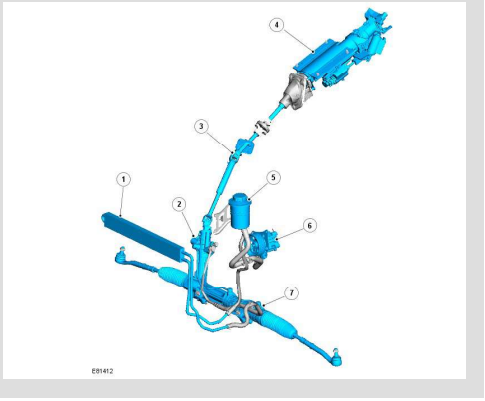
PUBLISHED: 11-MAY-2011
2011.0 RANGE ROVER (LM), 211-02

POWER STEERING (G1311588)

POWER STEERING COMPONENT LOCATION

NOTE:

Generic overview shown; components may differ on some models.



ITEM	DESCRIPTION
1	Fluid cooler (if fitted)
2	Servotronic valve
3	Lower column
4	Upper column
5	Power steering fluid reservoir
6	Power steering pump
7	Steering gear

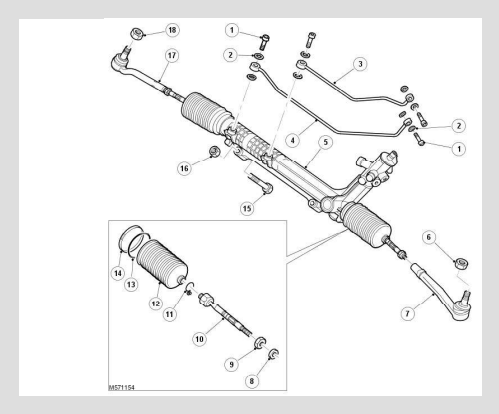
INTRODUCTION

A ZF power steering gear is fitted on the front subframe. The unit is a conventional-end take-off rack and pinion power assisted unit with the addition of ZF Servotronic assistance.

Servotronic adds electronic control and speed sensitive steering to the steering gear. The Servotronic feature provides easy and comfortable steering operation when parking, improved 'road feel' at increased road speeds and adds an integrated, positive centre feel feature which optimizes steering wheel torque during high speed driving.

The Servotronic system is controlled by software which is incorporated into the central junction box (CJB). The software responds to road speed signals and modifies the assistance via a transducer valve located on the steering gear valve.

STEERING GEAR



ITEM	DESCRIPTION
1	Banjo bolt (4 off)
2	Seal (8 off)
3	Pipe
4	Pipe
5	Steering gear
6	Nut M14
7	left-hand (LH) tie rod
8	Spacer
9	Locknut M16
10	Inner tie rod joint
11	Clamp (2 off)
12	Gaiter (2 off)
13	Seal (2 off)
14	Clamp (2 off)
15	Torx bolt M12 (2 off) - rack to subframe mounting
16	Nut M12 (2 off) - rack to subframe mounting
17	right-hand (RH) tie rod

ITEM	DESCRIPTION
18	Nut M14

The steering system comprises the mechanical steering gear, the valve and an integrated hydraulic power cylinder.

The steering gear uses a rack with an integrated piston which is guided on plain bearings within the gear housing. The pinion, which is attached to the valve runs in bearings and meshes with the rack teeth. The rack is pressed against the pinion by a spring loaded yoke which ensures that the teeth mesh without any play. The pinion is connected to the valve rotor via a torsion bar.

The rotary motion of the steering wheel is converted into axial movement of the rack by the pinion and is initiated by the valve. This motion is transferred into movement of the wheels by adjustable tie rod arms.

The rotary valve is used to control the pressurized fluid required for power assistance. The valve comprises a valve body, a control bush and a torsion bar. The valve body has eight control grooves in its bore. The control bush also has eight radial grooves which are matched to the valve. The control bush is positively attached to the pinion. The torsion bar is the connecting element between the valve body, the pinion and the control bush.

Torque input from the steering wheel is passed to the valve body and causes a rotary motion of the torsion bar. The valve body changes its relative position to the control bush and subsequently the relative positions of the control grooves is also changed. This allows pressurized fluid to pass via the mismatched grooves to the rack piston and provide the required assistance in the selected direction.

The piston is located at one end of the rack housing. Each side of the piston is connected to fluid pressure or fluid return via a metal external pipe which is connected to the valve housing.

Each end of the rack has a threaded hole which provides for the fitment of an inner tie rod joint. The external ends of the rack are sealed with gaiters which prevent the ingress of dirt and moisture. The inner tie rod joints have a long outer threaded shank which screws into the outer tie rod. The steering toe can be adjusted using the threaded end of the inner tie rod. When the correct toe is achieved, a locknut on the inner tie rod is tightened to prevent further inadvertent movement.

