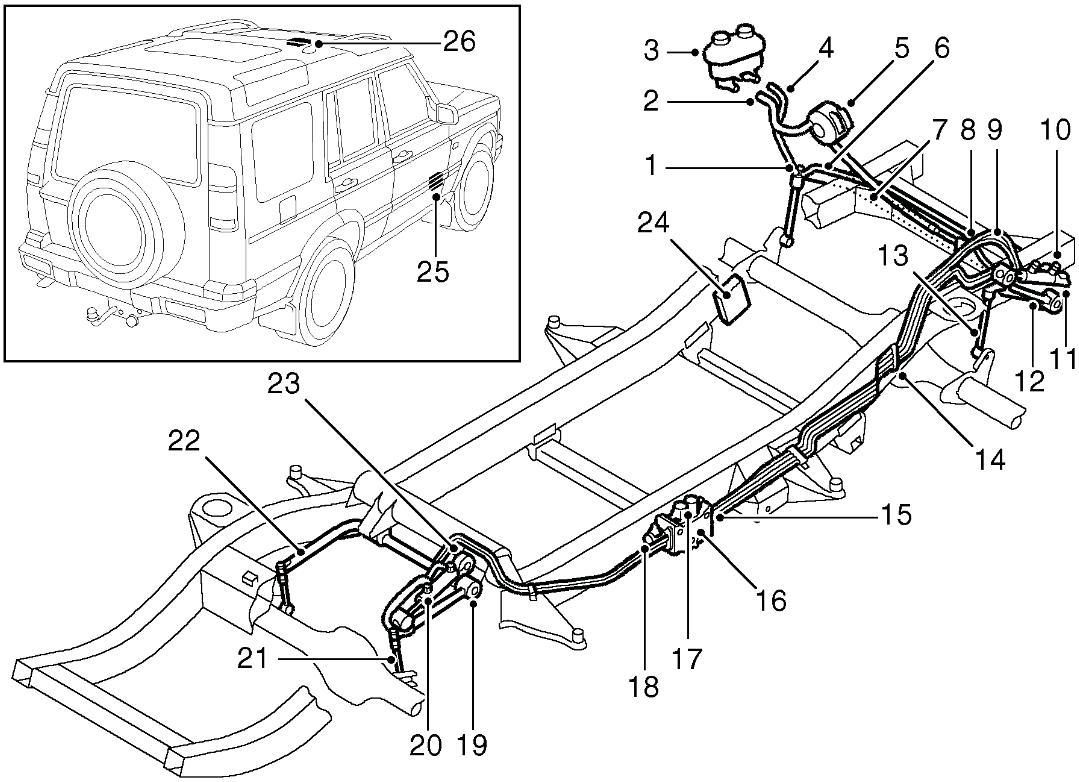
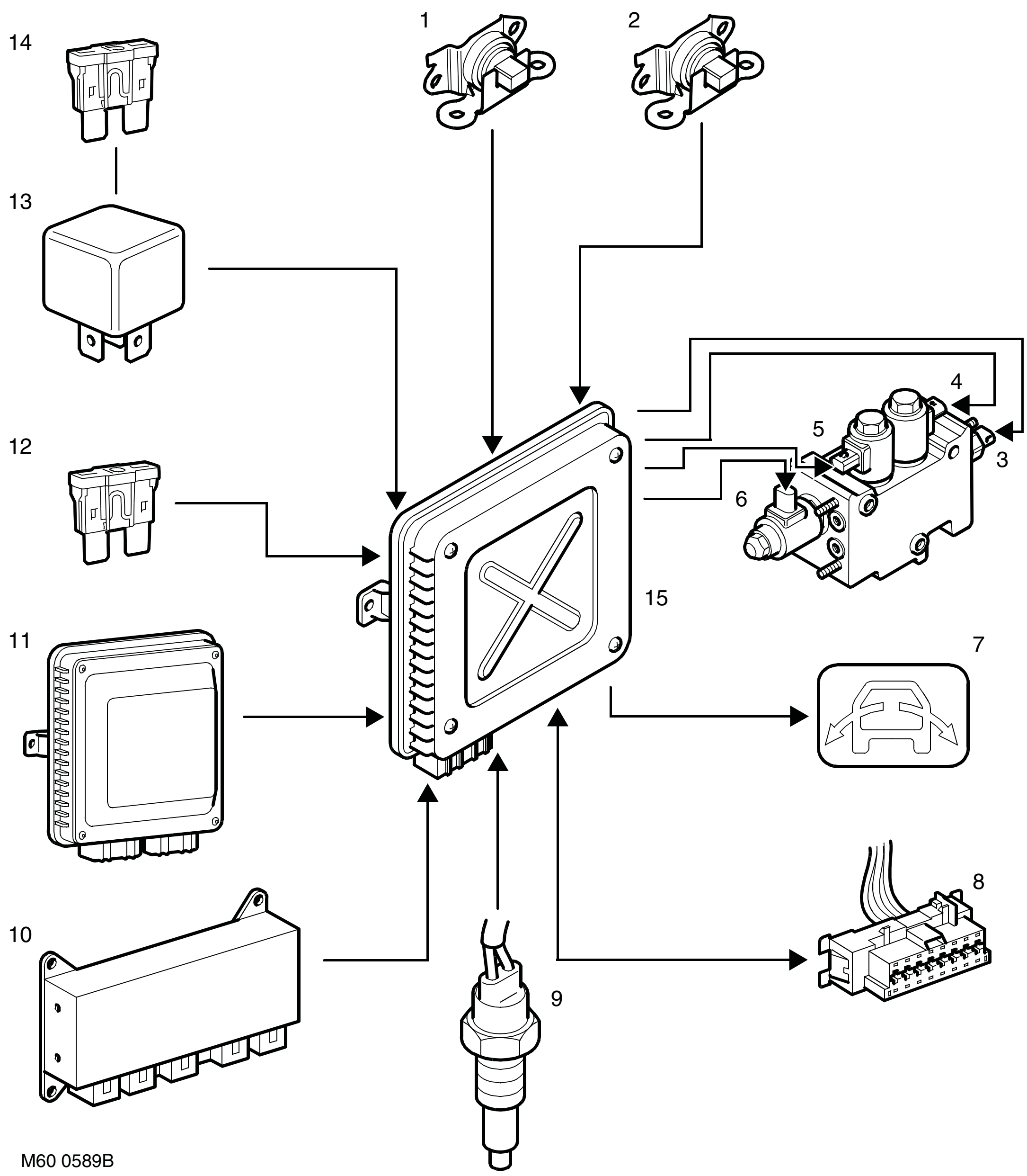
ACE system component layout



