sensor is mounted in the air filter housing duct. The IAT sensor provides information used to calculate fuel injection timing and rate when starting the engine in cold weather.

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Objectives:

- **Identify the features of the air management system.**
- **Identify the various air management system components.**
- **Match the turbo components with their respective modes of operation.**

“The turbocharger has three sections: the compressor, the turbine, and the center section with control mechanism.”

Air Management System

The main components of the Air Management System on the 2004 VT 365 are the turbocharger and the Exhaust Gas Recirculation System.

Turbocharger

The turbocharger has three sections: the compressor, the turbine, and the center section with control mechanism. The control portion of the turbocharger has three main components: the control valve, a set of movable vanes, and a hydraulic actuator.

The turbocharger is assembled with a conventional compressor wheel and turbine wheel on a common shaft. The center section of the turbocharger supports the wheel shaft with precision bearings that are lubricated with engine oil.

The turbine housing contains a set of movable vanes. The vanes are positioned to control the flow of exhaust gases through the turbine housing.

When the vanes move to a more closed position, the smaller openings between the vanes cause the exhaust gases to speed up. The gases impact the turbine wheel with greater force and this results in higher compressor wheel

speeds, greater intake manifold boost, and higher exhaust backpressure, or EBP.

The turbo vane position is controlled by the ECM. The ECM provides a pulse width modulated signal to the coil of the control valve. The magnetic field created by the signal positions a spool within the control valve.

The spool directs a portion of the turbocharger lube oil to either side of the hydraulic actuator. As the signal pulse width increases, the oil flow against the face end of the piston moves the vanes to a more closed position. When the signal decreases, oil flow against the rod side of the piston moves the vanes to a more open position.

The ECM determines the correct EBP for the engine's operating conditions and uses that value to calculate the control valve signal. The ECM then uses the exhaust backpressure value from the EBP sensor as a feedback signal for the vane position.

If the pressure is not correct, the ECM modifies the signal to the control valve. After the signal to the valve is updated, the ECM monitors the EBP sensor value to determine if the desired backpressure was achieved. This constant positioning of the vanes is

“The ECM determines the correct EBP for the engine's operating conditions and uses that value to calculate the control valve signal.”

used to control boost and to achieve the correct EGR flow.

One of the government-regulated emissions from diesel engines is oxides of nitrogen. Oxides of nitrogen are formed at high temperatures when fuel is burned in the presence of nitrogen.

Since the air we breathe is part nitrogen, and the temperatures are high in the combustion chamber, the formation of oxides of nitrogen from an internal combustion engine are high.

“The level of oxides of nitrogen emitted by the engine can be reduced by lowering the combustion temperature.”

The level of oxides of nitrogen emitted by the engine can be reduced by lowering the combustion temperature. The VT 365 uses cooled exhaust gases recirculated back to the combustion chamber to reduce temperatures.

Exhaust Gas Recirculation System

The EGR system is composed of the EGR cooler, the EGR valve, and the EGR drive module. The EGR cooler is bolted to the bottom of the right side of the intake manifold.

“Exhaust gases flow through tubes in the cooler while coolant flows around the tubes.”

The cooler receives hot exhaust gases from the right bank exhaust up-pipe. Exhaust gases flow through tubes in the cooler while coolant flows around the tubes.

Heat transfers to the coolant, lowering the temperature of the exhaust gases. The exhaust gases then enter a passage in the intake manifold that leads to the EGR valve.

The EGR valve mounts in the manifold and meters the cooled exhaust gases into the intake air.

The valve opening amount and the difference between the pressure in the intake manifold and the pressure in the exhaust manifold determines the flow through the EGR valve.

The EGR valve pintle position is controlled by a DC stepper motor contained in the upper housing of the EGR valve.

The EGR valve receives its commands from the EGR drive module. The module, mounted on a bracket near the ECM, receives a signal from the ECM across the CAN 2 Link.

Three sensors mounted in the valve housing act as feedback sensors, constantly identifying the position of the motor armature to the drive module.

The drive module constantly compares the desired position to the actual position and notifies the ECM of any faults over the CAN 2 link.

“The drive module constantly compares the desired position to the actual position and notifies the ECM of any faults over the CAN 2 link.”

