We build a better future

Service Guide
Hyundai Forklift
80D-9

Table of content

General machine introduction

80D-9 VER_01

- Engine: CUMMINS QSF3.8
- Displacement: 3800 ccm
- Rated Power: 102 HP/2200 rpm
- Max Torque: 42 kgm/1600 rpm
- Noise level (dBA): 107 Lwa / 78.6 Lpa
- Vibration level: ????? m/s^2
- Max speed: +/- 31 km/h
- Fuel con. (60 VDI): 80D-9 – 8.5 l/h

70D-9 –

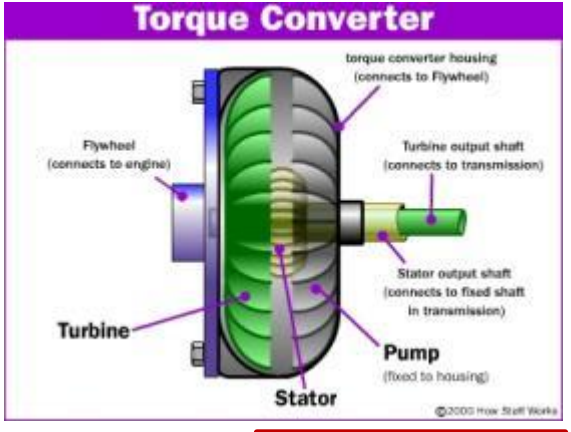
60D-9 –

50D-9 –

Transmissions
Converters
Differentials

Torque converter theory

A torque converter is a type of fluid coupling, which allows the engine to spin somewhat independently of the transmission. If the engine is turning slowly, such as when the machine is idling, the amount of torque passed through the torque converter is very small, so keeping the machine still requires only a light pressure on the brake pedal. If you were to step on the gas pedal while the machine is stopped, you would have to press harder on the brake to keep the car from moving. This is because when you step on the gas, the engine speeds up and pumps more fluid into the torque converter, causing more torque to be transmitted to the wheels.

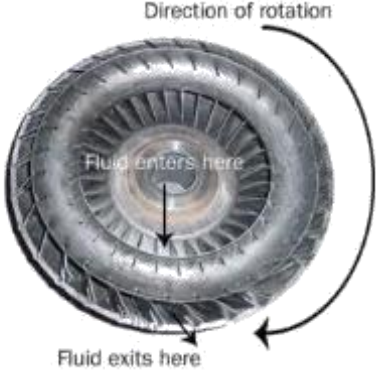


Converter can be tested in 2 ways:

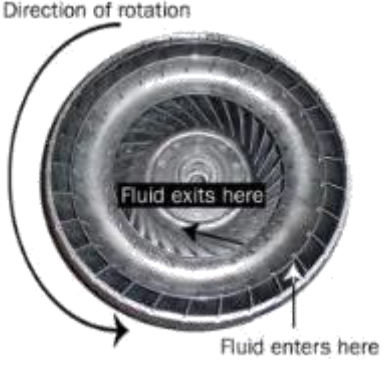
T/C Stall
1867±100 rpm

A. Inlet – Outlet pressure test

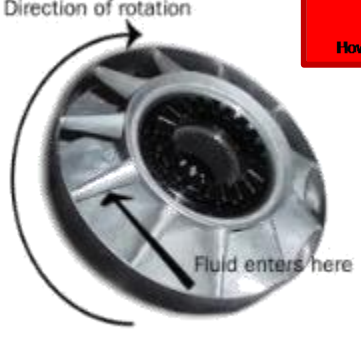
B. Stall test: If the converter is working, engine RPM will drop under load conditions at full acceleration.



The pump section of the torque converter is attached to the housing



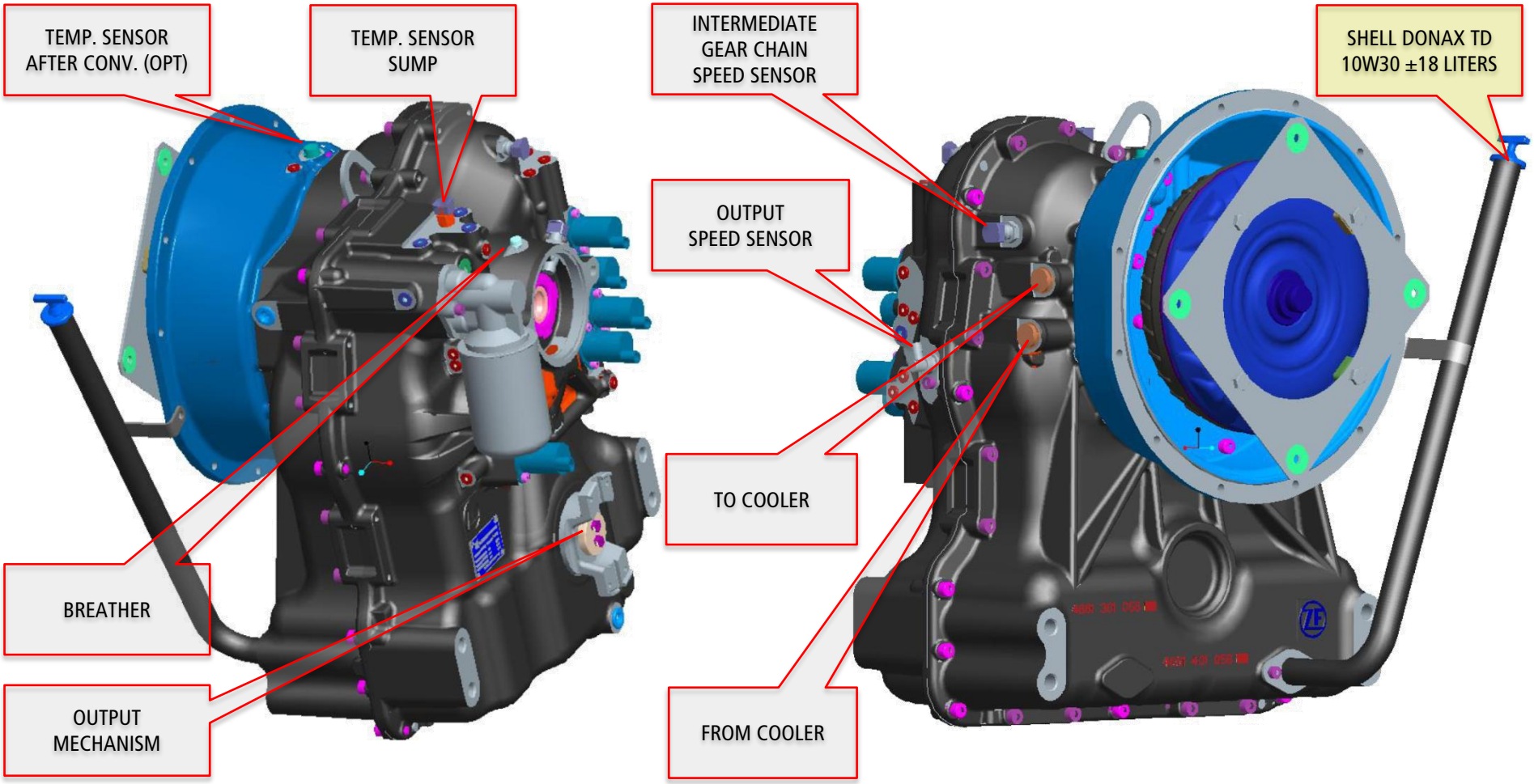
The torque converter turbine: Note the spline in the middle. This is where it connects to the transmission.



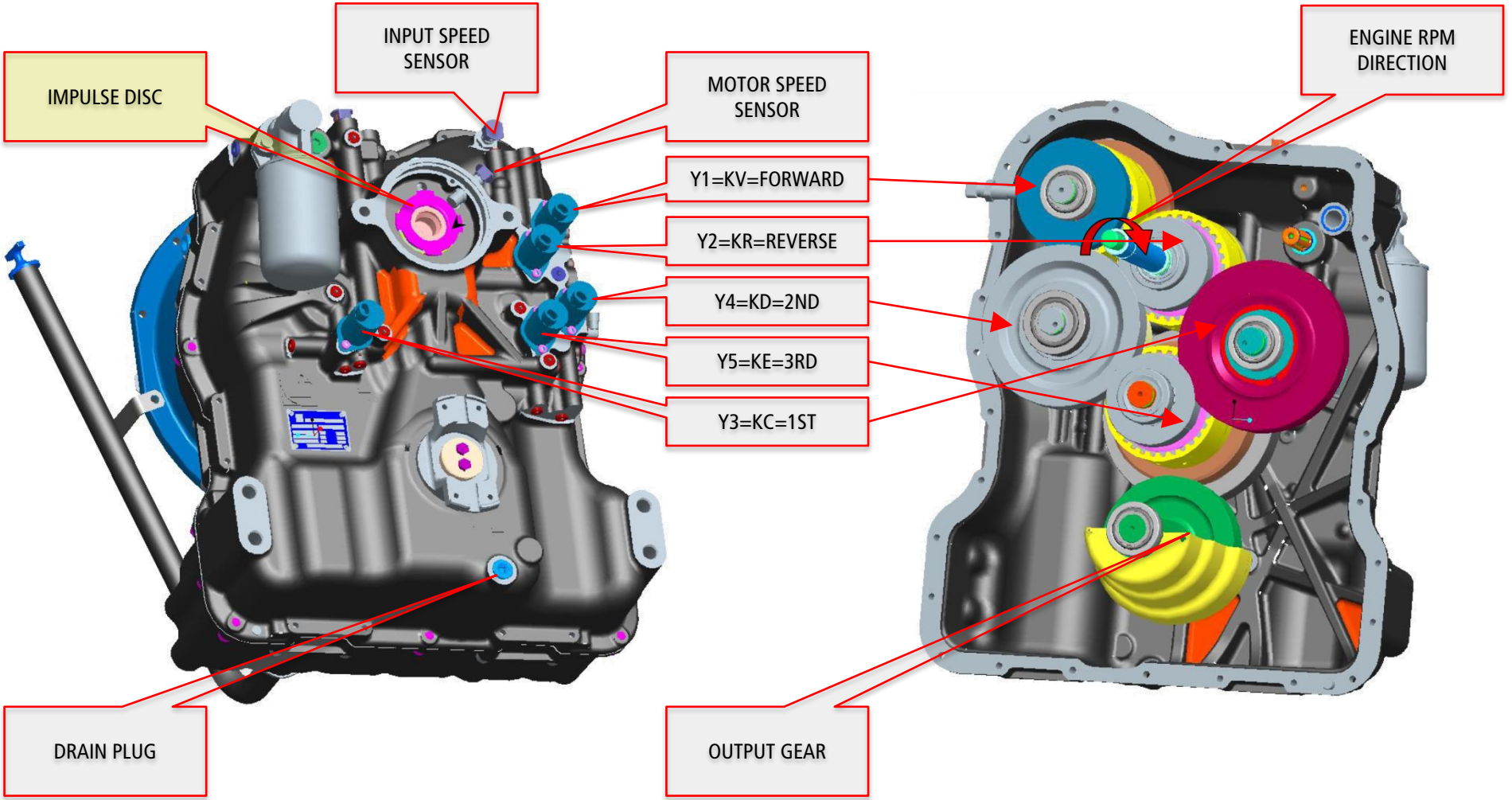
How Torque Converters Work.mp4

The stator sends the fluid returning from the turbine to the pump. This improves the efficiency of the torque converter. Note the spline, which is connected to a one-way clutch inside the stator.