M60 0588A

1 Anti-roll bar link
2 Suction hose
3 ACE/PAS reservoir
4 Return pipe
5 ACE pump
6 Pressure pipe
7 Torsion bar - front
8 Actuator hose
9 Actuator hose
10 Actuator
11 Short arm
12 Long arm
13 Anti-roll bar link
14 Isolator and bracket (2 and 4 way) 7 off
15 Pressure transducer
16 Valve block
17 Directional control valve 2 off
18 Pressure control valve
19 Long arm
20 Actuator
21 Anti-roll bar link
22 Torsion bar - rear
23 Short arm
24 ACE ECU
25 Accelerometer - lower
26 Accelerometer - upper

ACE system control diagram



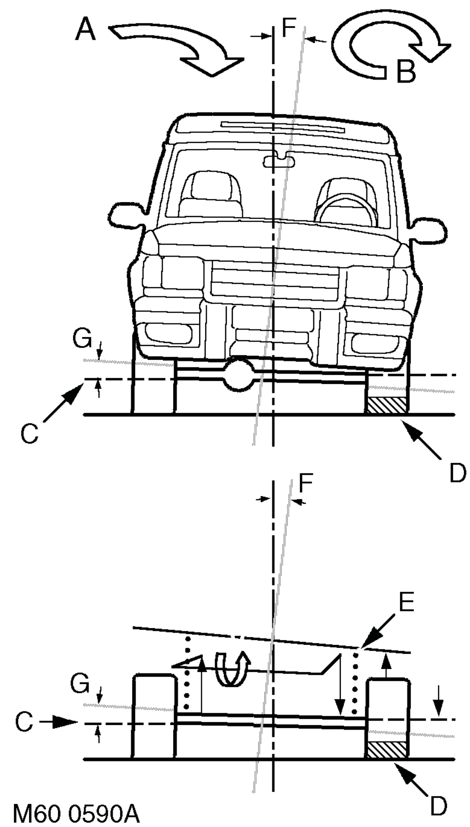
1 Upper accelerometer
2 Lower accelerometer
3 Pressure transducer
4 Directional control valve
5 Directional control valve
6 Pressure control valve
7 Instrument pack warning lamp
8 Diagnostic socket
9 Reverse lamp switch
10 SLABS ECU
11 Engine Control Module (ECM)
12 Ignition feed
13 ACE relay
14 Battery supply
15 ACE ECU

Description - ACE

General

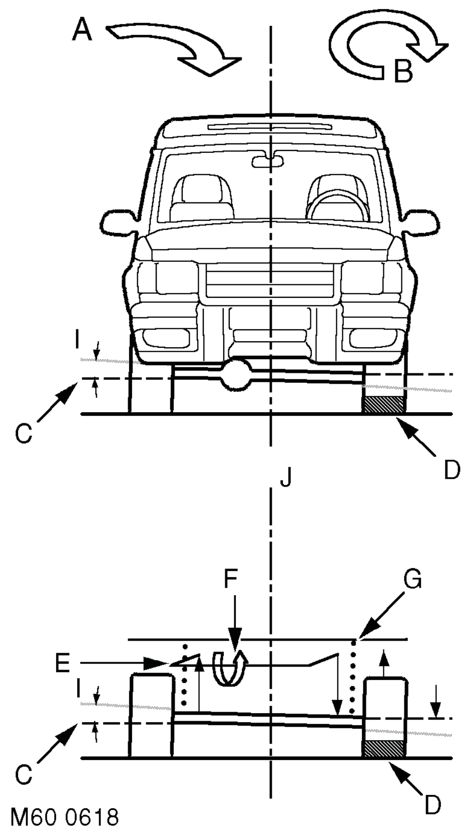
The Active Cornering Enhancement (ACE) system is used to control vehicle roll angles. The following illustrations show the difference in body roll angle between a conventional 'passive' anti-roll bar and the ACE system.

Conventional 'passive' anti-roll bar



- **a** Direction of travel - Right hand bend
- **b** Body roll
- **c** Axle roll
- **d** Tyre squash
- **e** Coil springs
- **f** Body roll angle
- **g** Axle roll angle

ACE system



- **a** Direction of travel - Right hand bend
- **b** Body roll
- **c** Axle roll
- **d** Tyre squash
- **e** Torsion/Anti-roll bar
- **f** Direction of torsion/anti-roll bar twist
- **g** Coil springs
- **h** Body roll angle
- **i** Axle roll angle
- **j** Reduced body roll angle with ACE system

The system is electrically and hydraulically operated with all operations controlled by an ACE ECU located behind the glovebox in the passenger side footwell. The ACE system comprises front and rear torsion bars and actuators, two accelerometers, ECU, hydraulic pump, valve block and a fluid reservoir.

The ACE system gives improved vehicle handling and suspension characteristics and is active for both on and off-road driving. This is achieved by hydraulic actuators applying torque to the front and rear torsion bars in response to lateral forces sensed by accelerometers. The ACE system prevents body roll with cornering forces of up to 0.4 g. From 0.4 g there is a progressive increase in body roll but significantly lower than a passive system. A passive system will have a progressive increase in roll angle as soon as cornering forces are applied and will have a higher roll angle than the ACE system for the same cornering force.

The ACE system can also detect if the vehicle is driven off-road. If off-road conditions are detected the ACE system operation will be reduced or completely disabled at a speed of 25 mph (40 km/h) or less.

Lateral acceleration of the body is sensed by two accelerometers and signals are transmitted to the ECU. The engine driven hydraulic pump supplies a constant hydraulic flow to the valve block. Two directional control valves are solenoid operated by the ECU and these supply fluid to the applicable side of each actuator to apply an equal and opposite force to the torsion bar. In operation the ACE system maintains the attitude of the vehicle body when cornering.

The ACE system uses a semi-synthetic hydraulic fluid which is the same as the fluid used for the PAS system. The total capacity of the ACE system is 1.62 litres (0.42 US Gallons).

CAUTION: The ACE hydraulic system is extremely sensitive to the ingress of dirt or debris. The smallest amount could render the system unserviceable. It is imperative that the following precautions are taken.
- **ACE components are thoroughly cleaned externally before work commences;**
- **all opened pipe and module ports are capped immediately;**
- **all fluid is stored in and administered through clean containers.**

In the event of an ECU or hydraulic failure the system will fail safe to a 'locked bars' condition. The 'locked bars' condition will allow the torsion bars to operate in a similar manner as conventional 'passive' anti-roll bars. Prolonged cornering forces will allow a progressive increase in roll angle due to hydraulic leakage through the actuators and valve block. Failures will be relayed to the driver by the illumination of the ACE warning lamp in the instrument pack. Faults are recorded by the ECU and can be retrieved using TestBook.