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Fuel Management System

Objectives:

- **Identify the components that make up the Fuel Supply System.**
- **Match each fuel supply component with their respective operation and function.**

“The VT 365 diesel engine uses International® common rail high-pressure fuel injection, which features electronically controlled injectors that are hydraulically actuated.”

Fuel Supply

The VT 365 diesel engine uses International® common rail high-pressure fuel injection, which features electronically controlled injectors that are hydraulically actuated. The system is composed of the fuel supply system, the injection control pressure system, and the injectors. The three systems work together to deliver the correct quantity of fuel into the combustion chamber at the right time.

The injection control pressure system takes engine lube oil and delivers it to the injectors under high pressure to supply the mechanical force required to push fuel into the combustion chambers. The fuel supply system is mechanical but both the injector and the injection control pressure system are ECM-controlled.

The fuel supply system provides fuel under pressure to the injectors. The three main components of the fuel system are the fuel pump, the fuel filter module, and the fuel lines that serve to transfer fuel through the system.

The combination fuel pump and power steering pump is mounted on the

right side of the rear cover and is driven off the rear gear train.

For the pump's protection, fuel drawn from the tank passes through the pump-mounted strainer before entering the pump.

The vane-type pump moves the fuel under pressure to the fuel filter module where water and sediment are separated from the fuel by the filter element. Fuel that passes through the element moves to the cylinder heads via individual steel lines.

The line is connected to the head with a banjo bolt that contains a check valve and orifice. Fuel passes through the valve and enters a drilled passage in the head that feeds the injectors. There is no fuel return from the cylinder heads. Fuel that enters the heads will stay in the head until it is injected into the combustion chambers.

The fuel pressure regulator valve is mounted on the front of the fuel filter module. The regulator drains fuel from the unfiltered side of the element when fuel pressure exceeds 55 psi. Fuel pressure depends on engine speed and load. At high-RPM, no-load conditions in which fuel usage is low, the fuel pressure will reach 70 psi. Fuel flow from the regulator returns to the fuel tank via the return line.

“Fuel pressure depends on engine speed and load.”

“The engine is available with two optional fuel system components: a water-in-fuel sensor and a fuel heater.”

The engine is available with two optional fuel system components: a water-in-fuel sensor and a fuel heater. The water-in-fuel sensor is mounted on the filter module and is exposed to the fuel in the filter housing. When water is detected, a dash lamp will warn the operator.

The fuel heater is located in the bottom of the filter module. The heater element has a built-in thermostat that turns the heater on at 45°F (7°C) and off at 75°F (24°C).

The filter module also incorporates a drain valve. The drain valve allows the operator to drain the filter module if water is detected in the fuel, and gives the technician a place to take a fuel sample.

“The fuel filter module has two pressure test points.”

The fuel filter module has two pressure test points. The pressure tap towards the front of the filter module allows the fuel pressure on the non-filtered side of the element to be measured. This location leaves the factory with a test port installed. The other location, towards the rear of the module, has a plug that can be removed to allow fuel pressure on the filtered side of the element to be measured.

NOTE:

The fuel pressure test port is not installed. Use tool #ZTSE4542 from the tool kit.

ICP System

The International® fuel system uses electronically-controlled and hydraulically-actuated unit injectors. Each injector is supplied with high-pressure oil to provide the mechanical force required for injector operation. The high-pressure oil system's main components are the reservoir, the high-pressure pump, the IPR valve, the high-pressure rails, and the tube assemblies that allow oil to flow from the pump to reach each of the rails.

The high-pressure pump is mounted to the crankcase in the rear of the engine's valley. The pump is gear-driven directly off the camshaft gear. The pump's inlet port aligns with an O-ringed port on the crankcase-mounting surface.

This port allows the pump to draw engine oil from the reservoir cast in the front of the crankcase V. Oil that passes from the reservoir to the pump must pass through the 150-micron screen held in place within the reservoir by the oil cooler. The reservoir is constantly refilled with filtered and cooled engine oil through a passage in the oil cooler cover.

High-pressure oil from the pump discharges through a rear-facing port into the branch adapter and the branch

Objectives:

- **Identify features of the injection control pressure system.**
- **Identify injection control pressure system components.**
- **Match injection control pressure system components with their functions.**

“The high-pressure pump is mounted to the crankcase in the rear of the engine’s valley.”

tube. Oil moves through the branch tube to the case-to-head tubes and then to the oil rails. The oil rails then distribute the pressurized oil to each injector's oil inlet through pipes on the bottom of the rail.