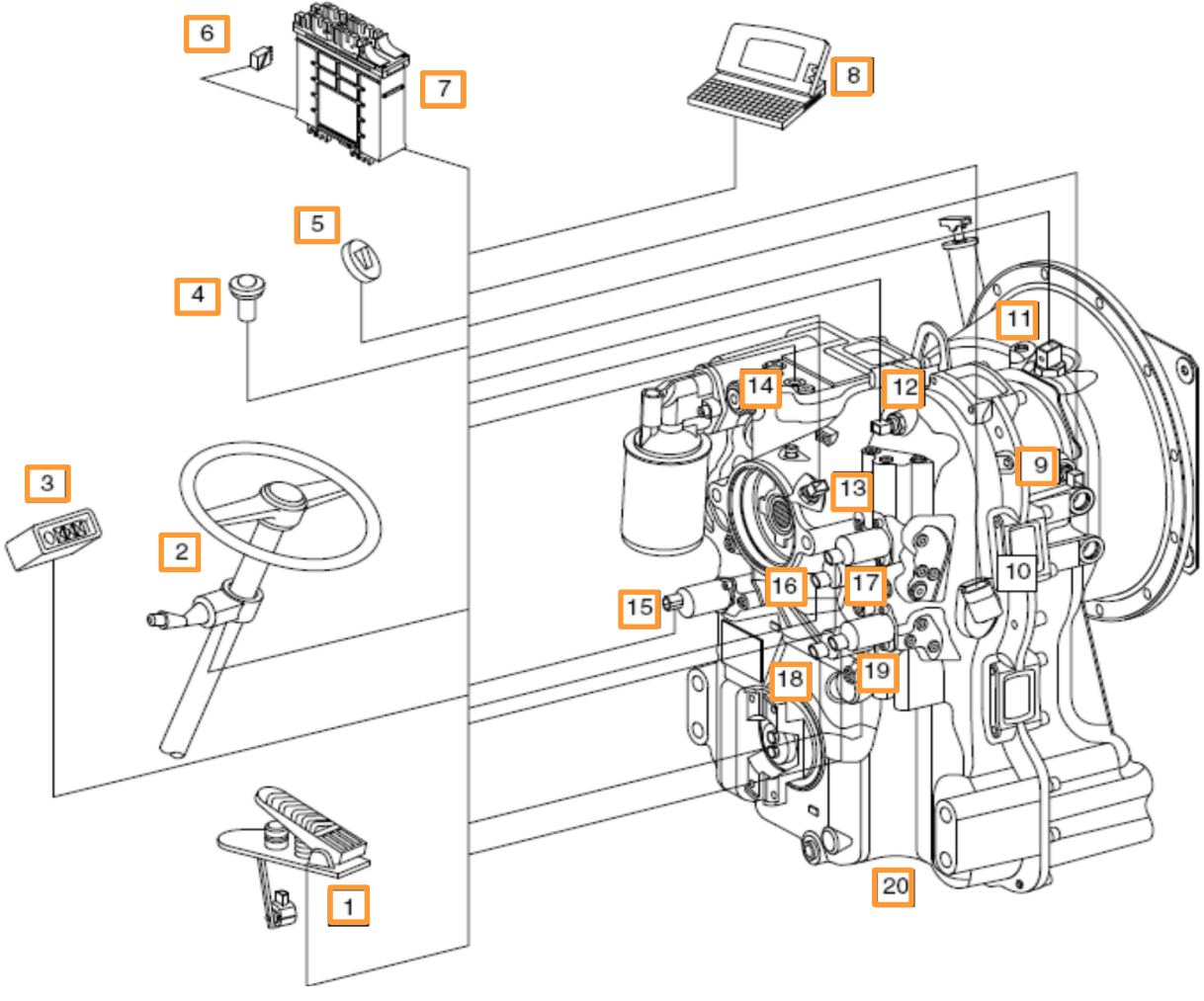
Transmission – ZF 3WG-94EC - COMPONENTS



Transmission – ZF 3WG-94EC - COMPONENTS



Transmission electric components

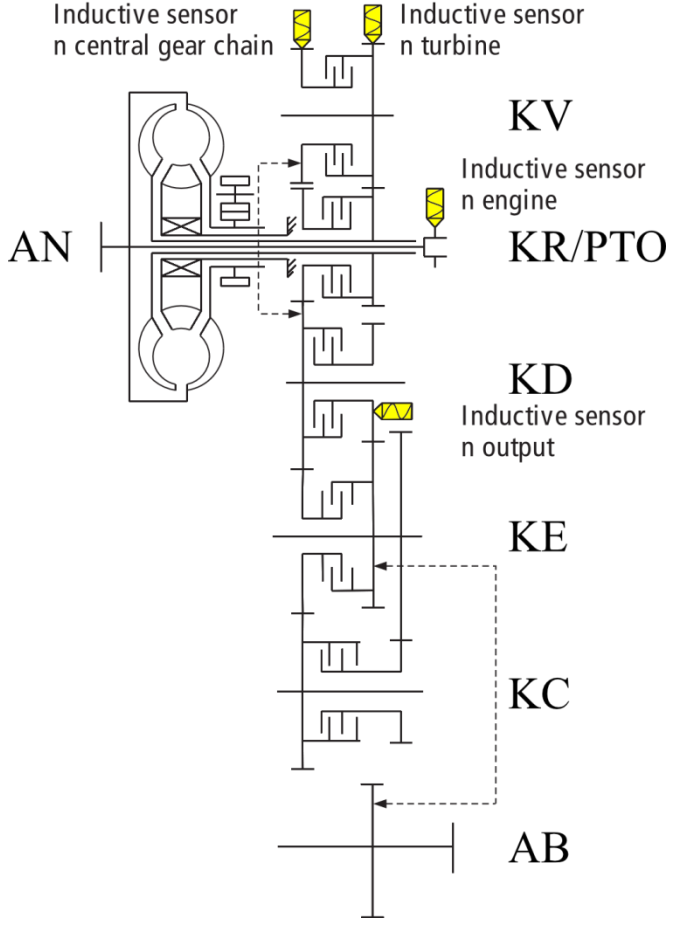


1. Inching pedal
2. Gear selector
3. Display
4. Inching mode switch
5. Switch Manual/Automatic
6. CAN connection
7. TCU
8. ZF diagnostic Testman /Pro
9. Inductive sensor - speed of central gear chain
10. Speed sensor - output
11. T* measuring point after converter (No. 63)
12. Inductive sensor - turbine speed
13. Inductive sensor - engine speed
14. T* measuring point for converter (No. 64)
15. Proportional valve Y3 - KC clutch: 1st speed
16. Proportional valve Y2 - KR clutch: REV
17. Proportional valve Y1 - KV clutch: FW
18. Proportional valve Y5 - KE clutch: 3nd speed
19. Proportional valve Y4 - KD clutch: 2nd speed
20. Ergopower transmission 3 WG-94 EC

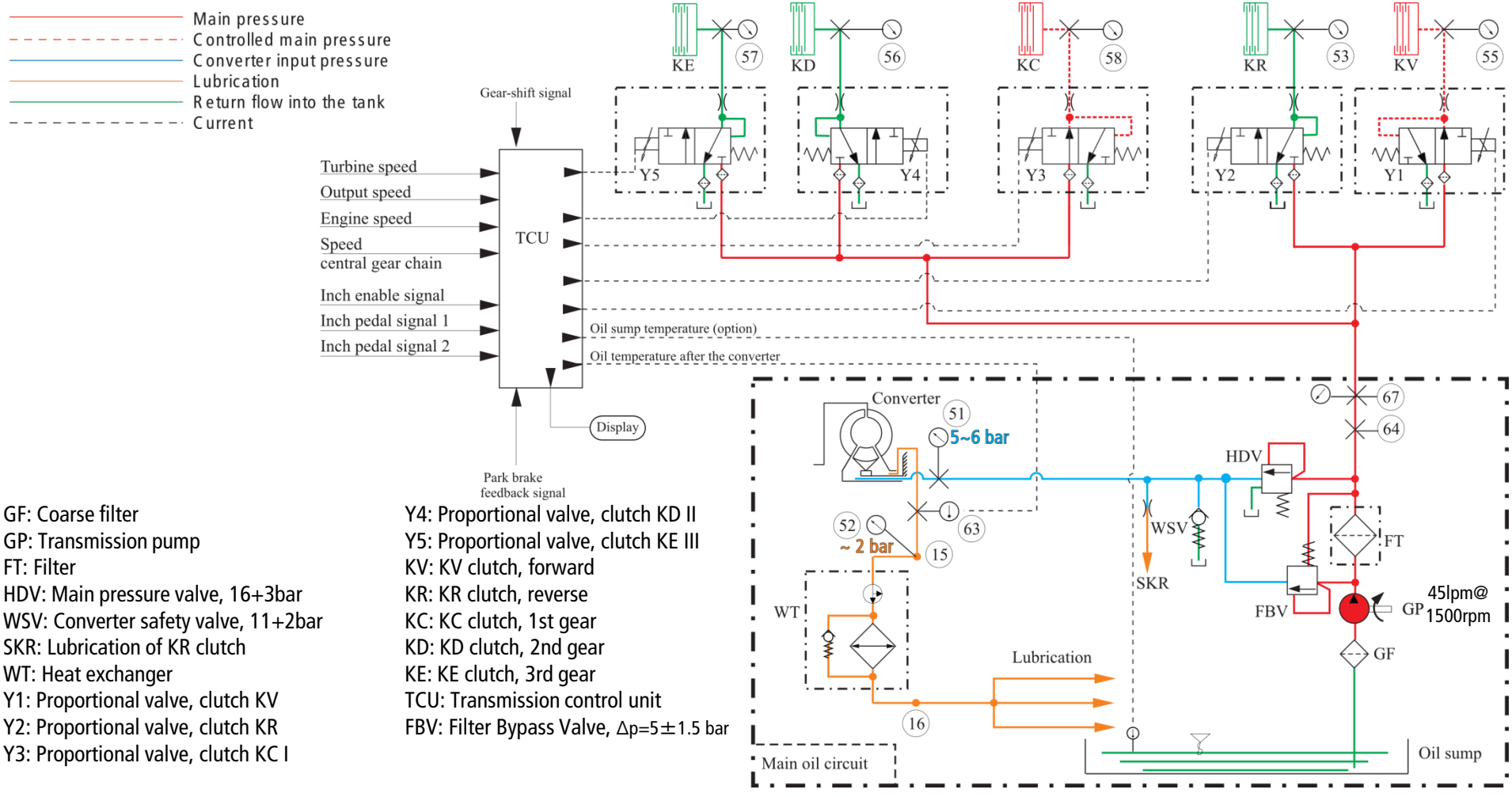
Transmission internal structure

No.		Denomination of item			Connection
		Measuring points for pressure oil and temperature:			
51	=	Before the converter - opening pressure		11+2 bar	M10x1
53	=	Reverse clutch	KR	16+3 bar	M10x1
55	=	Forward clutch	KV	16+3 bar	M10x1
56	=	Clutch	KD	16+3 bar	M10x1
57	=	Clutch	KE	16+3 bar	M10x1
58	=	Clutch	KC	16+3 bar	M10x1
63	=	Temperature after the converter 100° C; short-term 120° C			M14x1.5
64	=	Temperature sensor			M12x1,5
67	=	System pressure		16+3 bar	M10x1
		Valves and connections:			
10	=	Breather			10x1
15	=	Connection to wards heat exchanger			7/8" 14 UNF
16	=	Connection from heat exchanger			7/8" 14 UNF
68	=	Connection after ZF filter			9/16-18 UNF-2B
69	=	Connection before ZF filter			7/8" 14 UN 2A
70	=	Converter safety valve (WSV)			
71	=	Main pressure valve (HDV)			
		Inductive transmitters and speed sensor:			
11	=	Inductive transmitter	n Engine	M18x1,5	
21	=	Inductive transmitter	n Turbine	M18x1,5	
34	=	Speed sensor	n Output	----------	
47	=	Inductive transmitter	n Central gear train	M18x1,5	