SERVOTRONIC TRANSDUCER VALVE

The Servotronic transducer valve is located in a port on the side of the steering gear valve housing. The valve is sealed in the housing with an O-ring seal and is secured with two long screws into threaded holes in the housing.

The Servotronic valve is a transducer controlled valve which responds to control signals supplied from the CJB. The CJB contains a microprocessor which receives road speed signals from the anti-lock brake system (ABS) module and calculates the correct controlling signal for the Servotronic valve. The Servotronic software within the CJB has a diagnostic capability which allows an approved Land Rover diagnostic system to check the tune of the steering.

The Servotronic valve determines the hydraulic reaction at the steering rack rotary valve and modifies the input torque required to turn the steering wheel. The Servotronic system allows the steering to be turned with minimum effort when

the vehicle is stationary or manoeuvred at slow speed. The hydraulic reaction changes proportional to the vehicle speed, with the required steering effort increasing as the vehicle moves faster. At high speeds, the Servotronic system provides the driver with a good feedback through the steering providing precise steering and improved stability.

A major advantage of the Servotronic system is that fluid pressure and flow through the rotary valve remains constant and allows full steering pressure to be available in an emergency where a sudden and unexpected steering correction may be required.

POWER STEERING PUMP

POWER STEERING PUMP – V8 GASOLINE VEHICLES

The pump is a positive displacement, vane type pump which supplies hydraulic pressure to the steering gear valve unit. The pump is driven by a Poly Vee belt from the crankshaft pulley and output from the pump increases proportionally with engine speed. A self-adjusting tensioner is fitted to maintain the correct tension on the belt.

The pump has an internal pressure relief valve which also incorporates a flow control valve. The pressure relief valve limits the maximum pressure supplied to the steering gear to 127 +/- 5 bar.

The flow control valve controls the flow to 10.0 liters/min regardless of engine speed.

The pump has a displacement of 14cc/rev.

For additional information, refer to: Specifications (211-02 Power Steering, Specifications).

A shaft runs longitudinally through the pump. One end of the shaft is fitted with a pressed-on drive pulley, the opposite end of the shaft is closed by a cover. The shaft runs in bearings located in the body and oil seals at each end of the shaft prevent leakage of hydraulic fluid.

The pump contains ten vanes which rotate within a cam ring and are driven by the shaft. As the vanes rotate, the cam ring causes the space between the vanes to increase. This causes a depression between the vanes and fluid is drawn from the reservoir via the suction hose into the space between the vanes.

As the shaft rotates, the inlet port is closed to the vanes which have drawn in fluid, trapping the fluid between the vanes. The cam ring causes the space between the vanes to reduce and consequentially compresses and pressurizes the hydraulic fluid trapped between them.

Further rotation of the shaft moves the vanes to the outlet port. As the vanes pass the port plate the pressurized fluid passes from the pump outlet port into the pressure hose to the steering gear.

The pressurized fluid is subject to control by the flow control and pressure relief valve. The flow control valve maintains a constant flow of fluid supplied to the steering gear irrespective of engine speed variations. The pressure relief valve modifies the pressure on the output side of the pump. A metering orifice is included in the discharge port of the pump. If the pressure in the orifice reaches a predetermined level, a spring loaded ball in the center of the flow control valve is lifted from its seat and allows pressurized fluid to recirculate within the pump.

The pressure relief valve will operate if the discharge from the pump is restricted; for example, steering held on full lock. If the output from the pump is blocked, all output is recirculated through the pump. In this condition, as no fresh fluid is drawn into the pump from the reservoir, the fluid temperature inside the pump will increase rapidly. Consequentially, periods of operation of the steering gear on full lock should be kept to a minimum to prevent overheating of the pump and the fluid within it.

POWER STEERING PUMP – V8 DIESEL VEHICLES

The pump is a variable displacement, vane type pump which supplies the required hydraulic pressure to the steering gear valve unit. The pump is located at the front of the engine and is driven by a Poly Vee belt which is directly driven from the crankshaft. A self-adjusting tensioner is fitted to maintain the correct tension on the belt.

The pump has an internal pressure relief valve which also incorporates a flow control valve. The pressure relief valve limits the maximum pressure supplied to the steering gear to: 122 +/- 4 bar.

The flow control valve controls the flow to 10.0 liters/min regardless of engine speed.

The pump has a displacement of 9.6cc/rev.

For additional information, refer to: Specifications (211-02 Power Steering, Specifications).

The output from the pump increases proportionally with the load applied to the steering valve unit. Inside the pump, a cartridge set consisting of 11 vanes and a rotor is mounted on the input shaft and is surrounded by the variable displacement cam.