ENGINE FACT:

The opening and closing of the spool valves during engine operation can cause pressure waves to develop in the rails.

A check valve and orifice in each case-to-head tube acts to dampen the pressure waves.

NOTE:
Depending on the date of production, the location of the high pressure oil check valve varies. Some valves are found in the case-to-head tube, while others are built into the port plug.

The pressure created by the high-pressure pump is called **Injection Control Pressure**, or ICP. The pressure requirement for ICP constantly varies with engine RPM and load. The ECM calculates the desired ICP and sends a signal to the injection pressure regulator valve. The IPR signal from the ECM positions a spool valve within the regulator that controls the amount of oil drained from the pressure side of the system. At high RPM, light load, the pump produces a larger volume of oil than what is needed for injector operation. Because of this, the IPR must drain a quantity of oil back to the engine's oil pan. At lower RPM and heavier load, the injectors require a larger amount of oil so the IPR will drain less from the system.

ENGINE FACT:

In addition to controlling the system pressure, the IPR also protects the system with an internal pressure relief valve that opens if the system pressure reaches 4,400 psi.

The ECM constantly monitors the action of the IPR from the ICP sensor.

This pressure is then compared to the desired pressure. If the pressure is incorrect, the IPR signal is changed to correct the pressure. This process occurs constantly and is called closed loop.

Injectors

Each VT 365 injector is mounted in a machined opening in the cylinder head with a stainless steel cup covering the lower portion of the opening. The cup serves as the coolant jacket in the bottom part of the opening, allowing better heat transfer from the injector to the coolant. The injector is sealed in the cylinder head with an O-ring above the fuel port, an O-ring below the fuel port, and a metal gasket at the nozzle tip.

The injector is held in the head with a self-extracting clamp. The clamp fits into a groove on the injector body and is attached to the cylinder head with one bolt. The bolt is held to the clamp with a ring that causes the clamp to extract the injector from its bore when the clamp bolt is turned counterclockwise and pulls the injector into the bore when turned clockwise.

Fuel from the cylinder head drilling enters a port on the side of the injector at approximately 60 psi. When the injector is in the fill stage, the fuel pressure lifts a check valve in the injector and fills the barrel and plunger area.

The operation of the G2 injector can be divided into four areas: the coil and spool valve, the intensifier piston, the barrel and plunger, and the nozzle.

Objectives:

- **Identify the components of the VT 365 injector.**
- **Match injector components with their functions.**

“Each VT 365 injector is mounted in a machined opening in the cylinder head with a stainless steel cup covering the lower portion of the opening.”

“The operation of the G2 injector can be divided into four areas: the coil and spool valve, the intensifier piston, the barrel and plunger, and the nozzle.”

“With the valve open, oil from the rail can enter the injector.”

Oil flow into and out of the injector is controlled by the IDM by positioning a spool valve in the top of the injector. The spool valve is controlled by two coils, the open coil and the close coil. The spool valve is located in a bore in the top of the injector and is positioned by the magnetic force generated when the IDM sends a 48-volt signal to the appropriate coil. In operation, when the IDM signals the open coil, the spool valve shifts to the open position and then the signal is turned off. The spool valve is held in position by residual magnetism. With the valve open, oil from the rail can enter the injector.

When high-pressure oil enters the injector, it pushes against the intensifier piston. The top of the intensifier piston is approximately seven times larger than the plunger end. Therefore, the plunger acts upon the fuel in the barrel with seven times the force. This allows 3,000 psi of ICP to pressurize fuel to approximately 21,000 psi.

When the plunger begins to move down in the barrel, and fuel pressure below the plunger starts to rise, the fuel inlet check valve closes. This prevents fuel from flowing back into the fuel rail in the cylinder head. Fuel pressure developed by the plunger travels down a passage to the nozzle area. When the force in the nozzle pushing on the

needle bevel exceeds the force of the nozzle spring, the needle rises and the fuel is injected through the nozzle holes into the combustion chamber.

When the IDM determines that the correct quantity of fuel has been delivered, a 48-volt signal is sent to the close coil, the spool valve shifts position, and the signal is turned off. With the spool valve in the closed position, high-pressure oil flow into the injector is stopped, and oil pressure pushing against the intensifier piston is allowed to drain through ports in the top of the injector. This action allows fuel pressure at the nozzle to drop.

