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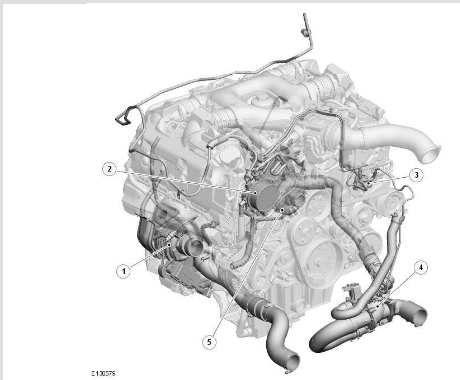
2011.0 RANGE ROVER (LM), 303-04B

FUEL CHARGING AND CONTROLS - TURBOCHARGER - TDV8 4.4L DIESEL

TURBOCHARGER (G1341916)

COMPONENT LOCATION



ITEM	DESCRIPTION
1	Primary variable vane turbocharger
2	Vacuum pump
3	Vacuum solenoid valve
4	Charge air inlet valve
5	Secondary fixed vane turbocharger

OVERVIEW

Air charging of the 4.4 liter V8 diesel engine is provided by one electronically actuated Variable Geometry Turbocharger (VGT) and one fixed vane turbocharger.

By turbocharging the engine, the density of the air entering the cylinders is increased, and therefore so is the amount of oxygen. This enables a greater quantity of fuel to be injected, thus increasing the engine's power output and improving specific fuel consumption.

Each turbocharger consists of 2 turbo elements, a turbine wheel and compressor wheel. These elements are enclosed separately in cast housings and mounted on a common shaft, which rotates in 2 semi-floating bearings.

With variable vane turbochargers, the inlet geometry (inlet area and flow angle) can be optimized over a wider range of engine operating conditions and also minimizes turbo lag (turbo lag is a term used to describe the response time from the time the accelerator is pressed to the time when the turbocharger begins to affect performance). This leads to a more rapid response and higher boost pressures at low engine speeds without sacrificing performance at higher engine speeds. The variable vane angle determines both the inlet area as well as the flow angle.

The variable vane turbocharger provides the following benefits:

- Improved engine power and torque
- Reduced fuel consumption
- Reduced emissions
- Quicker turbocharger response

The 4.4L V8 diesel engine uses two turbochargers; a fixed vane type (secondary) and a variable vane (primary) type. The fixed vane turbocharger is fitted to the left-hand (LH) cylinder bank and the variable vane turbocharger is fitted to the right-hand (RH) cylinder bank.

Both turbochargers are used in a parallel sequential turbocharging system which enables the engine to achieve quick throttle response at low engine speeds and efficient use of exhaust gas energy at high engine speeds.

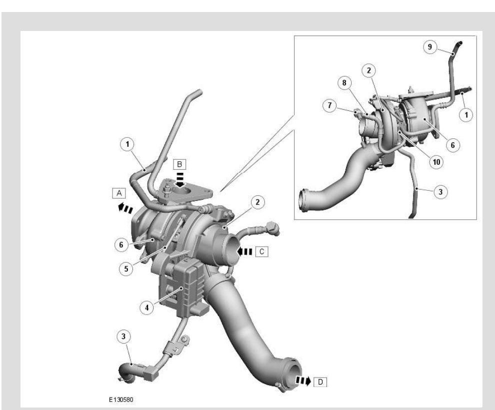
The variable vane turbocharger has an engine control module (ECM) controlled electronic rotary actuator. The rotary actuator adjusts the turbine vanes to optimize the exhaust gas flow and velocity onto the turbine wheel to maintain the required boost pressure. A feed back sensor in the rotary actuator continuously informs the ECM as to the position of the vanes during the turbochargers operation. If the vanes fail to reach the requested position an error code is generated known as a diagnostic trouble code (DTC).