When the ignition switch is moved to position II, the warning lamp will illuminate for two seconds to check functionality. The warning lamp functionality can also be checked using TestBook.

TestBook must also be used to perform a bleeding procedure after maintenance operations have been performed to ensure that complete system bleeding is performed. Trapped air in the system can seriously reduce the system performance.

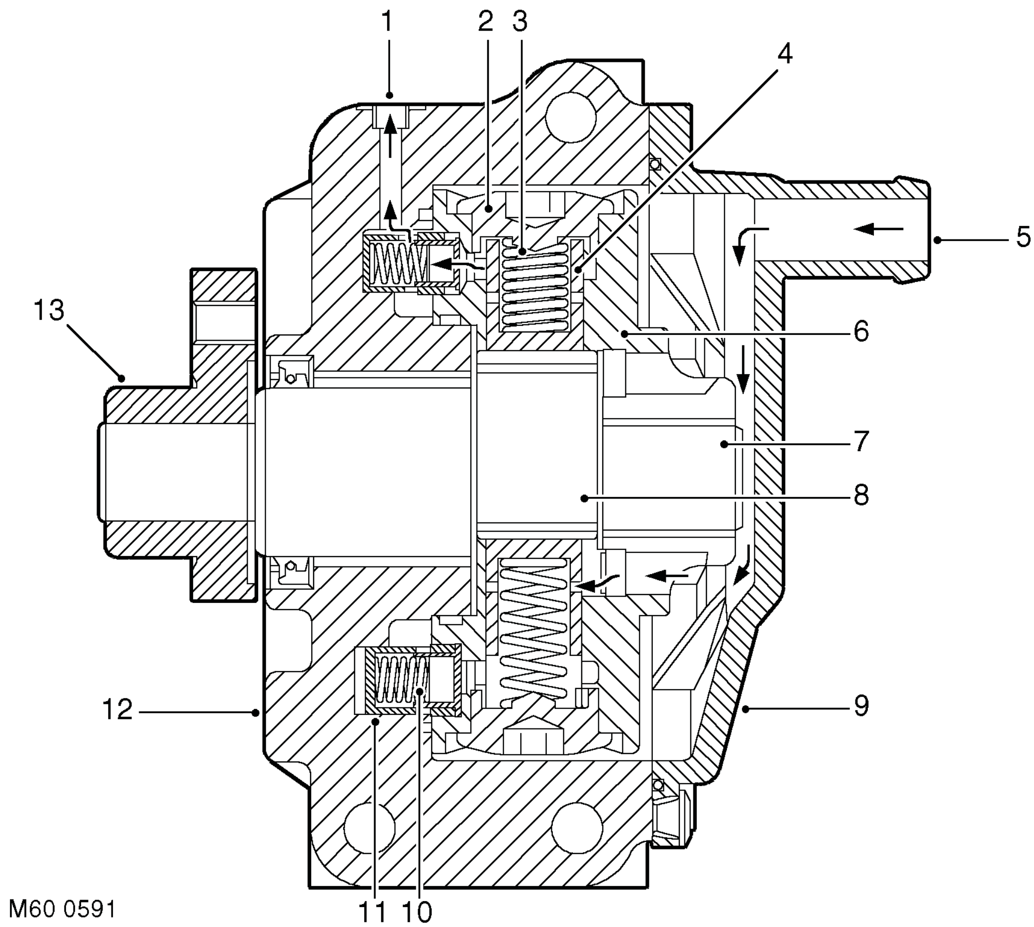
Fluid reservoir

The moulded plastic fluid reservoir is mounted on the left hand side of the engine compartment on a bracket which is attached to the inner wing. The reservoir is dual purpose, being divided into two separate chambers; one for the ACE system and one for the PAS system. Each chamber has its own filler neck and cap and is identified by moulded lettering on the reservoir adjacent to each filler.

A non-serviceable filter assembly is fitted in the base of each chamber. The filter is made from fine stainless steel mesh which is moulded into the body of the reservoir. The filter removes particulate matter from the fluid before it is drawn into the hydraulic pump.

Upper and lower fluid level marks are moulded onto the reservoir body. The capacity of the ACE reservoir chamber to the upper level mark is 0.5 litre (0.13 US Gallon).

Hydraulic pump



1 Outlet port
2 Cap
3 Piston spring
4 Piston
5 Inlet port
6 Cylinder housing
7 Shaft
8 Cam
9 Inlet housing
10 Spring
11 Discharge valve
12 Housing
13 Pulley attachment flange

The hydraulic pump is attached to a bracket on the left hand side of the engine and is driven at crankshaft speed by the auxiliary drive belt. The pump is of the radial piston type which delivers fluid at high pressure.

The radial piston pump has six pistons located in bores in a cylinder housing. A central shaft, which is driven by a pulley and the auxiliary drive belt, has a cam which operates the pistons as it rotates.

As the cam lobe reaches each piston, the piston is pushed outward, moving the fluid above the piston. The pressure created by the fluid flow from the bore opens a spring loaded discharge valve and allows the fluid to flow to the pump outlet port. When the piston reaches its full stroke, the flow reduces and the discharge valve closes under spring pressure.

As the cam lobe moves away from the piston, a spring pushes the piston down the bore creating a vacuum above the piston. As the piston moves down the bore, ports in the piston are exposed and connect with the fluid inlet. The vacuum draws fluid into the piston filling the piston and the chamber above it. As the piston is again pushed upwards, the ports are closed off by the bore and the fluid opens the discharge valve and flows to the outlet port.

The above sequence is applied to each of the six pistons for every revolution of the central shaft and cam. When the engine is running the sequence occurs rapidly creating a constant flow of fluid. The fluid flow varies with the engine speed and the rotational speed of the central shaft. The pressure felt at the actuator, created by the flow from the pump, is controlled by the pressure control valve in the valve block.