“When the IDM determines that the correct quantity of fuel has been delivered, a 48-volt signal is sent to the close coil...and the signal is turned off.”

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Base Management System

Objectives:

- **Identify the function of each component within the cooling system.**
- **Identify the numerous pathways of the cooling system.**
- **Identify the proper coolant type.**

“The purpose of the cooling system is to move excess heat energy from the engine components to the radiator.”

Cooling System

The purpose of the cooling system is to move excess heat energy from the engine components to the radiator. Heat transfers to the air flowing through the radiator, removing excess heat energy. Then the coolant is recirculated back to the engine. Major components of the cooling system are the front cover with thermostat and water pump, the coolant passages of the crankcase and cylinder heads, and the EGR cooler and oil cooler.

The water pump is belt driven and mounts in a cavity on the front cover. The pump pulls coolant from the radiator through the front cover coolant inlet and directs the coolant to three passages on the front of the crankcase. Two passages direct coolant through the crankcase around the cylinders, up through passages in the crankcase deck and head gasket to the cylinder head. While the coolant flows through the cylinder head, heat transfers from the engine to the coolant once the engine warms up.

Coolant flows in the cylinder head from the back of the head toward the front and then back into a passage in the

crankcase. Coolant then enters the front cover and is directed to the thermostat.

If coolant is at operating temperature, the thermostat opens and coolant flows through the thermostat to the radiator. If coolant is below the opening temperature of the thermostat, the coolant is directed through the front cover bypass passage back to the water pump. Circulation in bypass mode helps the engine achieve a quicker warm-up.

“If coolant is at operating temperature, the thermostat opens and coolant flows through the thermostat to the radiator.”

The third passage on the front cover directs coolant to the oil cooler cover. Coolant flows through a passage in the cooler and is directed to the oil cooler inlet. As the coolant passes through the cooler, heat transfers from the cooler to the coolant and reduces the engine's oil temperature. Coolant exiting the oil cooler cover enters the EGR cooler. Again, heat transfers from the cooler to the coolant to lower EGR gas temperatures. Then the coolant moves through a passage in the intake manifold back to the front cover. Coolant returned from the EGR cooler mixes with coolant from the cylinder heads and then moves to the thermostat.

When the optional air compressor is mounted, the compressor is supplied with coolant by a hose from the front cover. Coolant flows through the

ENGINE FACT:

Extended life coolant does not need to be replaced for 300,000 miles, 12,000 hours, or 5 years if the extender is added at 150,000 miles, 6,000 hours, or 30 months.

ENGINE FACT:

The 2004 VT 365 is designed with a single- or dual-belt drive, depending on the configuration. If it is configured with an alternator alone or with an alternator and an air conditioning compressor, one belt does the job.

compressor, absorbing heat, and then returns to the front cover and flows to the thermostat.

The VT 365 is designed to use extended life coolant. Extended life coolant can be identified by its red/orange tint in contrast to the green tint of conventional coolant.

If the engine is configured with an air compressor, a second belt drives the unit.

Lubrication System

Objectives:

- **Identify the function of each component within the lubrication system.**
- **Identify the numerous pathways of the lubrication system.**
- **Determine the correct capacities of the oil lubrication system.**

In the 2004 VT 365, lube oil is used for engine lubrication, valve tappet operation, piston crown cooling, injector activation, and turbocharger control.

The main components of the system are the oil pump and regulator valve, the oil cooler and filter module with valves, and the oil passages.

The gerotor type oil pump gear set rides in a cavity machined into the front cover. The inner rotor of the gear set is driven directly off two flats on the crankshaft.

The pump draws oil from the oil pan into the pick-up tube, through a passage in the upper oil pan and lower crankcase, then into the pump itself.

Rotation of the pump-gear set forces oil to the outlet side of the pump and causes oil to leave under pressure.

The pressure regulator is mounted on the front cover below the pump and is accessible through a removable plug. If oil pressure exceeds 55 psi, the regulator piston begins to open and dumps excess oil back to the inlet side of the pump.

Oil discharged from the pump moves through the front cover, up a vertical passage in the crankcase, then into the oil cooler cover.

Oil travels through the cooler and into the filter housing. Oil passes through the filter media, through the standpipe and into the crankcase passages that feed oil to the left and right bank oil galleries.