The parallel sequential turbocharging system comprises the two turbochargers and the ECM. The primary variable nozzle turbine operates through the entire engine speed range but is at its most efficient at engine speeds of up to 2400 rpm. At engine speeds above 2400 rpm under load, the fixed vane secondary turbine comes into operation, with both of the turbochargers now running in a parallel bi-turbo mode.

The maximum position of the turbocharger vanes (fully open) is also an emergency default position in the event of an electrical fault. This lowers the chance of engine damage due to excessive boost.

SYSTEM OPERATION

PRIMARY TURBOCHARGER



ITEM	DESCRIPTION
A	Exhaust outlet
B	Exhaust inlet
C	Cool atmospheric air
D	Hot compressed air
1	Oil feed connection
2	Compressor housing
3	Oil return connection
4	Rotary actuator motor
5	Actuator lever
6	Turbine housing
7	Banjo bolt
8	Engine coolant feed pipe
9	Engine coolant return pipe
10	Coolant pipe connection flange

The turbine wheel of the turbocharger uses the engine's exhaust gasses to drive the compressor wheel. The compressor wheel draws in fresh air which is supplied to the engine cylinders in a compressed form.

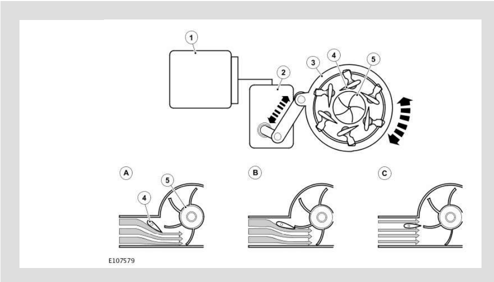
The primary variable vane turbocharger allows the optimum inlet geometry (inlet area and flow angle) to be used over a wide range of engine operating conditions. This allows a rapid speed of response and higher boost pressures at low engine speeds. The variable vane angle determines both the inlet area as well as the flow angle, as controlled by the ECM. The variable vanes allow efficient use of the exhaust gas energy which in turn improves turbocharger and engine efficiency. At low engine speeds this greatly assists the increase in turbocharger boost pressure.

In response to signals from various sensors the ECM, via an electronic rotary actuator and lever, controls the rotation of the turbocharger’s adjustment ring, which in turn rotates the vanes. The rotary output shaft has a high-accuracy contact-less position sensor, which can supply the ECM with its actual position.

The electronic actuator provides the following advantages:

- Quicker response
- Fewer parts

The variable vanes are attached to a rotating adjustment ring, located at the inlet of the turbine housing. The adjustment ring, operated by the electronic actuator, rotates to alter the angle of the vanes. The vanes in turn vary the flow of the exhaust gases directed onto the turbine wheel, which enables the shaft to spin faster or slower. This varies compressor speed and boost pressure.



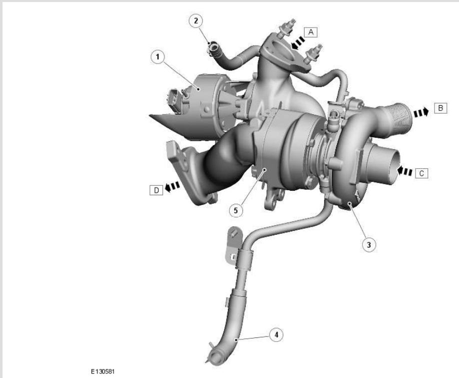
ITEM	DESCRIPTION
A	**Low Engine Speed**. At low engine speeds the volume of exhaust gas is low so the vanes are moved towards the closed position to reduce the turbine inlet area. This reduction causes an increase in the gas velocity into the turbine wheel thereby increasing wheel speed and boost.
B	**Moderate Engine Speed** As the engine speed increases and the volume of exhaust gas increases the vanes are moved towards the open position to increase the turbine inlet area and maintain the gas velocity.
C	**Maximum Engine Speed** At maximum engine speed the vanes are almost fully open maintaining the gas velocity into the turbine wheel
1	ECM
2	Actuator motor
3	Adjusting ring
4	Vanes
5	Turbine

The variable vanes in the primary turbocharger improve the exhaust gas power transfer to the turbine wheel which in turn drives the compressor wheel. At low engine speeds this greatly assists the increase in turbocharger boost pressure.