Transmission schematics

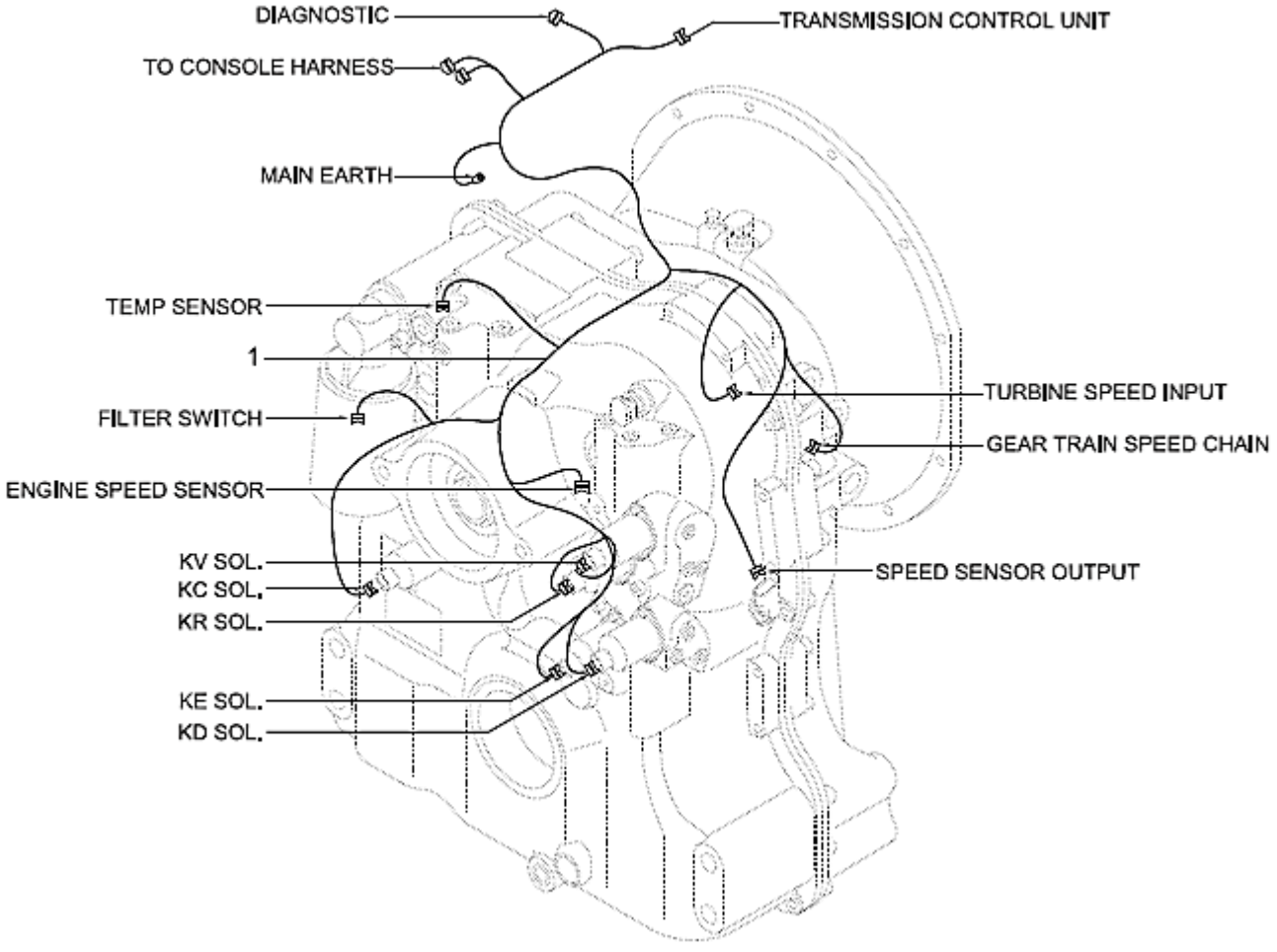


Transmission hydraulic diagram

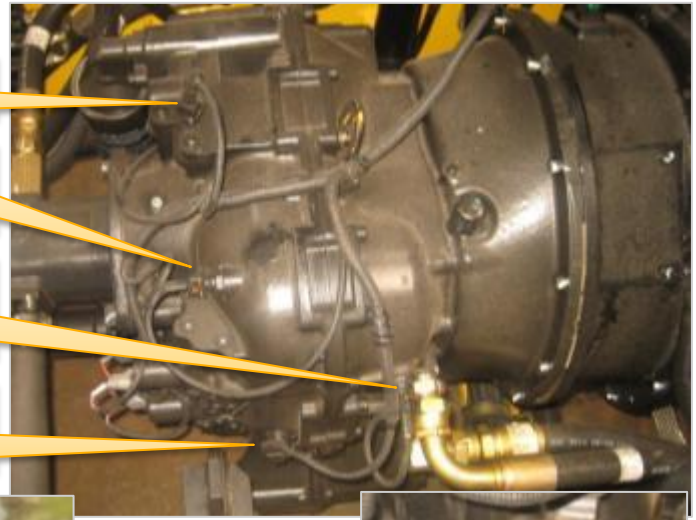


GF: Coarse filter
GP: Transmission pump
FT: Filter
HDV: Main pressure valve, 16+3bar
WSV: Converter safety valve, 11+2bar
SKR: Lubrication of KR clutch
WT: Heat exchanger
Y1: Proportional valve, clutch KV
Y2: Proportional valve, clutch KR
Y3: Proportional valve, clutch KC I
Y4: Proportional valve, clutch KD II
Y5: Proportional valve, clutch KE III
KV: KV clutch, forward
KR: KR clutch, reverse
KC: KC clutch, 1st gear
KD: KD clutch, 2nd gear
KE: KE clutch, 3rd gear
TCU: Transmission control unit
FBV: Filter Bypass Valve, $\Delta p = 5 \pm 1.5$ bar

Transmission harness



Transmission sensors and TCU



Temperature sensor

Inductive sensor - n turbine

Inductive sensor - n central gear chain

SPEED SENSOR OUTPUT

TRANSMISSION CONTROL UNIT **TCU**

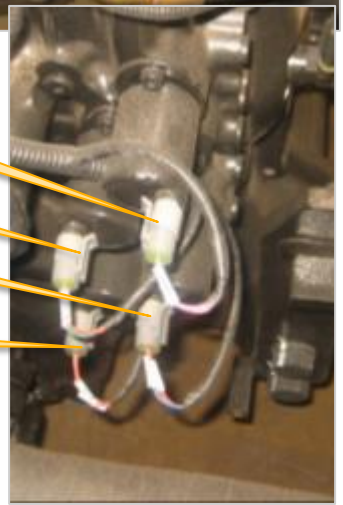
KV-FW

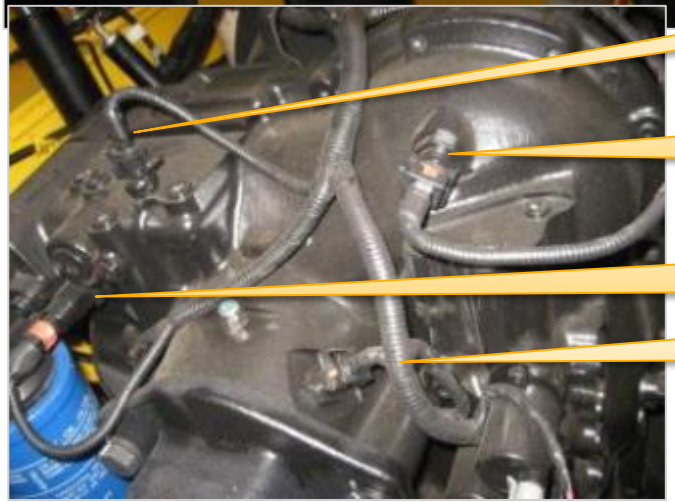
KR-REV

KD-2ND

KE-3RD

KC–1ST





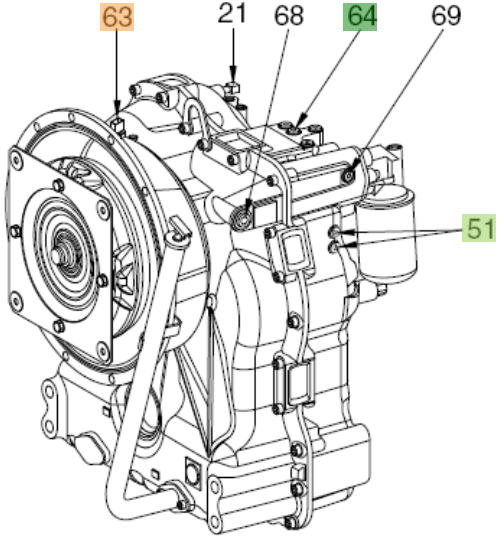
Temperature sensor

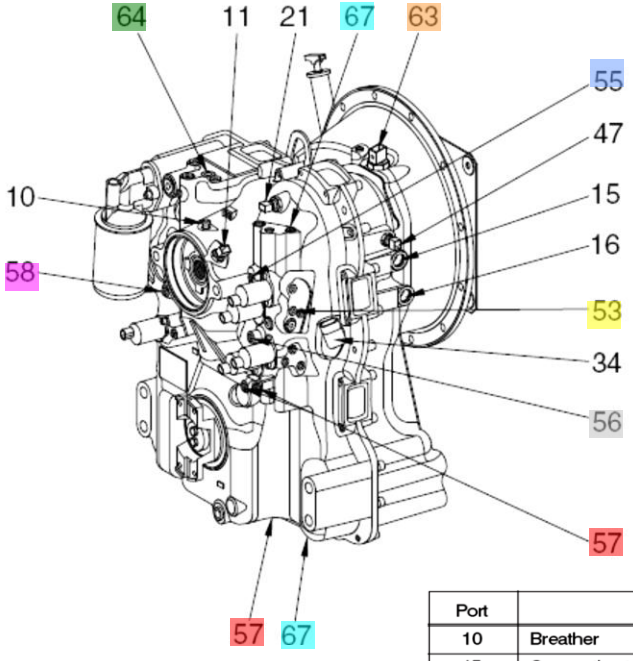
Inductive sensor - n turbine

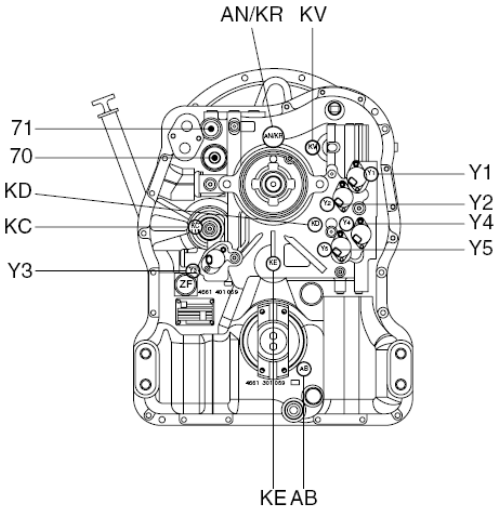
Pressure sensor – clogged filter indication