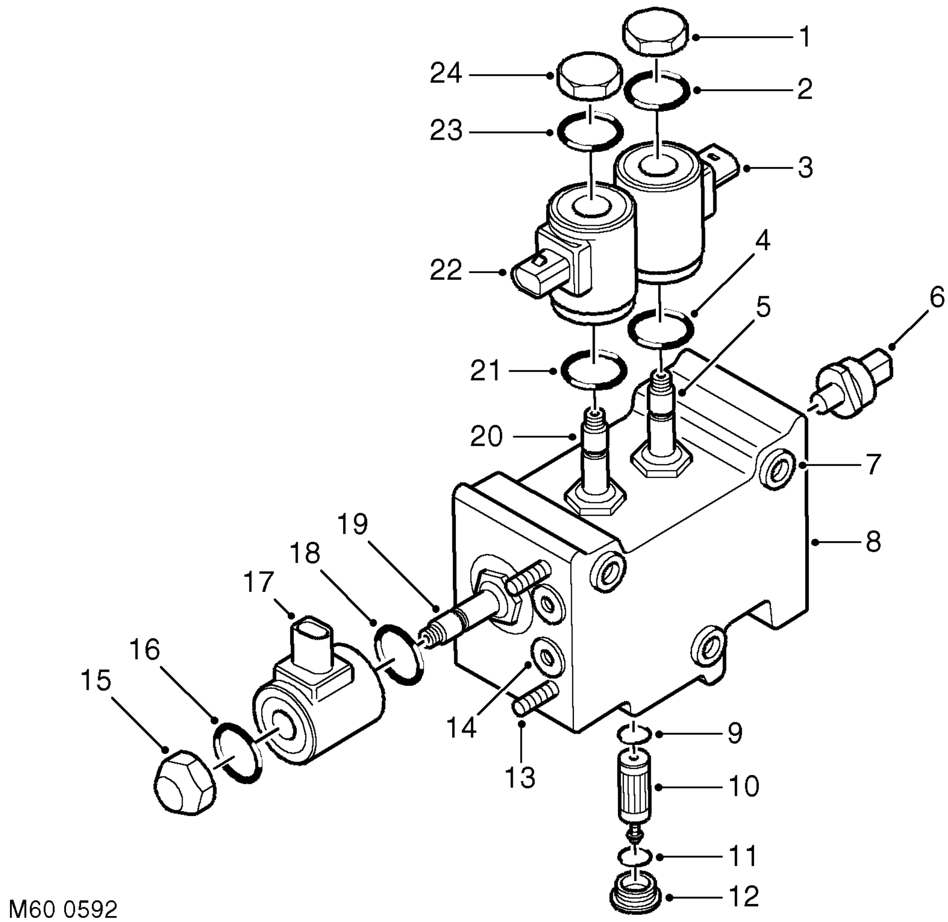
The pump has a displacement of 8.5 cm^3/rev and an operational pressure of 135 bar (1958 $lbf.in^2$). The pump output flow ranges from 7.0 l/min (1.85 US Gallons/min) at 775 rev/min to 9.25 l/min (2.44 US Gallons/min) at 7625 rev/min.

System pipes
Fluid is moved through the ACE system via a series of pipes and hoses. The pipes are mounted on brackets at strategic points to assure quiet operation of the system.

The pipes from the pump to the valve block and from the valve block to the reservoir are one piece items which are fitted at the factory before the body is attached to the chassis. If these pipes require replacement in service, the pipes must be cut to facilitate their removal. 'In service' replacement pipes are available in two parts with a connector to seal the joint.

The flexible hose which supplies pressure from the pump to the supply pipe attached to the front cross member is fitted with an attenuator. The attenuator comprises a bullet shaped valve which is located between two spiral wound springs held at each end of the flexible hose. This valve operates as a restrictor to damp pressure waves of hydraulic fluid from the pump, reducing noise and strain on components downstream. The attenuator is integral with the supply hose and pipe and cannot be serviced separately.

Valve block



1 Cap
2 'O' ring
3 Coil
4 'O' ring
5 Directional control valve 1 (extend)
6 Pressure transducer
7 Mounting bush 3 off
8 Valve block
9 'O' ring
10 High pressure filter
11 'O' ring
12 Cap
13 Stud 4 off
14 Pipe connections
15 Cap
16 'O' ring
17 Coil
18 'O' ring
19 Pressure control valve
20 Directional control valve 2 (retract)
21 'O' ring
22 Coil
23 'O' ring
24 Cap

The valve block directs hydraulic pressure to the actuators via solenoid operated directional control valves. A solenoid operated pressure control valve regulates the required pressure to the actuators. The three valve solenoids are controlled by signals received from the ACE ECU. A pressure transducer monitors the pressure delivered by the pump. A replacable high pressure filter is installed into the lower face of the valve block and filters fluid before it reaches the valves.

The valve block is located on the outside of the right hand chassis longitudinal. The valve block is secured to the chassis with three bolts and rubber bushes. The rubber bushes isolate the valve block from the chassis, preventing hydraulic noise from the valve block transmitting through the chassis and body.

The two solenoid operated directional control valves (DCV's) are fitted to ports in the top face of the valve block. The DCV's are screwed into the valve block and sealed with O ring seals. Each DCV has a solenoid for electrical operation of the valve. The solenoid is sealed to the DCV with two O ring and secured with a cap. The cap, coil and O rings are serviceable items. The DCV's are non-serviceable and failure of a DCV requires the replacement of the valve block assembly.

The pressure control valve is fitted to a port in the rear face of the valve block. The pressure control valve is screwed into the valve block and sealed with O rings. The pressure control valve has a coil for electrical operation. The coil is sealed to the pressure control valve with two O rings and secured with a cap. The cap, coil and O rings are serviceable items. The pressure control valve is non-serviceable and failure requires replacement of the valve block assembly.

The pressure transducer is fitted to a port in the forward face of the valve block. The pressure transducer is screwed into the valve block and sealed with an O ring seal. The pressure transducer is a serviceable item.

The high pressure filter locates in a port on the lower face of the valve block. The gauze and fibre filter is sealed in the port with O ring seals. A threaded cap secures the filter in the valve block and is also sealed with an O ring seal. A threaded hole on the lower face of the filter allows a bolt to be fitted to remove the filter from the port. If a system component is replaced, the filter must be changed.

Four ports are located on the forward face of the valve block and two ports on the rear. Each port is fitted with a seal pack which contains two O ring seals and backing rings. The ACE pipes locate and seal in the seal packs and are secured to the valve block with the studs and nuts located on the forward and rear faces.