The right bank gallery feeds the right bank cam followers, piston cooling jets, cam bearings, and the main bearings. The left bank gallery feeds only the left bank cam followers and the left bank piston cooling-jets.

Crankshaft cross-drillings between the crankshaft main bearing journals and the connecting rod journals allow pressurized oil at the main bearings to pass through the crankshaft and lubricate the rod bearings.

“Oil discharged from the pump moves through the front cover, up a vertical passage in the crankcase, then into the oil cooler cover.”

Oil that passes through the filter also moves through a passage in the oil filter base to provide oil to the turbocharger supply tube and, if equipped, the optional air compressor.

“Oil also passes through an opening in the cooler cover to fill the high-pressure pump reservoir.”

Oil also passes through an opening in the cooler cover to fill the high-pressure pump reservoir.

Oil from the cam followers travels up the push tubes, and splash lubricates the valve train components.

To protect the engine, the oil filter base includes a cooler bypass valve and a filter bypass valve. During engine operation when the oil is cold and thick, the engine is protected from reduced oil flow by the cooler bypass valve. When the oil pressure at the cooler inlet is 20 psi greater than the oil pressure in the filter, the cooler bypass valve opens and the oil goes directly into the filter, bypassing the oil cooler.

In addition, there is a filter bypass valve located in the top of the oil filter standpipe. If the filter becomes restricted, the filter bypass valve opens and allows oil to continue to lubricate the engine.

There is also an anti drain-back valve in the oil filter base. The anti drain-back valve is used to stop oil in the filter housing from draining back to the sump when the engine is shut down.

In addition to these valves, the filter base has a drain valve. The drain valve opens automatically when the filter-housing cap is removed and the filter is lifted. This facilitates draining the filter housing of used oil during an oil change.

Crankcase Ventilation

The VT 365 has a closed crankcase. The left bank valve cover has a breather box connected between the turbocharger compressor inlet boot and the crankcase.

Crankcase gases that enter the boot are pulled into the intake charge and recirculated into the combustion chambers.

ENGINE FACT:

The service interval for the engine oil and filter is 10,000 miles, 350 hours, 1,000 gallons of fuel, or 6 months.

ENGINE FACT:

The system does not require maintenance, but technicians should be aware that recirculation of crankcase gases back into the intake will leave an oil residue in the turbo and the charge-air-cooler piping.

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NOTES

Module III Unique Service Procedures VT 365

This module covers special repair considerations for 2004 VT 365 engines. This information is provided as a preliminary overview to help technicians deal with any immediate repair work that may be required.

“Before performing work of any kind, refer to ISIS® for the most current service information.”

Before performing work of any kind, refer to ISIS® for the most current service information.

As we have already mentioned, detailed step-by-step diagnostic and repair procedures will be covered in the upcoming programs of this training series.

As we review these VT 365 repair procedures, keep in mind that proper service techniques, environmental concerns, and safety are the most important parts of the process.

“When working on the engine, keep the work area and tools as clean as possible.”

Perform service inside a well ventilated, dry shop. Make sure the vehicle is parked on a flat surface, with the parking brake set and the wheels blocked.

When working on the engine, keep the work area and tools as clean as possible. Also, clean all connections

or fittings before disconnecting or removing components.

Use a suitable pan to catch any fluid when disconnecting components.

All engine line openings should be immediately plugged during removal and remain so until reinstallation to prevent the entry of dirt, moisture and other foreign material.

Exercise extreme caution once the valve cover is removed. Even the slightest particle can cause unexpected problems.

Wear safety glasses and chemical-blocking nitrile gloves when performing work of any kind.

Before we get started, always be sure you follow proper service procedures. For example, be sure the batteries are disconnected before performing engine work.

Oil Filter Replacement

Loosen the oil filter cap to drain oil from the filter housing to the crankcase.

Remove the oil filter and discard it properly.

Note that the oil filter snaps into the oil filter lid.

“Remove the oil filter and discard it properly.”

Install the new oil filter element, and tighten the oil filter cap to the recommended torque.

Refer to ISIS® for the appropriate torque specification.

Fuel Filter Replacement

“Using the drain valve located on the side of the fuel filter housing, drain the fuel into an appropriate container.”