ENGINE SPEED SENSOR

Transmission pressure check points





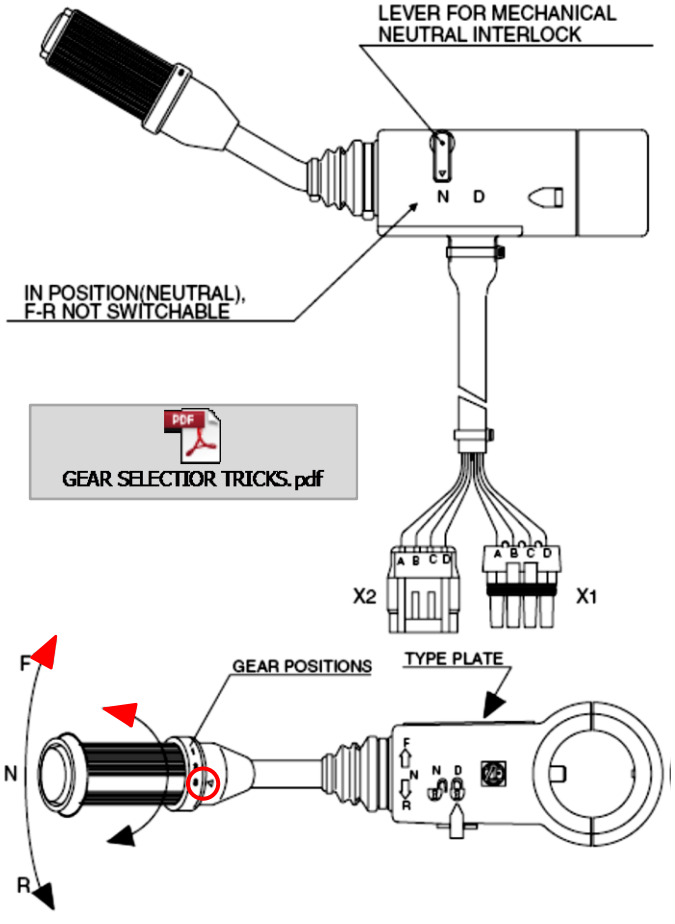


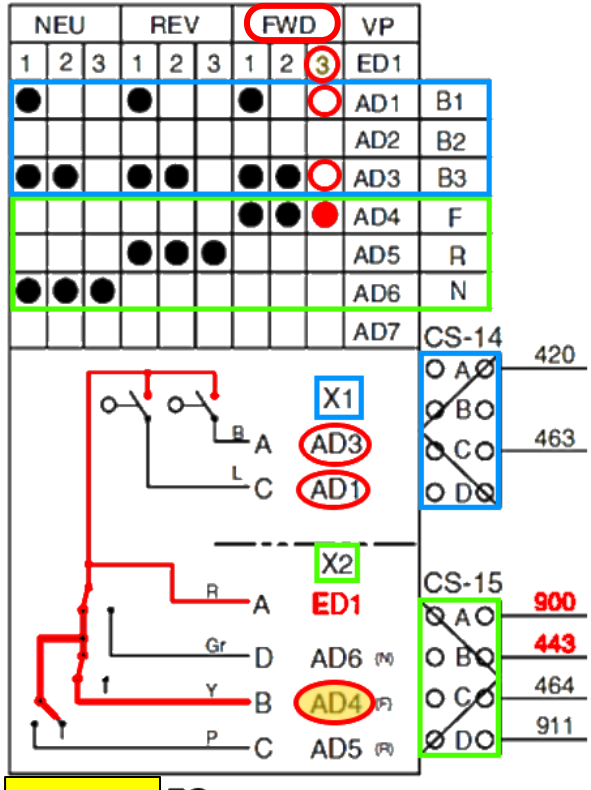
Port	Description		Size
51	Before the converter - opening pressure	11 + 2 bar	M10x1
53	Reverse clutch KR	16 + 3 bar	M10x1
55	Forward clutch KV	16 + 3 bar	M10x1
56	Clutch KD	16 + 3 bar	M10x1
57	Clutch KE	16 + 3 bar	M10x1
58	Clutch KC	16 + 3 bar	M10x1
63	Temperature after the converter 100° C ;short-term 120° C		M14x1.5
64	Temperature sensor		M12x1.5
67	System pressure	16 + 3 bar	M10x1

Port	Description	Size
10	Breather	M10x1
15	Connection towards heat exchange	7/8" 14 UNF
16	Connection from heat exchanger	7/8" 14 UNF
68	Connection after fine filter	9/6-18 UNF-2B
69	Connection before fine filter	7/8" 14 UN 2A
70	Converter safety valve(WSV)	
71	Main pressure valve(HDV)	

Port	Description		Size
11	Inductive transmitter	n Engine	M18x1.5
21	Inductive transmitter	n Turbine	M18x1.5
34	Speed sensor	n Output	-
47	Inductive transmitter	n Central gear train	M18x1.5

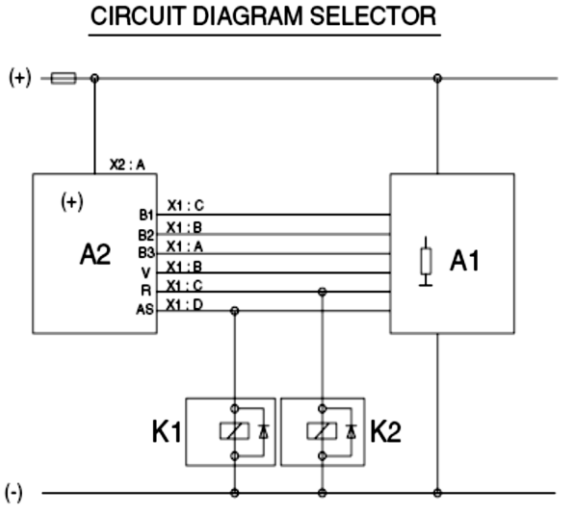
Transmission gear selector





EXAMPLE **F3**

AD3 = OPEN
AD1 = OPEN
AD4 + A = 443+900



K1 = Relay starter interlock
K2 = Relay reverse lights
A1 = TCU(Transmission Control Unit)
A2 = Gear selector

Transmission AEB clutch calibration

1. Start engine after parking the machine on flat floor and blocking wheels.
2. Release parking brake.
3. With stepping on the service brake, operate T/M STALL(in 3rd speed).

(To avoid defect of clutch pack, repeat -10 sec of operation and then10 sec rest in neutral)

4. When the T/M oil temperature reaches 75~80° C, lock the parking brake and then shift gear to neutral position to keep the machine at LOW RPM.
5. Connect the AEB STARTER to T/M controller.
6. Push AEB STARTER over 3 seconds.
7. Confirm the status of AEB from the DISPLAY.

- Normal operation shows "ST, KR, KV, KC, KD, KE" orderly for 3~5minutes.
- After the successful completion, it displays " OK".
- With a new controller, it may display "F6" error code before AEB, but after AEB, it will disappear.

8. In case of abnormal running, it may display "STOP" with the appropriate error code.
9. After troubleshooting, start the machine again to repeat above.

As the STALL operation has to be done, the SERVICE BRAKE must be locked perfectly to avoid the fatal accident.

ZF and HHIE p/n: 0501-211-778

Carryout these tests every 1000H or when the T/M has been serviced

Transmission AEB inching pedal calibration

The brake pedal serves to actuate the hydraulic brakes on the front axle. At the beginning of the pedal stroke, the inching spool of the transmission control valve is actuated to shift the hydraulic clutch to neutral and turn off the driving force. By treading the pedal further, the brake is applied.

INITIALIZING THE INCHING SENSOR

1. Start engine after parking the machine on flat floor and blocking wheels.
2. Release parking brake and keep neutral gear shift.
3. Adjust the inching sensor linkage so that the regular voltage is supplied to inching sensor when operating the pedal.
   (Regular voltage : Before pedal operation(1±0.1V), After pedal operation(3.5±0.1V))
4. Stop the engine and then just KEY ON.(Release parking brake, keep neutral gear)
5. Connect the AEB STARTER to the T/M controller.
6. Push AEB STARTER over 3 seconds.
7. If display shows "▼IP", Step on the pedal fully.
8. If display shows "▲IP", release "OK"
9. After the successful completion, it displays "OK".
10. In case of abnormal running, it may display "STOP" with the appropriate error code.
11. After troubleshooting, start the machine again to repeat above.

⚠ Above works are to be done with the parking brake released, so machine's wheels must be blocked for safety.

Transmission display codes – during operation

Symbol	meaning	remarks
1F, 1R 2F, 2R 3F, 3R 4F 5F 6F LF, LR	actual gear and direction left digit shows actual gear right digit shows actual direction limp home gear	
F or R, no gear	Clutch Cutoff	
F or R flashing	direction F or R selected while turbine speed is too high	**CAUTION** gear will engage if turbine speed drops
NN	not neutral, waiting for neutral after power up or a severe fault	to engage a gear, first move shift selector to neutral position and again to F or R position
**	oil temperature too low, no gear available	warm up engine / transmission
*N	oil temperature low, only one gear available	warm up engine / transmission
1 bar (special symbol)	manual mode 1st gear	
2 bars	manual mode 2nd gear	
3 bars	manual mode 3rd gear	
4 bars	manual mode 4th gear and also 5th and 6th gear in 6WG	
4 bars and 2 arrows	automatic mode	
Bars flashing	6 WG: converter lockup clutch open 4 WG: Downshift mode activ	difference of engine and turbine speed above a certain limit and lockup clutch not activated
Spanner	at least one fault activ	select neutral to get fault code displayed
Fault code	see fault code list	
WS	warning sump temperature	changes between actual gear/direction while driving, in neutral only displayed if no fault is detected (spanner)
WR	warning retarder temperature	changes between actual gear/direction while driving, in neutral only displayed if no fault is detected (spanner)
WT	warning torque converter temperature	changes between actual gear/direction while driving, in neutral only displayed if no fault is detected (spanner)
WE	warning high engine speed	changes between actual gear/direction while driving, in neutral only displayed if no fault is detected (spanner)
WV	warning high output speed (velocity)	changes between actual gear/direction while driving, in neutral only displayed if no fault is detected (spanner)
WL	warning high transmission input torque (load)	changes between actual gear/direction while driving, in neutral only displayed if no fault is detected (spanner)
WO	warning high transmission output torque (load)	changes between actual gear/direction while driving, in neutral only displayed if no fault is detected (spanner)
PN	direction F or R selected while parking brake engaged	transmission in neutral until parking brake is released **CAUTION**: vehicle starts to move after release of parking brake
EE flashing	no communication with display	checked wiring from TCU to display

(2) Abbreviations

OC	: Open circuit
SC	: Short circuit
OP mode	: Operating mode
TCU	: Transmission control unit
EEC	: Electronic engine controller
PTO	: Power take off

Transmission display codes – during AEB-mode

Symbol	meaning	remarks
PL	AEB - Starter is plugged at the diagnostic plug	
ST	AEB-Starter-button is pressed	
KA…..KE KV,KR	Calibrating clutch KA..KE, KV or KR resp.	KA, KB for 2 gear transmission KC, KD, KE for 3 gear transmission
_ and Kx	wait for start, initialization of clutch Kx, x: 1, 2, 3, 4, V, R	
≡ and Kx	fast fill time determination of clutch Kx	
= and Kx	compensating pressure determination of clutch Kx	
OK	calibration for all clutches finished	Transmissions stays in neutral, you have to restart the TCU (ignition off/on) after removing AEB-Starter
STOP	AEB canceled (activation stopped)	Transmissions stays in neutral, you have to restart the TCU (ignition off/on)
STOP and Kx	AEB stopped, clutch Kx can't be calibrated	Transmissions stays in neutral, you have to restart the TCU (ignition off/on)
Spanner and Kx	Kx couldn't be calibrated, AEB finished	Transmissions stays in neutral, you have to restart the TCU (ignition off/on)
Δ E	engine speed too low, ⇨ raise engine speed	
∇ E	engine speed too high, ⇨ lower engine speed	
Δ T	transmission oil temperature too low, ⇨ heat up transmission	
∇ T	transmission oil temperature too high ⇨ cool down transmission	
FT	transmission temperature not in defined range during calibration	Transmissions stays in neutral, you have to restart the TCU (ignition off/on)
FB	operating mode not NORMAL or transmission temperature sensor defective or storing of Calibrated values to EEPROM-has failed.	Transmissions stays in neutral, you have to restart the TCU (ignition off/on)
FO	Outputspeed_not_zero	Transmissions stays in neutral, you have to restart the TCU (ignition off/on)
FN	Shift lever not in Neutral position	Transmissions stays in neutral, you have to restart the TCU (ignition off/on)
FP	Parkbrake_not_applied	Transmissions stays in neutral, you have to restart the TCU (ignition off/on)
STOP	AEB - Starter was used incorrect or is defective. Wrong device or wrong cable used	Transmissions stays in neutral, you have to restart the TCU (ignition off/on)