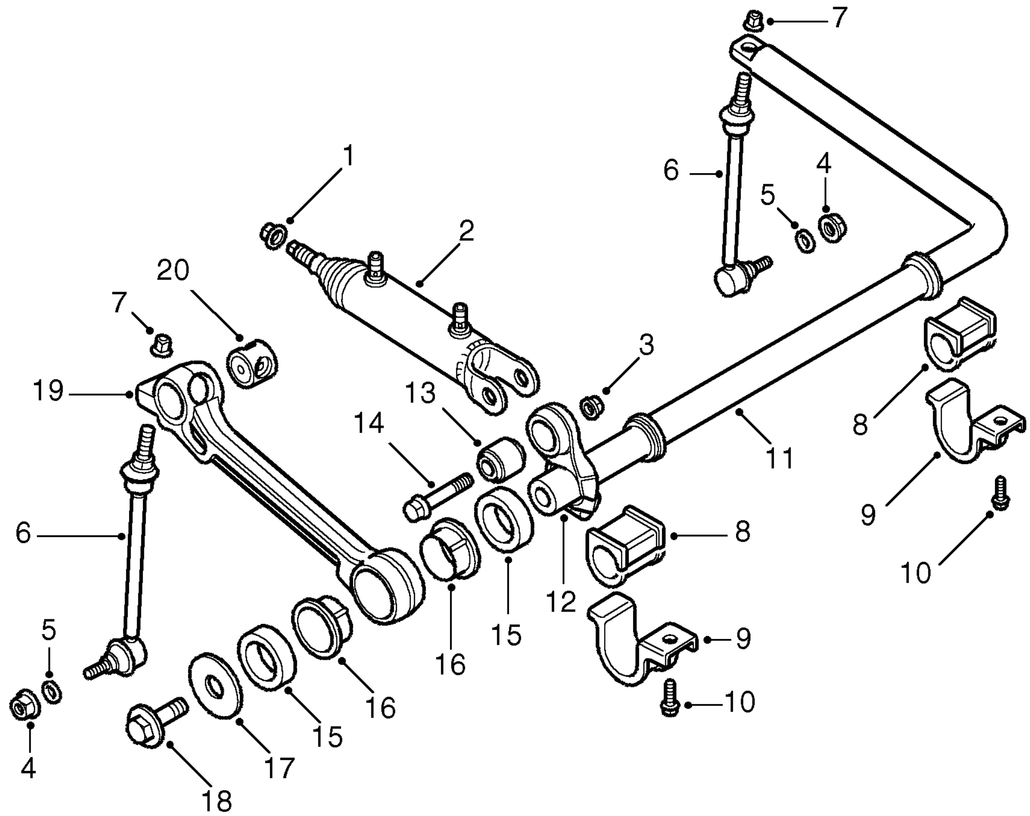
Actuators

Two actuators are used for the ACE system and are attached to the front and rear torsion bars. The actuators apply hydraulically generated force to the torsion bar to oppose lateral forces caused by the vehicle cornering.

Each actuator is a conventional double-acting cylinder. A piston is attached to a rod and moves within the cylinder when hydraulic pressure is applied. The rod is sealed at the point where it exits the cylinder. The outer end of the rod is threaded and locates in a bush in the ACE long arm and secured with a nut. A rubber gaiter covers the rod and prevents dirt and moisture from damaging the rod surface and cylinder seals. The cylinder has a forked attachment which locates on the short arm bush and secured with a bolt and nut.

Two banjo connections provide for the attachment of the hydraulic hoses from the ACE valve block. The connections provide hydraulic flow to each side of the piston to extend or retract the rod.

Torsion bar



M60 0593A

Front torsion bar shown, rear torsion bar similar

1 Locknut
2 Actuator
3 Locknut
4 Locknut 2 off
5 Washer
6 Anti-roll bar link
7 Locknut
8 Bush
9 Clamp plate
10 Bolt 2 off
11 Torsion bar
12 Short arm
13 Bush
14 Bolt
15 Outer slipper bush 2 off
16 Inner slipper bush 2 off
17 Washer
18 Bolt
19 Long arm
20 Bush

The front and rear torsion bar assemblies are similar in their construction, the rear torsion bar being narrower than the front. Each torsion bar is made from 35 mm (1.38 in.) diameter spring steel bar.

The right hand end of the torsion bar has a machined spigot which provides for the attachment of the forged steel short and long arms. The spigot for the short arm is splined and mates with splines in the short arm. The short arm is located in a specific position on the splines and clamped to the spigot with a Torx bolt and locknut. The short arm is not a serviceable item other than the actuator attachment bush. The smaller spigot diameter locates the long arm. The long arm is fitted with a slipper bush which is located on the spigot and secured with a large washer and a special bolt. The slipper bush comprises two inner and two outer bushes which are installed from each side of the long arm. The outer bushes have three lugs which locate in the long arm to prevent the bush from rotating. The long arm also provides the attachment point for the actuator piston rod and the anti-roll bar link.

The actuator has a forked end which locates on the bush in the short arm and is secured with a bolt and nut. The piston rod of the actuator locates through a hole in a cast boss on the long arm which is fitted with a special bush. A shoulder on the piston rod seats in a hole in the bush and a locknut on the end of the piston rod secures the rod to the long arm and bush.

The front torsion bar is attached to the front chassis cross member. Two rubber bushes are fitted to the torsion bar and are located in clamp plates. The clamp plates are located in slots in the cross member and secured with bolts.

The rear torsion bar is attached to the tubular cross member at the rear section of the chassis. Two rubber bushes are fitted to the torsion bar and are located in clamp plates. The clamp plates are located in fabricated brackets attached to the tubular cross-member and secured with bolts.

Two anti-roll bar links are mounted on brackets on the front and rear axles. Each anti-roll bar link is fitted with a spherical bearing at each end. One bearing is attached to the link at a 90° angle. The threaded shank of the bearing is located through a hole in a bracket on the axle and secured with a locknut; a washer is installed on the threaded shank between the bearing and the bracket. The second spherical bearing is attached in-line with the link and locates in the torsion bar on the left hand side and the long arm on the right hand side. The front anti-roll bar links are longer than the rear links and are not interchangeable.