At high engine speed and exhaust gas flow, the ECM increases the vane opening to avoid overspeed of the turbines and provide a smooth high speed operation. At this point the dual mode boosting system comes into affect by utilizing the secondary (fixed vane) turbocharger.

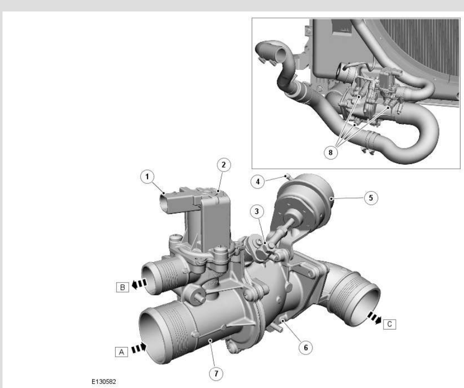
The primary turbocharger receives water and oil cooling to allow it to maintain the optimum operating temperature. Engine coolant from the cylinder block is directed through the body of the turbocharger bearing housing and is returned into the cooling circuit via a hose connection with the heater return pipe. Engine oil from the engine oil cooler is also directed into the bearing housing and serves to lubricate and cool the bearings. The oil is returned to the system via a pipe connection to the sumo.

SECONDARY TURBOCHARGER



ITEM	DESCRIPTION
A	Exhaust inlet
B	Hot compressed air
C	Cool atmospheric air
D	Exhaust outlet
1	Turbine shut-off valve
2	Oil feed connection
3	Compressor housing
4	Oil return connection
5	Turbine housing

CHARGE AIR INLET VALVE



ITEM	DESCRIPTION
A	Charge air inlet from secondary turbocharger

ITEM	DESCRIPTION
B	Air by-pass valve outlet to clean air duct
C	By-pass valve outlet to charge air cooler
1	Electrical connector
2	Recirculation valve
3	Shut-off valve mechanism
4	Vacuum pipe connection
5	Shut-off valve vacuum actuator
6	Shut-off valve body
7	Recirculation valve body
8	Bolt (3 off)
9	Fan cowl

The charge air inlet valve is located at the bottom LH corner of the engine cooling fan cowl, behind the engine cooling radiator. Three moulded bosses on the fan cowl provide the attachment for the valve which is secured with 3 bolts.

The charge air inlet valve is controlled by the ECM for the recirculation valve and the shut-off valve vacuum operation. The inlet valve is used to control the operation of the secondary turbocharger.

The shut-off valve vacuum is controlled by the ECM which controls a vacuum control solenoid. The control solenoid is attached to a bracket which located on the front of the LH cylinder head.

The vacuum is produced by the vacuum pump which is driven off the RH cylinder bank inlet camshaft gear. The vacuum pump is connected to the vacuum control solenoid via a series of pipes. The ECM controls the vacuum control solenoid to supply vacuum to the shut-off valve vacuum actuator which opens when the vacuum is present. A position sensor on the shut-off valve informs the ECM that the valve has opened or closed.

If vacuum is lost to the shut-off valve actuator, the actuator defaults to the closed position. The ECM detects this condition and will operate the turbochargers in mono-turbo mode, with restricted performance. A DTC will also be recorded in the ECM.

If the recirculation valve develops a fault it will default to the closed position. In this position an overspeed of the primary turbocharger will occur. This overspeed is sensed by the manifold absolute pressure (MAP) sensor which detects the increase in pressure. The ECM registers the signals from the MAP sensor and operates the turbochargers in mono-turbo mode with restricted engine torque and DTC's recorded.