(2) Abbreviations

OC	: Open circuit
SC	: Short circuit
OP mode	: Operating mode
TCU	: Transmission control unit
EEC	: Electronic engine controller
PTO	: Power take off

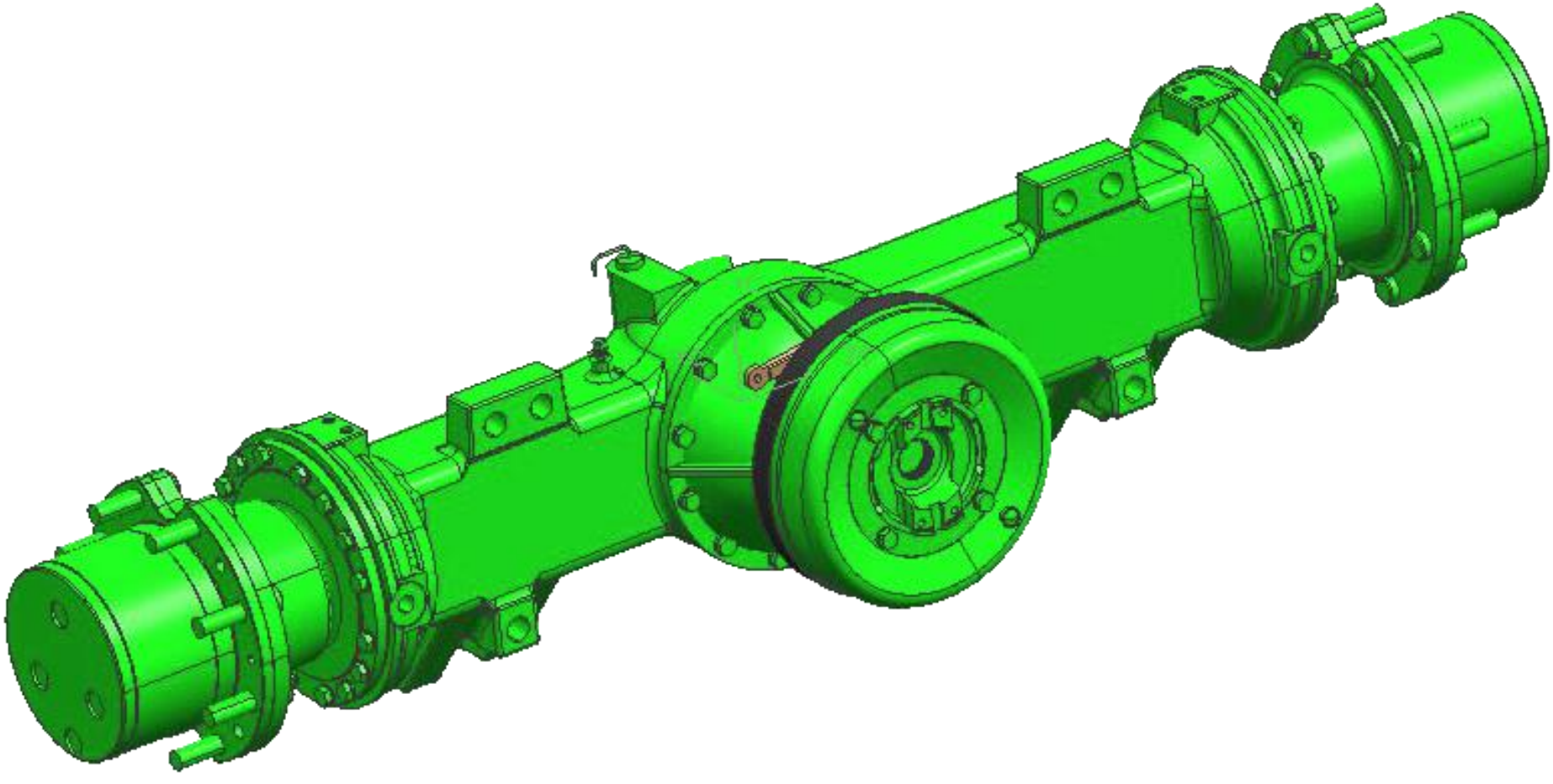
Transmission display codes – during Inchpedal calibration

Symbol	meaning	remarks
IP ⇓	push down the pedal slowly until endposition is reached and hold this position	
IP ⇑	Release the pedal slowly until endposition is reached	
IP □ blinkt	A problem occurred, release the pedal slowly until endposition is reached	If the expected enposition could not be reached, release the pedal and try again
OK	Finished inchpedal calibration successful	
FN and Stop	Shift lever not in Neutral position	Calibration is aborted
FS and Stop	sensor supply voltage AU1 is out of the specified range	Calibration is aborted
FO and Stop	Outputspeed is not zero	Calibration is aborted
SL and Stop	sensor voltage below specified rangel	Calibration is aborted
SU and Stop	sensor voltage above specified rangel	Calibration is aborted
IL and Stop	sensor position for released pedal out of specified range	Calibration is aborted
IU and Stop	sensor position for pressed pedal out of specified range	Calibration is aborted
TO and Stop	time-out calibration, pedal not moved after calibration start	Calibration is aborted
DL and Stop	angle between pedalpositions released and pressed to small	Calibration is aborted
DU and Stop	angle between pedalpositions released and pressed to big	Calibration is aborted
FI and Stop	sensor signal 1 and 2 don't match together	Calibration is aborted

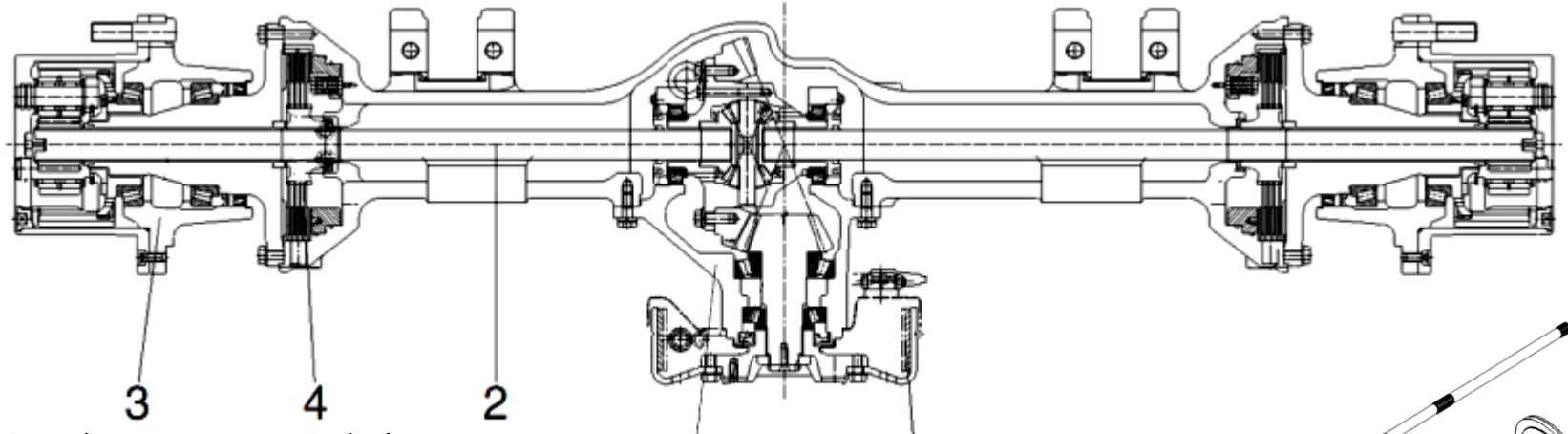
(2) Abbreviations

OC	: Open circuit
SC	: Short circuit
OP mode	: Operating mode
TCU	: Transmission control unit
EEC	: Electronic engine controller
PTO	: Power take off

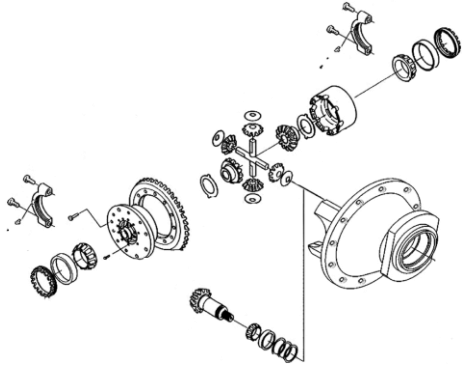
Front axle

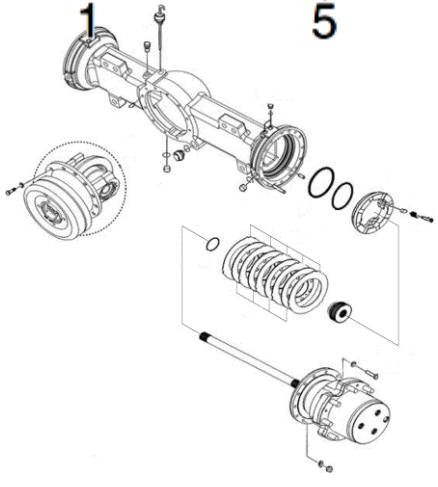


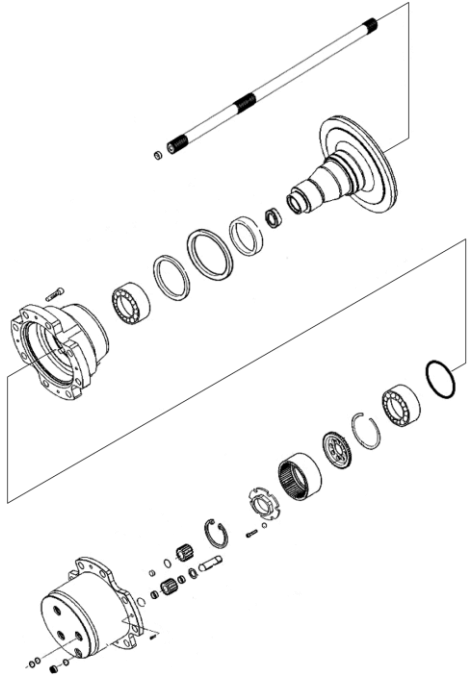
Front axle structure



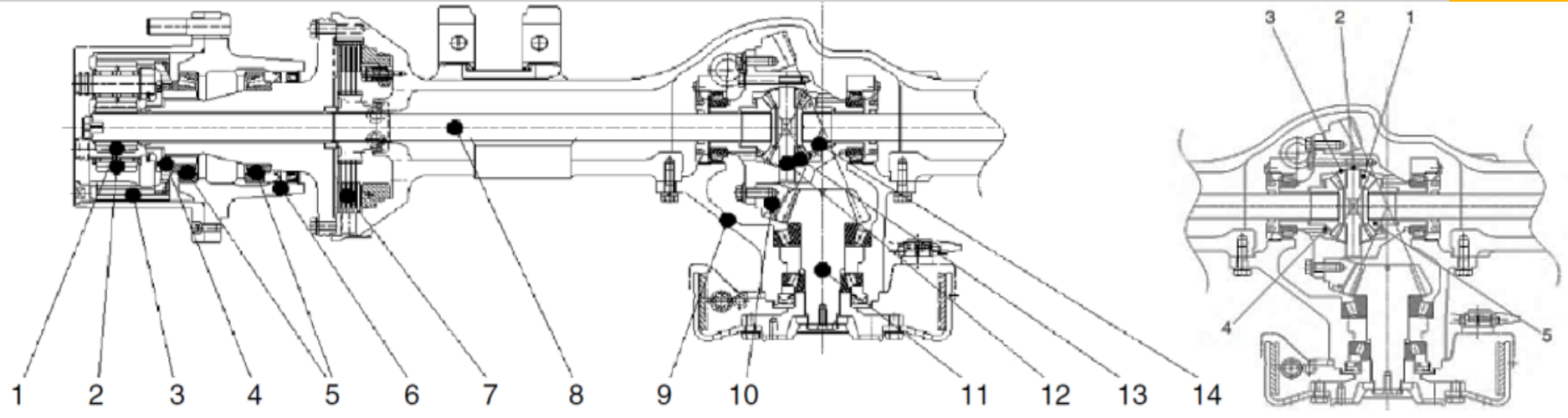
1. Diff. carrier ass'y
2. Drive shaft
3. Drive wheel
4. Disc brake
5. Parking brake