Accelerometers

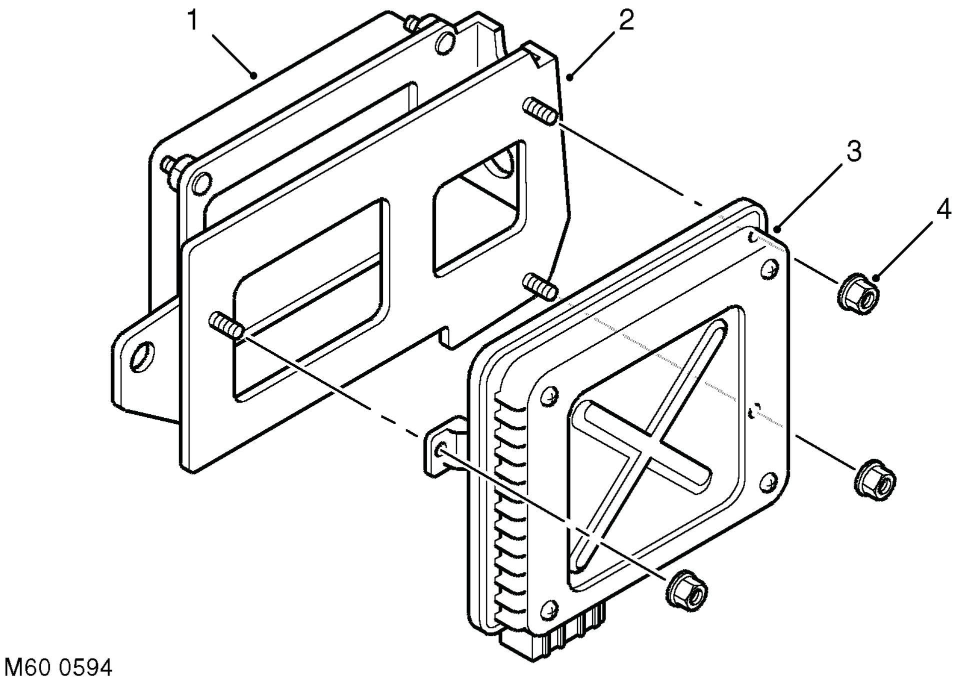
Two accelerometers are used for the ACE system. The upper accelerometer is mounted on a bracket, behind the headlining adjacent to the rear view mirror and the sunroof ECU. The lower accelerometer is located on a bracket on the inner sill panel under the RH front floor.

The lower accelerometer is the primary sensor used to measure lateral acceleration of the vehicle for roll control. The upper accelerometer is used by the ECU for roll correction and fault detection in conjunction with the lower accelerometer.

Each accelerometer is a solid state capacitive acceleration sensor and operates on a 5 V supply from the ECU. The upper and lower sensors can measure acceleration in the range of ± 1.10 g and return an output to the ECU of between 0.5 and 4.5 V.

Failures of an accelerometer are recorded by the ECU and can be retrieved using TestBook. A special tool is required to remove and replace a sensor in the bracket.

ACE Electronic control unit (ECU)



1 Body Control Unit (Ref. only)
2 Bracket
3 ACE Electronic control unit
4 Attachment nuts 3 off

The ACE ECU is mounted on a bracket behind the passenger glove box and is identified from the other ECU's by its single electrical harness connector. The single 36 pin connector is located on the lower face of the ECU and mates with a connector from the main harness. The connector supplies power, ground, signal and sensor information to/from the ECU for control of the ACE system.

The ACE ECU receives a battery power supply from fuse 15 in the engine compartment fusebox via the ACE relay, also located in the engine compartment fusebox. The ECU provides an earth path for the relay coil, energising the coil and supplying power to the ECU.

An ignition on signal is supplied from the ignition switch via fuse 29 in the passenger compartment fusebox. The ignition on signal provides an input to the ECU which tells the ECU that ignition has been selected on and initiates a 250 ms start time. The start time is used to prevent functions operating when software routines are being initialised.

The ignition on signal, when removed, tells the ECU that the ignition is off. The ECU will remain powered for thirty seconds after the ignition is turned off. The thirty second period allows the ECU to store values and fault flags in the memory. These values are read by the ECU when the next ignition on signal is received.

An engine speed signal is transmitted to the ECU from the Engine Control Module (ECM) as a pulsed digital signal. The engine speed signal is used by the ACE ECU to detect that the engine is running and hydraulic pressure for ACE system operation is available.

A road speed signal is transmitted to the ACE ECU as a pulsed digital signal from the Self-levelling/Anti-lock Braking System (SLABS) ECU. The road speed signal is used by the ACE ECU for on and off-road roll compensation.

When reverse gear is selected, an input is received from the reverse lamp switch. When the ACE ECU detects that reverse gear has been selected, the ACE system reverts to a 'locked bars' condition until reverse gear is disengaged.

The diagnostic connection allows diagnostic interrogation of the ACE ECU. The diagnostic socket allows diagnostic equipment to be connected to interrogate the ACE ECU for fault codes.

When system faults are detected by the ECU, the ACE warning lamp in the instrument pack is illuminated by the ECU continuously in amber for minor faults or flashing red with an audible warning for faults which require the driver to stop the vehicle immediately.

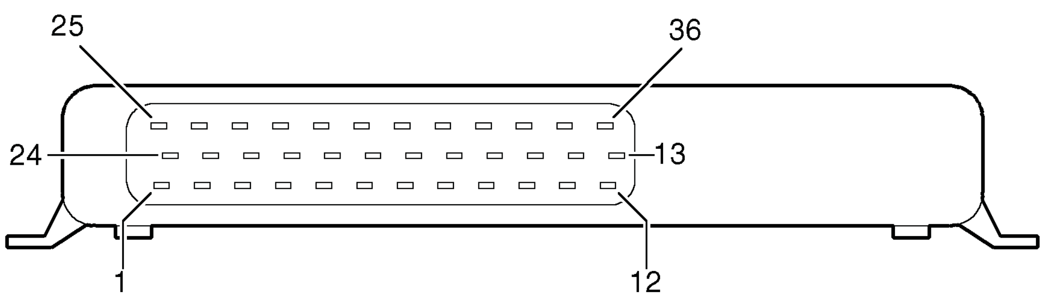
The ACE ECU supplies a control current to the pressure control valve in the valve block. The current supplied by the ECU is determined by a number of input signals from the upper and lower accelerometers, road speed etc.. The pressure control valve controls the hydraulic pressure supplied to the actuators proportional to the current supplied by the ECU.

Power is supplied to the two solenoid operated directional control valves (DCV's) in the valve block by the ECU. Together, the DCV's control the direction of flow of hydraulic fluid to the actuators. When the ECU supplies power to the solenoids the valves open allowing hydraulic fluid to flow to the actuators. When power is removed the valves close.

The pressure transducer in the valve block receives a 5 V supply from the ECU. The pressure transducer measures hydraulic pressures in the range of 0 to 180 bar (0 to 2610 $lbf.in^2$) and returns a linear output voltage to the ECU dependent on hydraulic pressure.

The ECU supplies a 5 V current to each of the accelerometers. Each accelerometer is capable of measuring lateral acceleration in the range of ± 1.10 g. An analogue input to the ECU of between 0.5 and 4.5 V relative to the lateral acceleration sensed is returned by each accelerometer. The ECU processes the two signals received to produce a 'pure' lateral acceleration signal which is then used as the main control signal for the ACE system.