NOTE:

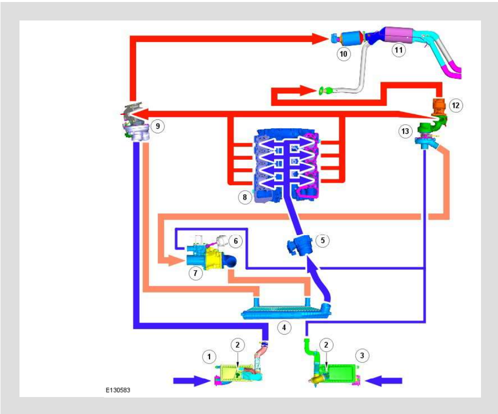
Any fault in the vacuum system will cause the engine to default to restricted engine torque. Always check the vacuum system for trapped, split, leaking or disconnected pipework.

DUAL MODE BOOSTING

The dual mode boosting system comprises two turbochargers and software within the ECM. The two turbochargers can operate in two modes; mono turbocharger operation or bi-turbocharger operation.

Mono Turbocharger Operation

Mono Turbocharger Schematic Diagram



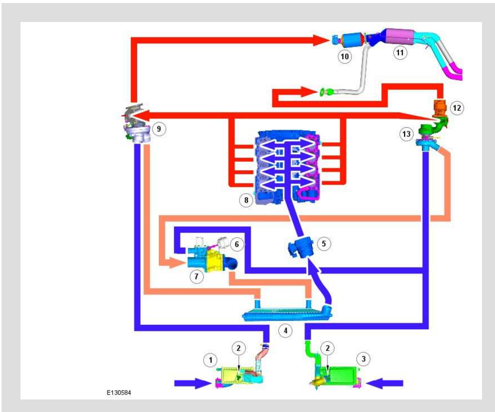
ITEM	DESCRIPTION
1	Air filter RH
2	Manifold Absolute Pressure and Temperature (MAPT) sensor (2 off)
3	Air filter LH
4	Charge air cooler
5	Throttle
6	Compressor shut-off valve
7	Recirculation valve
8	Engine
9	Variable vane turbocharger
10	Catalytic Converter
11	Diesel Particulate Filter (DPF)
12	Turbine shut-off valve
13	Fixed vane turbine

Fresh air is drawn through the air filter and the mass air flow (MAF) meter to the primary turbocharger compressor. The compressed air is then passed through the charge air cooler and into the engine.

The turbine shut-off valve on the secondary turbocharger is closed and therefore exhaust gasses are unable to operate the secondary turbocharger turbine. In this condition all turbo charging boost pressure is produced by the primary turbocharger using exhaust gasses from all 8 cylinders, giving exceptional response.

Bi-Turbocharger Switching Operation

Bi-Turbocharger Switching Schematic Diagram

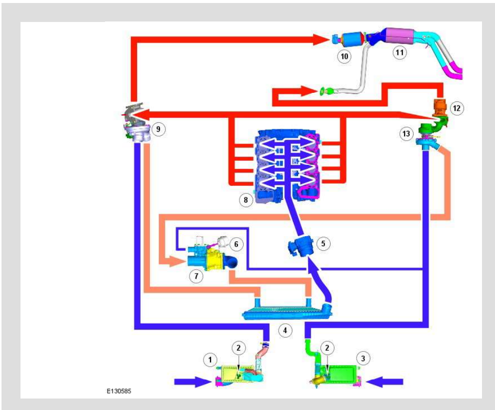


ITEM	DESCRIPTION
1	Air filter RH
2	Manifold Absolute Pressure and Temperature (MAPT) sensor (2 off)
3	Air filter LH
4	Charge air cooler
5	Throttle
6	Compressor shut-off valve
7	Recirculation valve
8	Engine
9	Variable vane turbocharger
10	Catalytic Converter
11	Diesel Particulate Filter (DPF)
12	Turbine shut-off valve
13	Fixed vane turbine

When the engine operating parameters approach the limits (approximately 2400 rpm under load) of the primary turbocharger, dual mode boosting control software within the ECM begins the switch to parallel bi-turbocharger operation. The secondary turbocharger is brought into operation by the opening of the turbine shut-off valve which allows exhaust gasses to flow through the turbine.