Front axle main components



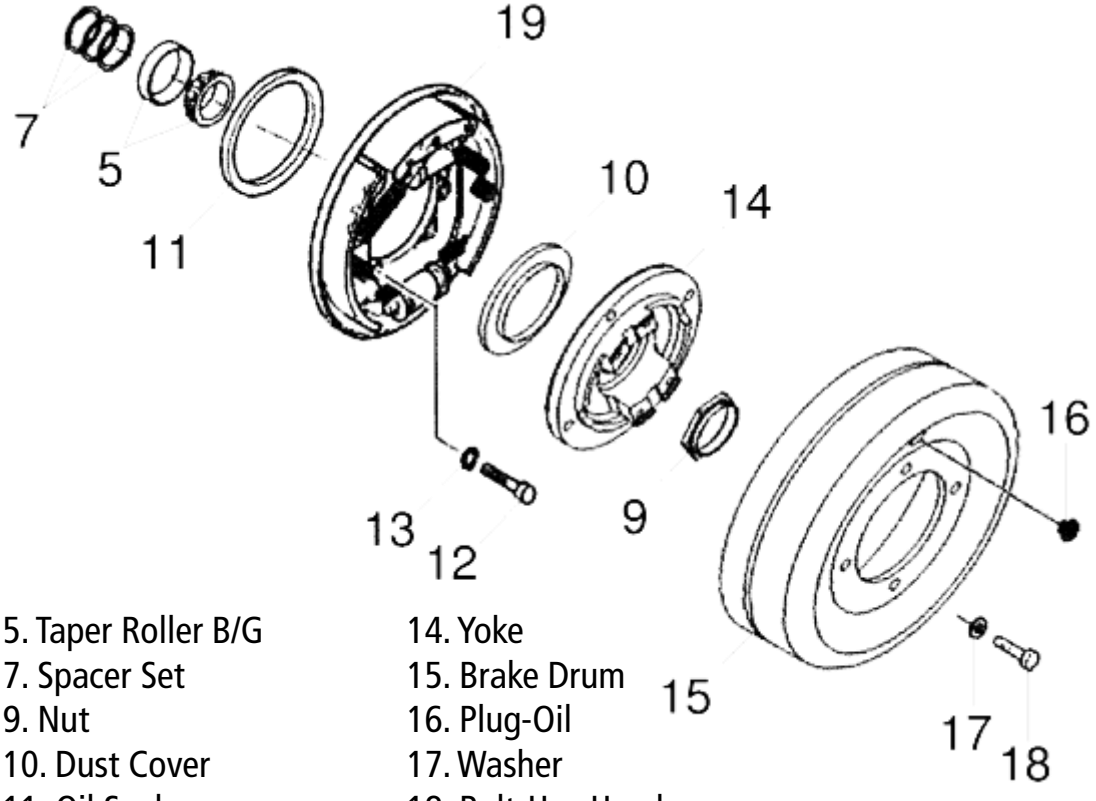
No	Item	Specification
1	Inner carrier	2.2±0.3kgf · m (15.9±2.2lbf · ft)
2	Spindle	12±0.5kgf · m (86.8±3.6lbf · ft)
3	Service piston	1.5±0.1kgf · m (10.8±0.7lbf · ft)
4	Adjuster nut	1.0±0.2kgf · m (7.2±1.4lbf · ft)
5	Differential cap	16±0.5kgf · m (116±3.6lbf · ft)
6	Differential case	6.0±0.5kgf · m (43.4±3.6lbf · ft)
7	Ring gear	13.5±0.5kgf · m (97.6±3.6lbf · ft)
8	Differential carrier assembly	18.0±0.5kgf · m (130±3.6lbf · ft)
9	Wheel hub rolling resistant	3.0±0.3kgf · m (21.7±2.2lbf · ft)
10	Parking brake	20.0±0.9kgf · m (144.7±6.5lbf · ft)
11	Brake drum	12.0±0.5kgf · m (86.8±3.6lbf · ft)

1. Sun gear
2. Planetary gear
3. Inner gear
4. Inner gear carrier
5. Tapered bearing
6. Hub assy
7. Disk brake
8. Drive shaft
9 Differential carrier assy
10. Ring gear
11. Pinion shaft
12. Spider
13. Differential pinion gear
14. Differential side gear

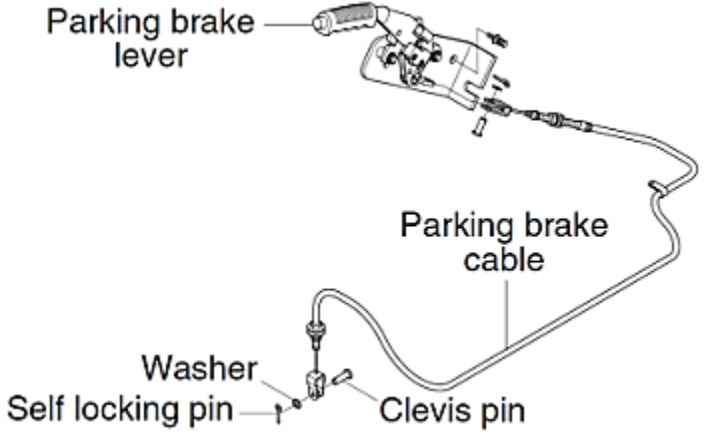
No	Item	Unit	Specification
1	Differential pinion gear inner diameter	mm(in)	20.000 - 20.021(0.787~0.788)
2	Spider outer diameter	mm(in)	19.959 - 19.980(0.786~0.787)
3	Pinion gear washer	mm(in)	1.92 - 2.08(0.076~0.082)
4	Side gear washer	mm(in)	1.95 - 2.05(0.077~0.081)
5	Side gear	-	-

Hand brake system

PARKING BRAKE - STRUCTURE



5. Taper Roller B/G
7. Spacer Set
9. Nut
10. Dust Cover
11. Oil Seal
12. Bolt
13. Washer Spring
14. Yoke
15. Brake Drum
16. Plug-Oil
17. Washer
18. Bolt-Hex Head
19. Brake Assy

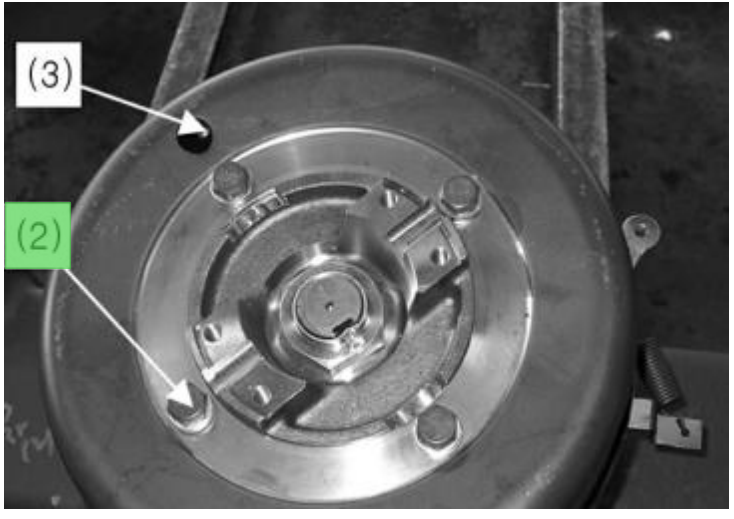


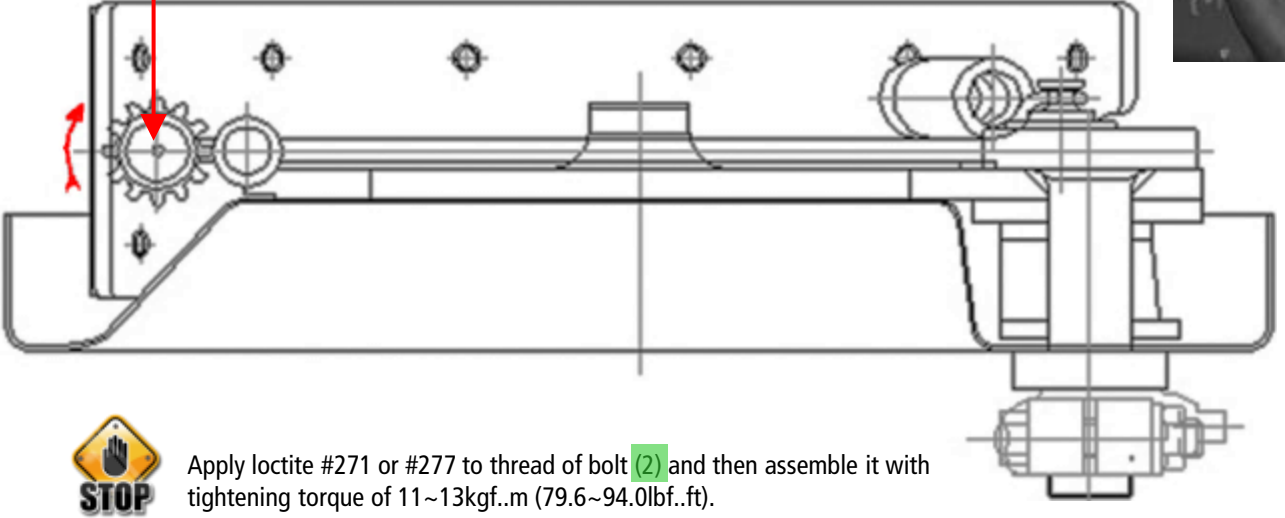
Hand brake system - PARKING BRAKE - ADJUSTMENT

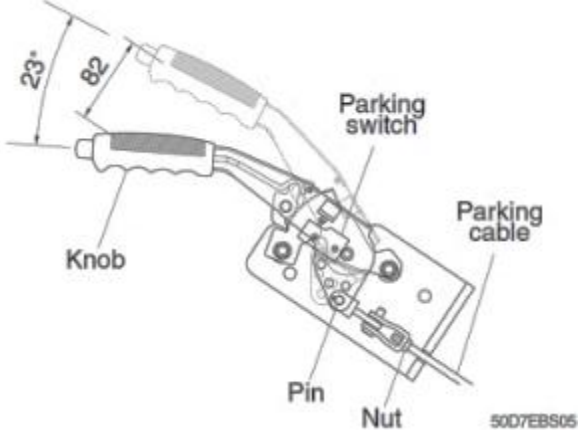
<u>The following procedures should be applied for brake shoe adjustment:</u>

1. Open rubber plug (3).
2. Adjuster should be turned according to *arrow direction* until occurring drum drag.
3. Adjuster should be turned *opposite direction* of the arrow sign by *4* clicks.
4. At that case, lining clearance is 0.1~0.25 mm.
5. Check drum drag after operating lever several times.