ACE ECU connector pin details



M60 0619

Pin No.	Description	Input/Output
1	Not used	-
2	Not used	-
3	Spare	Input
4	Not used	-
5	Road speed	Input
6	ARC relay	Output
7 to 9	Not used	-
10	K line (diagnostics)	-
11	Ignition switch	Input
12	Accelerometer - lower (supply)	Output
13	Pressure transducer (supply)	Output
14	Reverse switch	Input
15	Accelerometer - lower (signal)	Input
16	Pressure transducer (signal)	Input
17	Accelerometer - upper (signal)	Input
18	Accelerometer - upper (supply)	Output
19	Engine speed	Input
20	Main earth 1	-

Pin No.	Description	Input/Output
21	Pressure transducer (earth)	Input
22	DCV 2 (earth)	Input
23	DCV 1 (earth)	Input
24	DCV 1 & 2 (supply)	Output
25	Pressure control valve (earth)	Input
26	Not used	-
27	Pressure control valve (supply)	Output
28	Main supply (+ V Batt)	Input
29 to 31	Not used	-
32	Main earth 2	-
33	Accelerometer - lower (signal)	Input
34	Accelerometer - upper (signal)	Input
35	Not used	-
36	Warning lamp	Output

Failure modes

Failures where the vehicle can still be driven safely are indicated by the ACE warning lamp illuminating continuously with an amber colour. The amber warning lamp will remain illuminated until the ignition is turned off. For all faults the warning lamp will only illuminate again if the fault is still present. Failures which require the driver to stop the vehicle immediately are indicated by the ACE warning lamp flashing with a red colour and an audible warning. All faults are recorded by the ACE ECU and can be retrieved with diagnostic equipment.

The following tables show the type of system failures and their effects on the system operation. Torsion bar 'floppy' means that fluid is allowed to circulate freely through the system. With no pressure in the actuators the torsion bar will have no effect on vehicle roll. 'Locked bars' means that all pump flow is directed through the valve block and returns to the reservoir. Both DCV's close and fluid is trapped in the actuators but can flow from one actuator to the other via the valve block. In this condition the torsion bar will perform similar to a conventional anti-roll bar, resisting roll but still allowing the axles to articulate.

Acceleration sensors

Failure	Effect
Valve stuck closed	No ACE control
Short circuit - Ground	No ACE control
Short circuit - VBatt	No ACE control
Loose sensor	Erractic ACE activity when driving in straight line

Pressure transducer

Failure	Effect
Short circuit - VBatt	Large sensor dead band - possible random movements

Road speed signal

Failure	Effect
Open circuit	No ACE control - 'Locked bars' condition
Short circuit - Ground	No ACE control - 'Locked bars' condition
Short circuit - VBatt	No ACE control - 'Locked bars' condition

Engine speed signal

Failure	Effect
Open circuit	No ACE control - 'Locked bars' condition
Short circuit - Ground	No ACE control - 'Locked bars' condition
Short circuit - VBatt	No ACE control - 'Locked bars' condition

Reverse gear signal

Failure	Effect
Open circuit	No reverse signal to ECU. ACE active in reverse, may give abnormal handling when reversing
Short circuit - Ground	No reverse signal to ECU. ACE active in reverse, may give abnormal handling when reversing
Short circuit - VBatt	Permanent reverse signal to ECU. Permanent 'Locked bars' condition

Ignition ON signal

Failure	Effect
Open circuit	ECU does not receive ignition ON signal. No ARC control, 'Locked bars' condition
Short circuit - Ground	ECU does not receive ignition ON signal. No ARC control, 'Locked bars' condition
Short circuit - VBatt	Permanent ignition ON signal to ECU. Possibility of flat battery

Pressure control valve failure

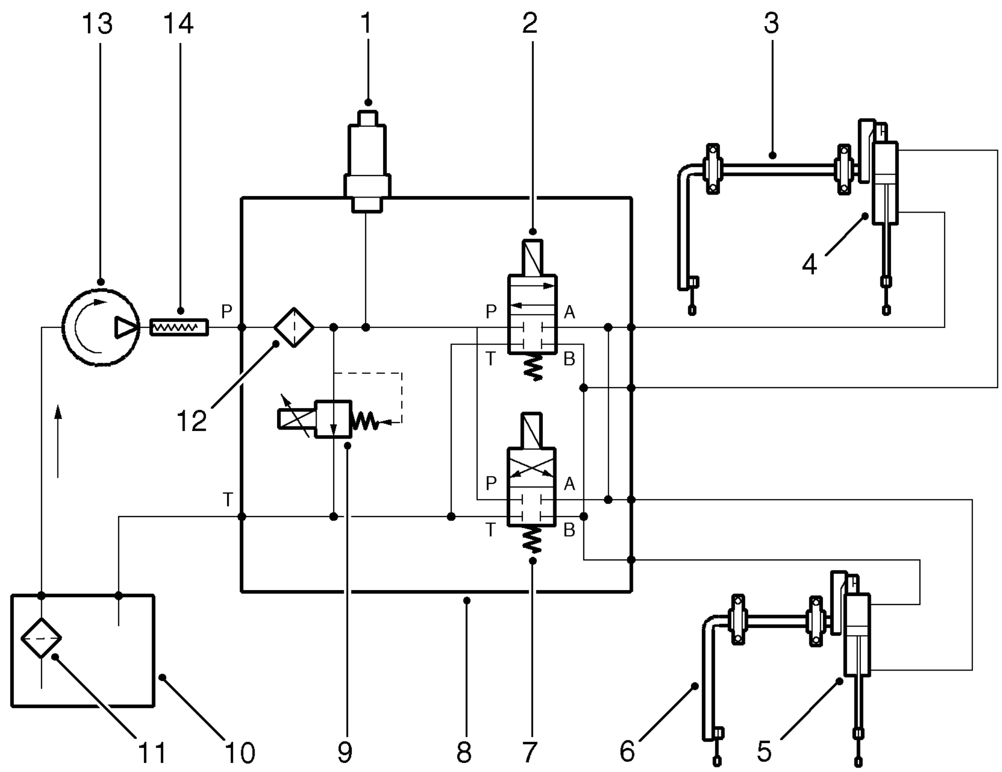
Failure	Effect
Open circuit	No ACE control
Short circuit - Ground	No ACE control
Short circuit - VBatt	No ACE control
Valve stuck open	No ACE control
Valve stuck closed	Maximum system pressure - no proportional control. Pressure relief valve operating at 185 bar (2683 $lbf.in^2$)