Initially, the secondary turbocharger does not produce a boost pressure to equal that of the primary turbocharger. Therefore, the initial boost pressure from the secondary turbocharger is fed via the recirculation valve into the clean air inlet for the secondary turbocharger. As the secondary turbocharger boost pressure output increases, the recirculation valve is then closed and the compressor shut-off valve opened to increase the boost pressure from the secondary turbocharger which is directed into the charge air cooler.

Bi-Turbocharger Dual Mode Schematic Diagram



ITEM	DESCRIPTION
1	Air filter RH
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5	Throttle
6	Compressor shut-off valve
7	Recirculation valve
8	Engine
9	Variable vane turbocharger
10	Catalytic Converter
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12	Turbine shut-off valve
13	Fixed vane turbine

The secondary turbocharger output is monitored by a secondary compressor outlet pressure sensor, which monitors the pressure increase in the secondary turbocharger and transmits the information to the ECM. The ECM monitors the pressure information and completes the transition to bi-turbocharger operation when the operating parameters are correct. The whole process from mono to bi-turbocharger operation takes 180 milliseconds.

The ECM will maintain the engine operating in bi-turbocharger operation with both primary and secondary turbochargers contributing to the air charge induction. When the dual mode boosting software determines that the engine operating parameters no longer require the use of dual mode boosting, the system switches back to mono turbocharger operation.

If the engine idles for more than 3 minutes, the secondary turbocharger is actuated to ensure correct lubrication. An air feed pipe, from the charge air pipe into the throttle assembly, supplies compressed air between the seals of the secondary turbocharger compressor stage to prevent oil leaking into the compressor housing when the turbocharger is not running. After 3 minutes of idling the ECM initiates bi-turbocharger mode to keep the secondary turbocharger shaft rotating to prevent oil from leaking into the secondary turbine housing.

CAUTION:

Ensure both ends of the pipe are securely connected to the secondary turbo and the air intake system to prevent damage to the turbo components.

BAROMETRIC PRESSURE SENSOR

When the vehicle is driven at high altitudes the ambient pressure reduces causing the compressor wheel to rotate faster to achieve the same boost pressure. To prevent the turbine wheel from over-speeding under these conditions a barometric pressure sensor, located in the ECM, protects the turbocharger by opening the vanes further to reduce the turbine wheel speed. This is known as the altitude margin of the turbocharger which, on the 4.4L TDV8 engine is above 2000 meters. Below 2000 meters engine deration is not necessary.

TURBOCHARGER LUBRICATION

The rapid acceleration and deceleration response demands of the turbocharger rely greatly on a steady flow of clean oil. The oil supplied from the engine's lubrication system provides lubrication to the turbocharger's spindle and bearings, while also acting as a coolant for the turbocharger centre housing.

To maintain the life expectancy of the turbocharger, it is essential that the oil has a free-flow through the turbocharger and unrestricted return to the engines sump. It is therefore imperative that the engine oil is replenished at regular service intervals with the recommended quality and quantity of oil.

TURBOCHARGER COOLING

As described above, both turbochargers receive an oil supply for lubrication and cooling purposes.

In addition to the cooling provided by the engine lubrication system, the primary turbocharger also requires a supply from the engine coolant system to assist with the cooling due to the high loads on the turbocharger.

A pipe connection from the cylinder block routes engine coolant through the body of the turbocharger bearing housing. Once the coolant has passed through the bearing housing it is returned to the cooling system via a connection with the heater return hose.

CHARGE AIR COOLER

The charge air cooler is used to increase the density of air as it flows from the turbochargers compressor to the intake manifold.

Compression of the charge air by the turbochargers raises the temperature of the air. This generation of heat expands the air density and consequently less oxygen is able to enter the cylinders, reducing the engines power. To overcome this, the air is routed through the charge air cooler before it enters the engine; the temperature is reduced by transferring the heat to atmosphere.

Cooling of the intake air also helps to reduce engine emissions by limiting nitrogen oxides (NOx) production.