Using the drain valve located on the side of the fuel filter housing, drain the fuel into an appropriate container.

Remove the fuel filter cap using an oil filter wrench. Remove and properly discard the element.

Close the fuel drain valve.

Install the new fuel filter element, and fill the fuel filter housing with clean fuel. Tighten the fuel filter cap until it's snug.



CAUTION:

Be careful not to pry against the valve cover sealing surface to remove the rail to prevent damage to the sealing surface.

High-Pressure Rail Removal

After removing the valve cover, remove the high-pressure rear oil supply plug. Remove the nine high-pressure oil rail bolts. Then pull the rail from the head.

Finally, remove the case-to-head tube assembly.

High Pressure Rail Installation

Install the rail onto the injectors and torque the nine bolts to the rocker lever carrier. Refer to ISIS® for the appropriate specifications.

Lubricate the case-to-head tube assembly O-rings, and install the tube into the oil rail opening.

Replace the high pressure rear oil supply plug, and torque it. Refer to ISIS® for the appropriate specifications.

Injector Removal

The injector connectors on the VT 365 are locked into the rocker lever carrier.

To disconnect the external engine wiring harness from the injector, push in on the spring-loaded metal clip on the harness.

To remove the injector connector from the rocker lever carrier, use ZTSE4650. Place the open end of the tool over the connector and push inward lightly to disengage the locks. Then pull the connector out of the rocker lever carrier.

To remove the injector, loosen the bolt that holds the injector in place. This will also unseat the injector from its bore.



CAUTION:

Note that the engine will not start if any of the four port plugs are not installed in the correct locations. Two of the plugs are found on the left side of the engine and two on the right side of the engine.

“To disconnect the external engine wiring harness from the injector, push in on the spring loaded metal clip on the harness.”



CAUTION:

Be sure that you don't pry on the injector coils to remove the injector. They may be damaged and are not replaceable. Also, watch for rocker-arm-to-injector interference.

Do NOT use air tools to remove the injector. This can lead to injector seat damage.

Carefully lift the injector from the bore.

Make sure that the copper gasket at the bottom of the injector has not fallen into the injector bore.

Carefully remove the external O-rings.

“Be careful not to scratch the injector body during removal, or the replacement O-rings may not seal.”

Be careful not to scratch the injector body during removal, or the replacement O-rings may not seal.

Carefully install new O-rings on the injector body.

Don't attempt to remove the oil inlet O-ring. It is not replaceable.



CAUTION:

To prevent wiring damage, don't pull on the wires while working with the injector.

To install the copper gasket to the injector tip, use a twelve point, 9 mm deep-well socket so that pressure is applied evenly around the gasket during installation.

If the gasket is misshaped or damaged during installation, it must be replaced.

The oil inlet O-ring cannot be serviced. If the O-ring leaks or is otherwise damaged, the injector must be replaced.

Lubricate the upper and lower O-rings on the body of the injector. Place the injector with its hold down clamp into the bore.

Make sure that the copper washer doesn't fall off the tip of the injector.

Tighten the hold down bolt to the specified torque.

Lubricate the internal O-ring at the top of the injector.

Reinstall the rail as described earlier in this module.

Cylinder Head Removal

The rocker lever carrier is held in place with eight small bolts and the 10 cylinder head bolts.

Remove the five small bolts that hold the cylinder head to the crankcase. Lift the cylinder head from the crankcase.

The rocker arm push rods must be installed in their original position during reassembly.

The valve bridges must be installed in their original position and orientation during reassembly.



CAUTION:

Removing any of the 14 mm cylinder head bolts from the VT 365 engine requires that the cylinder head be removed, and that the cylinder head gasket and the cylinder head bolts be replaced.

NOTE:

Special tool ZTSE4697 will allow the rocker arms to be removed without removing the 14 mm cylinder head bolts.



CAUTION:

If the rocker arms and/or valve bridges are not correctly installed, premature valve train wear may result.

Glow Plug Harness Removal and Installation

“To properly remove the glow plug wiring harness from the glow plugs, use ZTSE4670.”

To properly remove the glow plug wiring harness from the glow plugs, use ZTSE4670.

Any other method could lead to wiring harness damage.

Glow Plug/Injector Sleeve Removal



CAUTION:

The cylinder head must be removed to replace the glow plug sleeve.