Directional control valves

Failure		Effect
DCV 1	**DCV 2**	
Valve open or stuck open	Valve open or stuck open	No ACE control - Anti-roll bars floppy
Valve closed or stuck closed	Valve closed stuck closed	No ACE control - 'Locked bars' condition (default)
Valve open or stuck open	Valve closed or stuck closed	Vehicle leans to left when pressure is applied to actuators
Valve closed or stuck closed	Valve open or stuck open	Vehicle leans to right when pressure is applied to actuators

Operation

Hydraulic circuit diagram



M60 0595A

1 Pressure transducer
2 Directional control valve 2
3 Front torsion bar assembly
4 Actuator
5 Actuator
6 Rear torsion bar assembly
7 Directional control valve 1
8 Valve block
9 Pressure control valve
10 Reservoir
11 Filter
12 High pressure filter
13 Hydraulic pump
14 Attenuator hose

Vehicle not moving
When the engine is running and the vehicle is not moving, both DCV's are closed, locking fluid in each side of the actuator pistons. The hydraulic pump draws fluid from the reservoir and passes it at very low pressure to the valve block. Because both DCV's are closed, after the fluid passes through the high pressure filter, it is directed through the pressure control valve to the reservoir. The pressure control valve is open fully to allow the full flow to pass to the reservoir. The DCV's will remain closed until the ECU detects a need to operate.

Vehicle moving and turning left
When the vehicle is turning left, the accelerometers detect the cornering forces applied and transmit signals to the ECU. The ECU determines that an opposing force must be applied to the torsion bars to counter the cornering forces. The ECU supplies a current to the solenoid of the DCV2. Simultaneously, a current is sent from the ECU to the pressure control valve which operates to restrict the flow of fluid returning to the reservoir.

The restriction causes the hydraulic pressure in the system to rise and the pressure is sensed by the pressure transducer which sends a signal to the ECU. The ECU determines from the inputs it receives what pressure is required and adjusts the pressure control valve accordingly.

The pressure in the system is applied to the annulus of each actuator, applying an opposing force to the torsion bar and minimising the cornering effect on the vehicle and maintaining the vehicle attitude. The fluid displaced from the full area of the actuator is returned to the reservoir via the valve block.

As the cornering force is removed when the vehicle straightens up, the ECU opens the pressure control valve to reduce the pressure in the system. The fluid bleeds from the actuator back into the system as the cornering force is reduced, removing the force from the torsion bar. When the vehicle is moving in a straight line DCV 2 closes.

Vehicle moving and turning right
When the vehicle is turning right, the accelerometers detect the cornering forces applied and transmit signals to the ECU. The ECU determines that an opposing force must be applied to the torsion bars to counter the cornering forces. The ECU supplies a current to the solenoid of the DCV1. Simultaneously, a current is sent from the ECU to the pressure control valve which operates to restrict the flow of fluid through the by-pass gallery.

The restriction causes the hydraulic pressure in the system to rise and the pressure is sensed by the pressure transducer which sends a signal corresponding to the pressure to the ECU. The ECU determines from the inputs it receives what pressure is required and adjusts the pressure control valve accordingly.

The pressure in the system is applied to the full area of each actuator, applying an opposing force to the torsion bar and minimising the cornering effect on the vehicle and maintaining the vehicle attitude. The fluid displaced from the annulus of the actuator is returned to the reservoir via the valve block.

As the cornering force is removed when the vehicle straightens up, the ECU opens the pressure control valve to reduce the pressure in the system. The fluid bleeds from the actuator back into the system as the cornering force is reduced, removing the force from the torsion bar. When the vehicle is moving in a straight line the DCV 1 closes.

Vehicle moving in a straight line
The ECU is constantly monitoring the signals received from the accelerometers and operates the DCV's and pressure control valve to maintain the vehicle attitude when the vehicle is moving.

Off-road driving
Off-road detection is achieved by the ECU by monitoring the signals from the upper and lower accelerometers for varying degrees of body movement. Off-road driving generates differing signals to the accelerometers which in turn produce differing outputs due to their vertical separation and the location of the roll centre of the vehicle. The two signals are passed through a filter to remove any offset caused by the vehicle leaning or the terrain. The ECU then uses this signal to calculate the percentage of road roughness.

Below 25 mph (40 km/h) the percentage of road roughness calculated is used by the ECU to limit the operation of the ACE system. The system is completely inoperative at speeds below 2 mph (3 km/h). At speeds above 25 mph (40 km/h) the system disables the percentage road roughness signal and full ACE system assistance is restored.

Side slope detection
The ECU uses side slope detection when the upper and lower accelerometers detect an average acceleration of more than $\pm$ 0.2 g and a road speed of less than 25 mph (40 km/h).

When side slope is detected both DCV's close to provide a 'locked bars' condition. This condition increases stability and gives a consistent vehicle response. As the road speed increases up to 25 mph (40 km/h), the level of average lateral acceleration must also increase and be maintained for the system to recognise that the vehicle is on a side slope. If the side slope angle is steep and the road speed is low, the ECU will detect the side slope in a short time.

ACE hydraulic system bleeding

60.60.13

Introduction

CAUTION: The ACE hydraulic system is extremely sensitive to the ingress of dirt or debris. The smallest amount could render the system unserviceable. It is imperative that the following precautions are taken.

- **ACE components are thoroughly cleaned externally before work commences;**
- **all opened pipe and module ports are capped immediately;**
- **all fluid is stored in and administered through clean containers.**

Check

1. Check the ACE system fluid level.
   ☞ **FRONT SUSPENSION, ADJUSTMENTS, Fluid level check - ACE system.**

Bleed

1. With vehicle on ramp, connect TestBook and follow bleed procedure as described.

Fluid level check - ACE system

60.60.14

Introduction

CAUTION: The ACE hydraulic system is extremely sensitive to the ingress of dirt or debris. The smallest amount could render the system unserviceable. It is imperative that the following precautions are taken.

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- **all fluid is stored in and administered through clean containers.**

Check

1. Clean reservoir around fluid level marks.
2. Visually check fluid level through side of reservoir. Fluid level must be between upper and lower fluid level marks.

Top-up

1. Clean reservoir around filler cap.
2. Remove filler cap from reservoir and fill to upper fluid level mark with recommended fluid.
   ☞ **CAPACITIES, FLUIDS, LUBRICANTS AND SEALANTS, Fluids.**
3. Fit filler cap to reservoir
4. Start and run engine for 2 minutes to circulate fluid.
5. If necessary, top-up reservoir to upper fluid level mark.