The variable displacement pump maintains a constant fluid output by varying the internal displacement of the pump, unlike a conventional fixed displacement pump which has to use a flow control valve to recirculate the excess flow within the pump. At low engine speeds, the internal displacement of the variable displacement pump is at its maximum to generate the controlled fluid output.

As the pump speed increases with engine speed, the increased flow inside the pump generates a back pressure within the pump. This back pressure causes the cam ring to move and reduce the internal displacement of the pump to maintain the constant fluid flow from the pump. As the internal displacement of the pump decreases, the power and torque required to drive the pump reduces, which leads to improved fuel economy.

FLUID RESERVOIR

The fluid reservoir comprises a body, cap and filter. The purpose of the reservoir is to contain a surplus of the hydraulic fluid in the system to allow for expansion and contraction of the fluid due to temperature variations. The fluid level ensures that the supply connection on the bottom of the reservoir is covered with fluid at all operating vehicle attitudes. Any air which is present in the system is exhausted from the system in the reservoir.

The body is a plastic moulding with two ports at the bottom which provide for the connection of the suction supply and return hoses. Moulded markings on the side of the reservoir denote the upper and lower fluid levels. A non-serviceable, 100 micron nylon mesh filter is fitted in the body. The filter removes particulate matter from the fluid before it is drawn into the pump supply connection.

The cap is rotated counterclockwise for one quarter turn to release from the body. The cap is fitted with an O-ring to prevent fluid leakage. The cap incorporates a breather hole to allow for changes in fluid level during operation and prevent vacuum or pressurization of the reservoir.

FLUID COOLER

The fluid cooler is located in the return line from the steering gear to the reservoir. The cooler comprises a flexible hose and a solid pipe which connect between the reservoir and the return pipe from the steering gear.

The cooler is a fabricated aluminium tube, through which the power steering fluid passes. The outer diameter of the cooler tube has aluminium loops attached to it which dissipate heat. Cool air entering the front of the vehicle passes over the cooler and flows through the loops. The loops act as heat exchangers, conducting heat from the fluid as it passes through the tube.

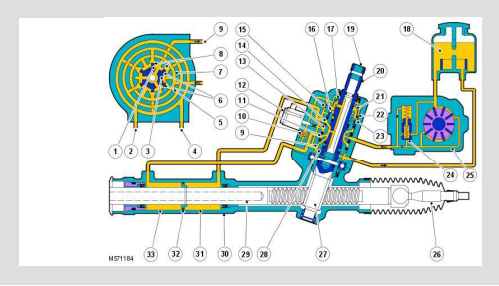
HIGH PRESSURE HOSE

The high pressure hose connecting the pump to the steering gear valve unit contains two attenuators. Each attenuator comprises a bullet shaped restrictor which is secured inside the hose. The restrictors damp pressure pulses from the pump, consequently reducing noise and strain on downstream components. The attenuators are an integral part of the hose and cannot be serviced separately.

HYDRAULIC CIRCUIT OPERATION

The following hydraulic circuits show power steering operation and fluid flow for the steering in a straight ahead, neutral position and when turning right. The circuit diagram for turning left is similar to that shown for turning right.

STEERING IN NEUTRAL POSITION



ITEM	DESCRIPTION
1	Return fluid control groove
2	Radial groove
3	Feed fluid control groove
4	Radial groove
5	Axial groove

ITEM	DESCRIPTION
6	Feed fluid control edge
7	Feed fluid radial groove
8	Return fluid control edge
9	Return fluid chamber
10	Cut-off valve
11	Radial groove
12	Servotronic transducer
13	Feed fluid radial groove
14	Radial groove
15	Orifice
16	Balls
17	Compression spring
18	PAS fluid reservoir
19	Torsion bar
20	Valve rotor
21	Reaction piston
22	Reaction chamber
23	Centering piece
24	Pressure relief/flow limiting valve
25	Power steering pump
26	Inner tie rod
27	Pinion
28	Valve sleeve
29	Steering gear
30	Gear housing
31	Power assist cylinder - right
32	Piston
33	Power assist cylinder - left

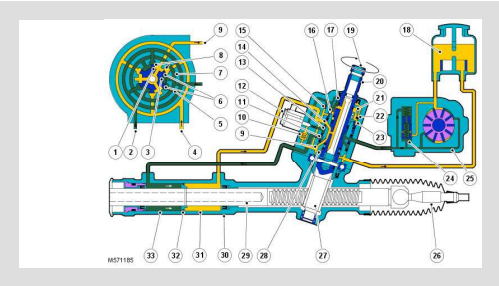
When the engine is started, the power steering pump draws fluid from the reservoir down the low pressure suction line. The fluid passes through the pump and is delivered, via a hose, to the steering rack valve unit.