(Repeat from beginning if drag is occurred)



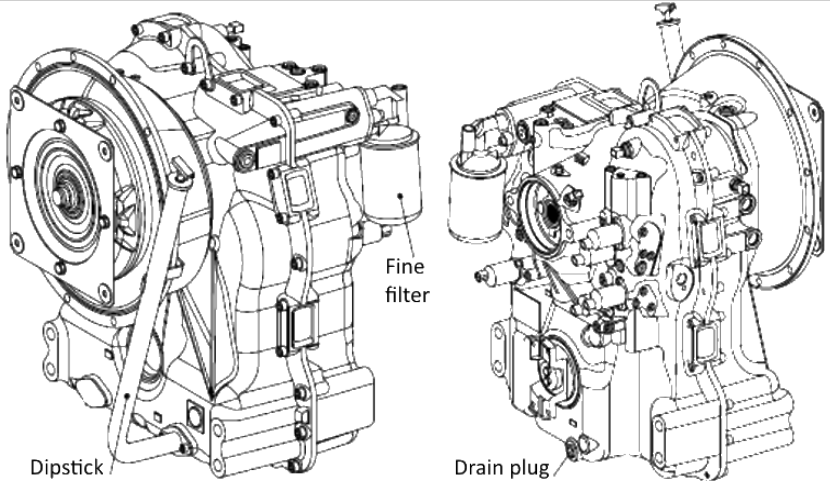


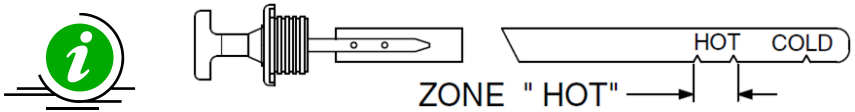


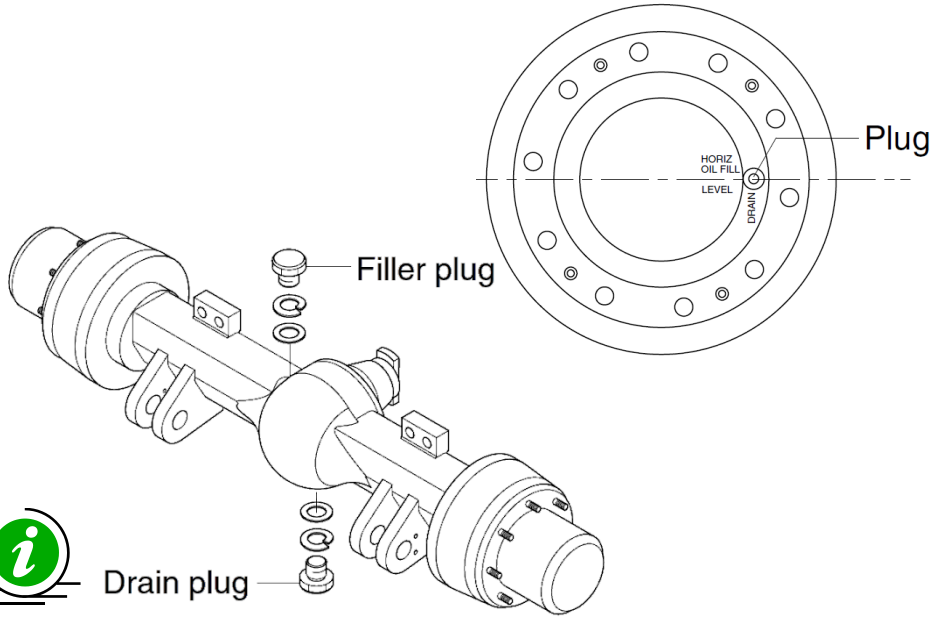
STOP

Apply loctite #271 or #277 to thread of bolt (2) and then assemble it with tightening torque of 11~13kgf..m (79.6~94.0lbf..ft).

Power train line – maintenance







T/M OIL – SHELL DONAX TD – ±18 L

CHECK DIPSTICK IN HOT CONDITION AND ENGINE RUNNING ON LOW IDLE !

SERVICE INTERVALS	
INITIAL 100 H	REPLACE OIL + FILTER
1000H / 6 MONTHS	REPLACE OIL + FILTER

GEAR OIL – SHELL DONAX TD – ±12.5 L CHECK LEVEL PLUG.

SERVICE INTERVALS	
INITIAL 100 H	REPLACE OIL
1000 H / 6 MONTHS	REPLACE OIL

Do not touch hot components or allow hot oil to contact your skin. Dispose of used oil in locally approved manner

Wet brake systems

BRAKE SYSTEM OUTLINE

P/SW TCU > rear brake lamps *(5Bar ±1)*

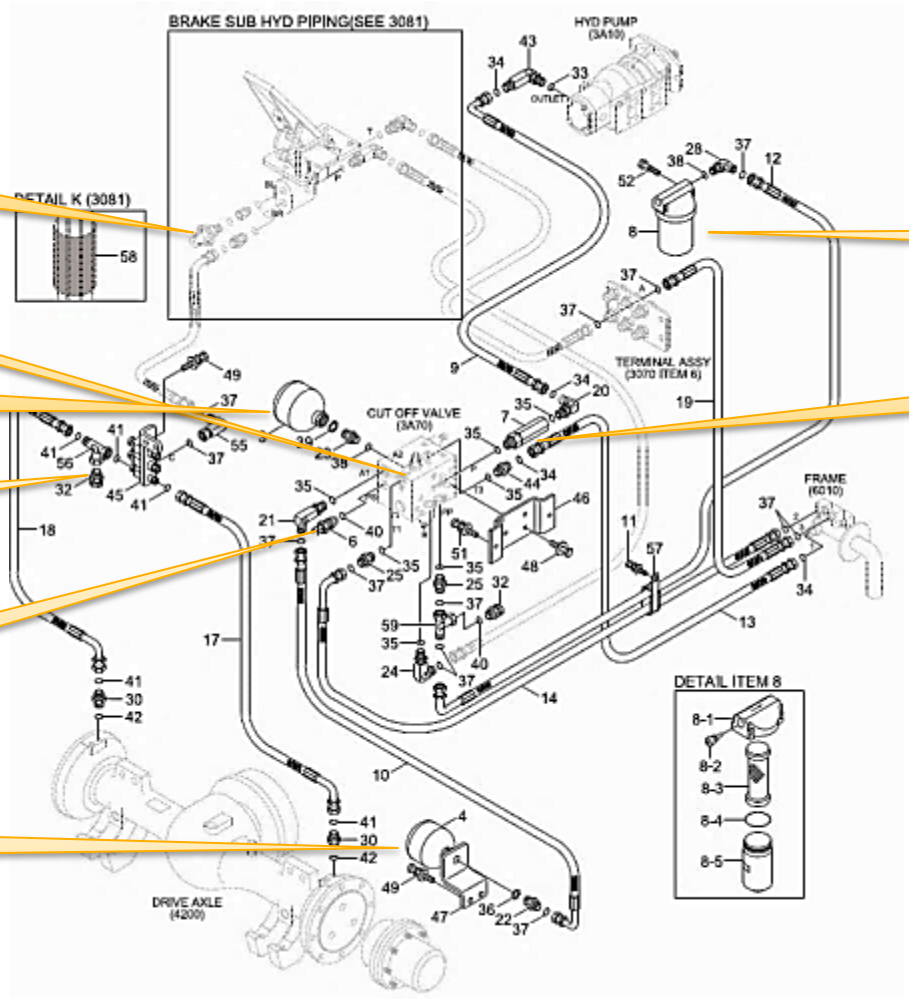
Cut Off valve

Accumulator on RCV pilot pressure

Pressure check port *(0 ÷150Bar)*

P/SW Charging (PS) *(95Bar ±5)*

Accumulator for brake system

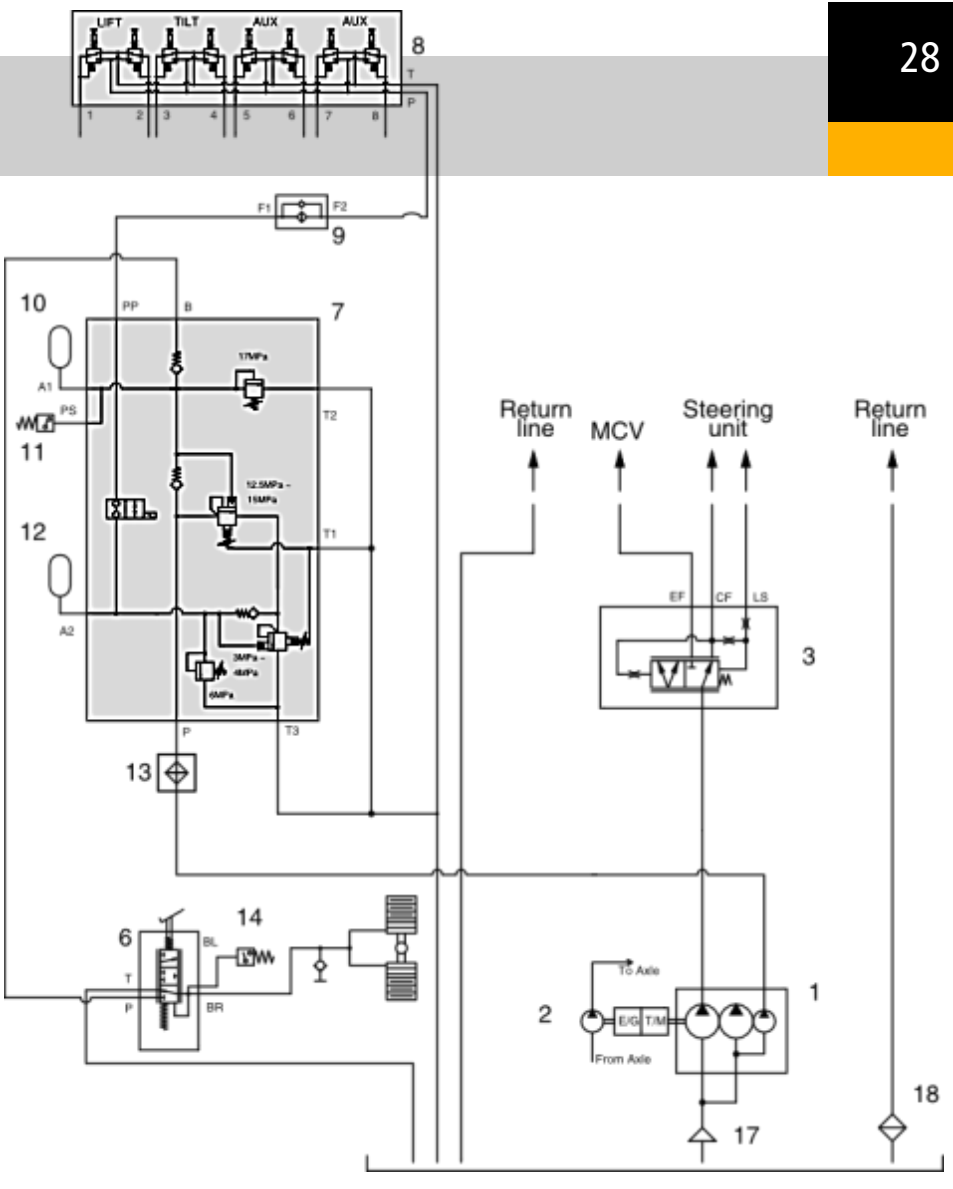


Filter on RCV pressure line

Line filter on "PP" of cut-off valve

BRAKE HYDRAULIC CIRCUIT

1. Main pumps.
2. Brake pump.
3. Priority valve.
6. Brake valve.
7. Cut-off valve.
8. RCV.
9. Line filter.
10. Accumulator (Brake system).
11. Pressure switch (Brake system).
12. Accumulator (RCV).
13. Line filter.
14. Pressure switch. (Stop Lamps/TCU input)
17. Strainer.
18. Return filter.