Using ZTSE4531, place the tap into the glow plug sleeve, and cut threads into the sleeve.

Remove the tap, and insert the puller into the glow plug sleeve.

Turn the puller clockwise until the sleeve is removed.

Glow Plug Sleeve Installation

Clean the old sealant residue from the bore with a wire brush before installing the new sleeve.

“Apply Loctite® 620 sealant to the two locations where the sleeve contacts the cylinder head.”

Apply Loctite® 620 sealant to the two locations where the sleeve contacts the cylinder head.

Use ZTSE4532 to drive the glow plug sleeve into the cylinder head.

Use a nylon brush to clean any sealant residue from the glow plug sleeve.

EGR Valve Removal

To remove the EGR valve, remove the two mounting screws from the intake manifold.

Rotate the valve so that the mounting tabs on the valve align with the EGR valve puller, tool ZTSE4543.

Position the other two legs of the puller on the bolt bosses of the intake manifold, and turn the forcing screw clockwise.

When reinstalling the valve, check the O-rings for cuts and nicks. Replace the O-rings as necessary.

EGR Cooler Removal

Before removing the EGR cooler, you must first drain the coolant from the cooling system.

To disconnect the hose that supplies coolant to the EGR cooler, rotate it and pull it until the tabs release.

Both the inlet and outlet for exhaust gasses are sealed with metal gaskets.

The coolant connections are sealed with O-rings within the hose.

“To remove the EGR valve, remove the two mounting screws from the intake manifold.”

“Before removing the EGR cooler, you must first drain the coolant from the cooling system.”

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NOTES

Turbocharger Removal

The right side exhaust up-pipe can be separated above the EGR exhaust connection.

This connection is sealed with a gasket.

There are two other connections that must be removed to remove the turbocharger.

One is at the left exhaust manifold; this is a flange seal without a gasket.

The other connection is at the turbine housing. It is held together with a V band clamp.

The turbocharger oil feed line is bolted to the oil filter base and sealed with an O-ring.

The connection at the turbocharger is a bolted flange and is sealed with a gasket.



CAUTION:

Since the VT 365 uses a closed crankcase ventilation system, it is normal to see oil carry over into the intake air system.

Remove all three bolts to remove the line from the turbocharger.

To disconnect the crankcase ventilation tube from the engine, remove the air inlet tube from the compressor

inlet, and rotate the vent counter clockwise until it releases.

The turbocharger is located on the pedestal with two dowel pins. Remove the three turbocharger bolts. Then lift the turbo off the pedestal.

The turbocharger oil drain tube is located under the turbocharger and is sealed with O-rings.

To remove the oil drain tube, pull it forward out of the high pressure pump cover.

“The turbocharger oil drain tube is located under the turbocharger and is sealed with O-rings.”

Intake Manifold

When reinstalling the intake manifold, the locating tabs on the intake manifold gasket should face up and toward the center of the engine.

Note that the intake manifold gasket and bolts can be pre-assembled to the intake manifold to make installation easier.

“Note that the intake manifold gasket and bolts can be pre-assembled to the intake manifold to make installation easier.”

High Pressure Pump Cover Removal

Remove the IPR Valve from the pump before attempting to remove the high pressure pump cover.

After removing the bolts that hold the high pressure pump cover to the crankcase, pull the cover straight up to disengage it from the pump body.

Replace the pump cover push-in-place gasket and the pump-to-cover seal ring whenever the pump cover is removed. Lubricate the pump-to-cover seal before pushing the cover into place over the pump body.

Front Cover Removal



CAUTION:

If the dowels are missing or damaged, the front cover could be misaligned, and damage to the cover or oil pump could result.

The front cover gasket is sealed with a dab of RTV sealant at the point where the two halves of the crankcase meet. This sealant must be cut before removing the front cover.

The front cover is aligned to the crankcase with dowels.

Alignment pins should be used to aid in installation.

The lube oil pump is positioned on the front cover with dowels and sealed with a push-in-place gasket.

When installing the front cover, a dab of RTV sealer must be applied to the joint between the upper crankcase and the lower crankcase.

Be aware that if too much sealant is applied, it could get into the lube oil system.

“The lube oil pump is positioned on the front cover with dowels and sealed with a push-in-place gasket.”

Conclusion

This concludes the introduction to 2004 VT 365 unique repairs and Program One of this VT 365 engine training series.

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