The pressurized fluid flows through a connecting bore in the valve and, via the feed fluid radial groove and the transverse bores in the valve sleeve, passes to the feed fluid control groove of the valve rotor.

In the neutral (straight ahead) position, the fluid passes over the open feed fluid control edges to all valve sleeve axial grooves. The fluid then passes through the open return fluid control edges and the return fluid control grooves of the valve rotor. The fluid then passes via connecting bores to the return fluid chamber and to the reservoir via an external hose.

Simultaneously, the radial grooves of the valve body and their associated pipes provide a connection between the left and right power assist cylinders.

STEERING IN RIGHT TURN POSITION



ITEM	DESCRIPTION
1	Return fluid control groove
2	Radial groove
3	Feed fluid control groove
4	Radial groove
5	Axial groove
6	Feed fluid control edge
7	Feed fluid radial groove
8	Return fluid control edge
9	Return fluid chamber
10	Cut-off valve
11	Radial groove
12	Servotronic transducer
13	Feed fluid radial groove
14	Radial groove
15	Orifice

ITEM	DESCRIPTION
16	Balls
17	Compression spring
18	Power steering fluid reservoir
19	Torsion bar
20	Valve rotor
21	Reaction piston
22	Reaction chamber
23	Centering piece
24	Pressure relief/flow limiting valve
25	Power steering pump
26	Inner tie rod
27	Pinion
28	Valve sleeve
29	Steering gear
30	Gear housing
31	Power assist cylinder - right
32	Piston
33	Power assist cylinder - left

When the steering wheel is turned to the right, the steering rack and piston moves to the left in the piston bore. The valve rotor is rotated to the right (clockwise) and pressurized fluid is directed over the further opened feed fluid control edges and to the associated axial grooves, the radial groove and via an external pipe to the left power assist cylinder chamber. The pressure applied to the piston from the left power assist cylinder chamber provides the hydraulic assistance.

An adaptable pressure build-up is achieved by the partially or fully closed feed fluid control edges restricting or preventing a connection between the fluid pressure inlet and the other axial grooves connected to the radial groove.

Simultaneously, the fluid pressure outlet to the pressurized axial grooves are restricted or partially restricted by the closing return fluid control edges. The fluid displaced by the piston from the right power assist cylinder chamber, flows through an external pipe to the radial grooves. From there the fluid passes to the associated axial grooves and on to the return fluid control grooves, via the further opened return fluid control edges. The return flow of fluid to the reservoir passes via interconnecting bores which lead to the return fluid chamber.

When the steering wheel is turned to the left the operating sequence is as above but the pressure is applied to the opposite side of the piston.

SERVOTRONIC OPERATION

When the vehicle is manoeuvred into and out of a parking space (or other similar manoeuvre), the Servotronic function of the CJB uses road speed data from the ABS module to determine the vehicle speed, which in this case will be slow or stationary. The CJB microprocessor analyses the signals and outputs an appropriate control current to the Servotronic transducer valve. The Servotronic valve closes and prevents fluid flowing from the feed fluid radial groove to the reaction chamber. An orifice also ensures that there is return pressure in the reaction chamber. This condition eliminates any 'reaction' ensuring that the steering is very light to operate, reducing the effort required to turn the steering wheel.

As the vehicle is driven and the road speed increases, the CJB microprocessor analyses the road speed signals from the ABS module and reduces the amount of control current supplied to the Servotronic valve. The Servotronic valve reacts to the control current and opens the valve by an amount appropriate to the road speed. This allows a controlled fluid supply from the feed fluid radial groove to the reaction chamber. The orifice prevents the loss of large amounts of fluid to the return fluid chamber. The higher fluid pressure acting on the reaction piston causes compression of the balls which are located between the reaction piston and the centering piece which in turn is securely connected to the valve sleeve. When driving in a straight line, this has a positive effect on the exact centralizing of the steering valve. When the steering valve is actuated, the balls, with a higher load on them, provide additional torsional resistance to rotation of the valve rotor. This mode of Servotronic assistance requires an established higher steering wheel torque until the hydraulic assistance required in the left or right power assist cylinder is determined.

At high driving speeds; for example on a highway, the Servotronic valve is fully open due to a very low or nonexistent control current supplied from the CJB. This enables maximum pressure supply from the feed fluid radial groove to the reaction piston. When the steering wheel is turned, the reaction pressure increases appropriate to the existing operating pressure and pressurizes the piston in the reaction chamber. As soon as the reaction pressure reaches its upper limit, the fluid is discharged to the return fluid chamber via the cut-off valve and prevents further increases in reaction pressure. This maintains the input torque applied through the steering wheel and provides the driver with an improved 'road feel' allowing precise steering and directional stability.