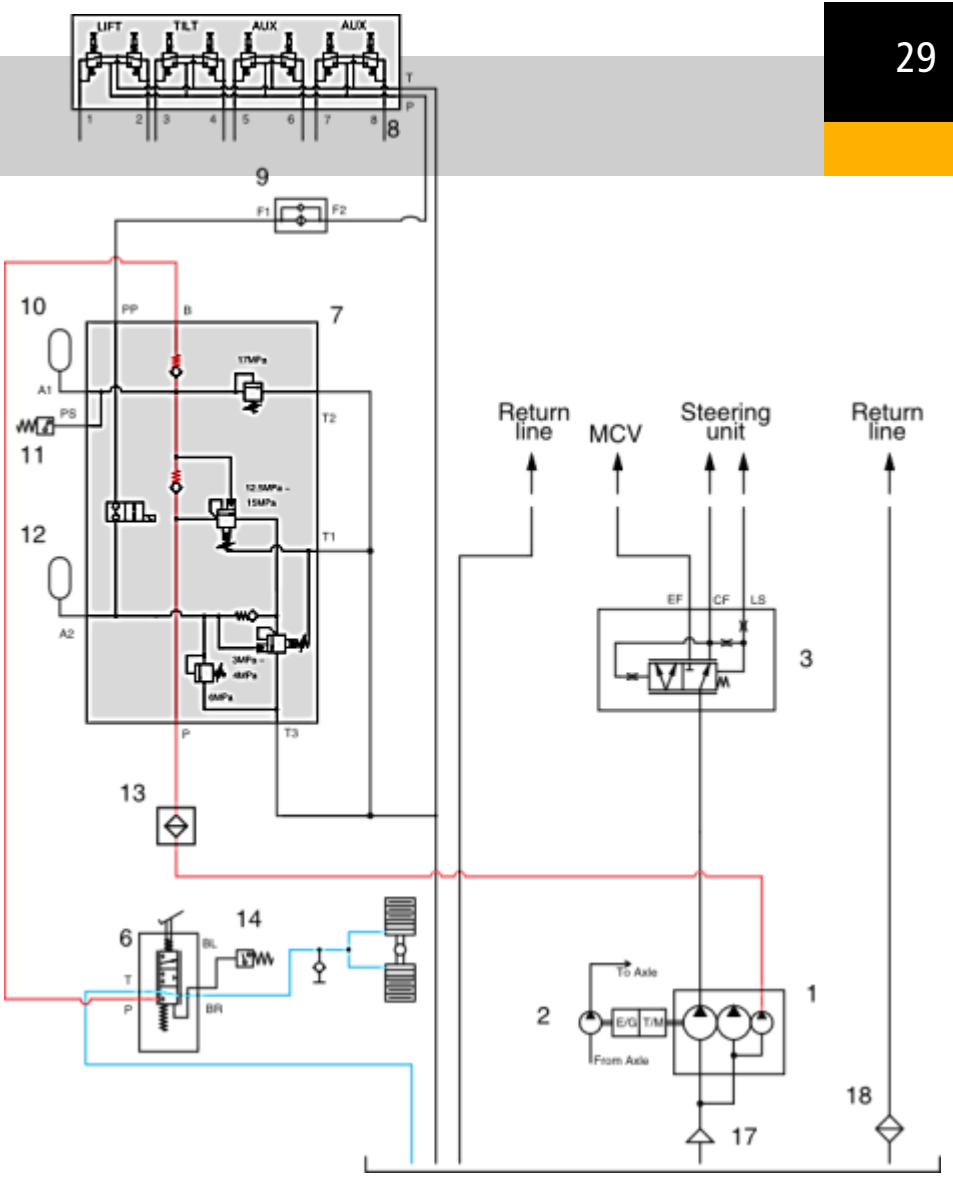


BRAKE HYDRAULIC CIRCUIT

SERVICE BRAKE RELEASED

- When the pedal of brake valve(6) is released, the operating force is eliminated by the force of the spring, and the spool is returned.

- When the spool removes up, the drain port is opened and the hydraulic oil in the piston of axles return to the tank. Therefore the service brake is kept released.



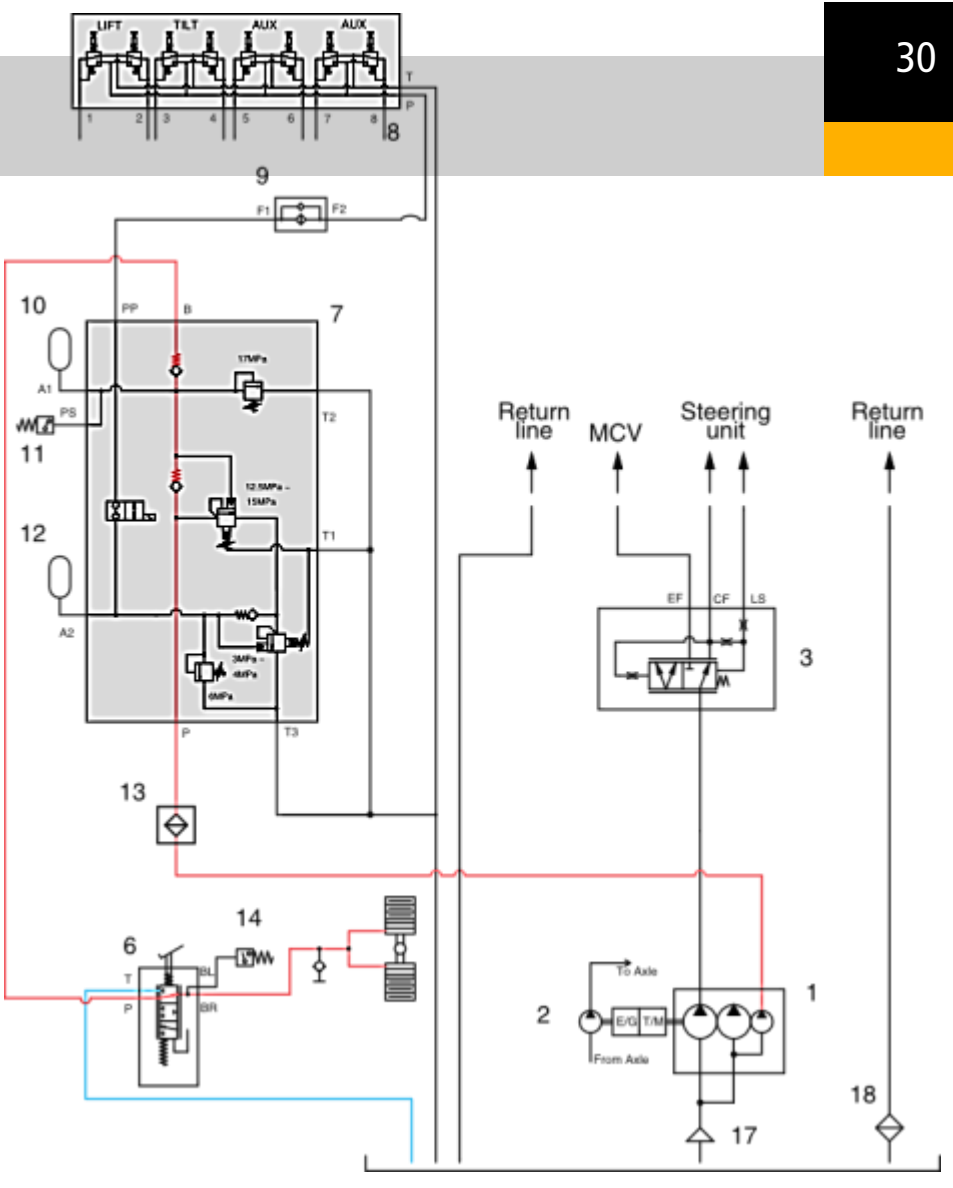
BRAKE HYDRAULIC CIRCUIT

SERVICE BRAKE OPERATED

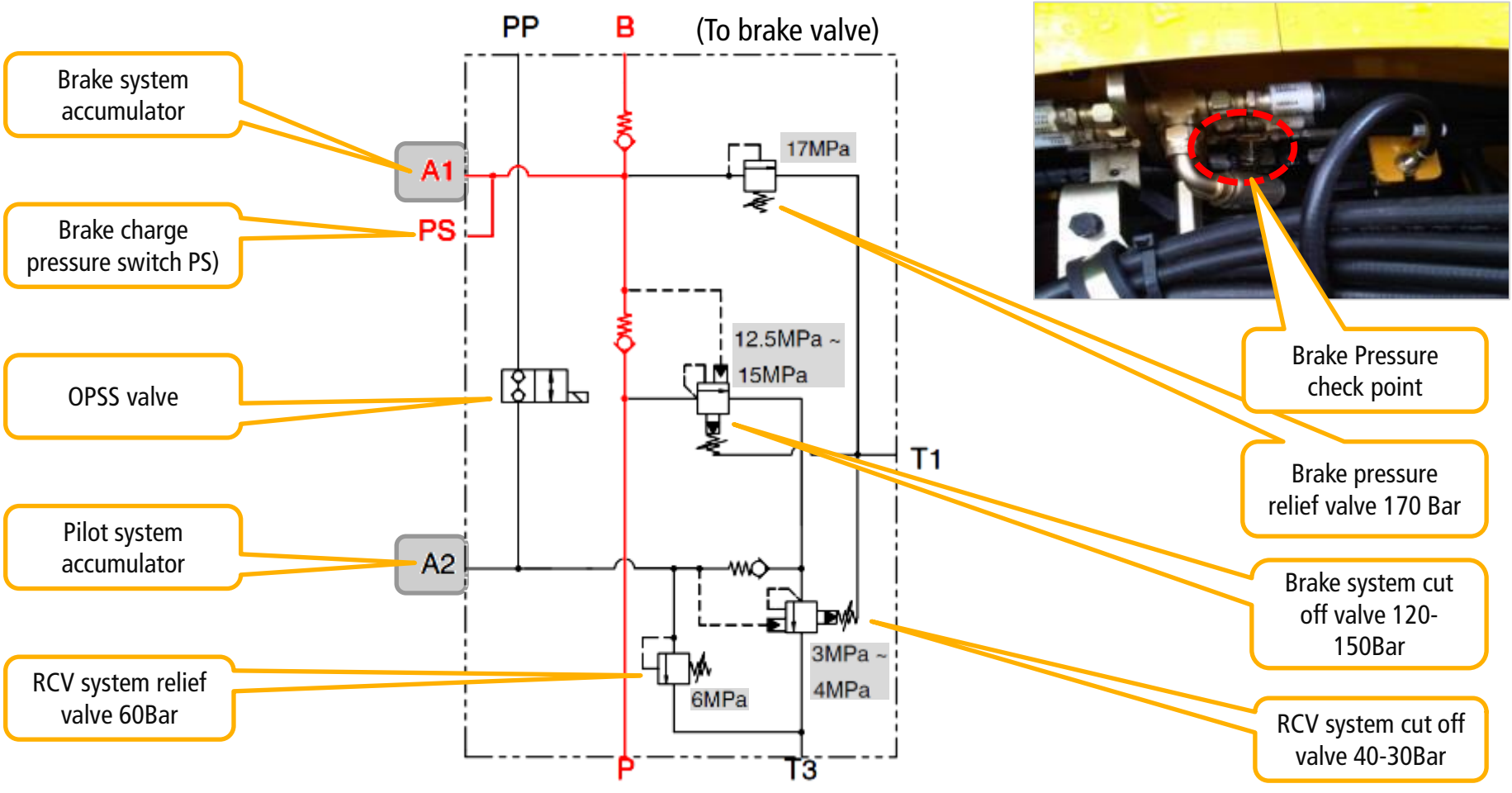
- When the pedal of brake valve(6) is pressed, the operating force overcomes the force of the spring and is transmitted to the spool.

- When the spool moves down, the inlet port is opened, and at the same time the hydraulic oil controlled by the cut-off valve(7) enters the pistons in the front axle.

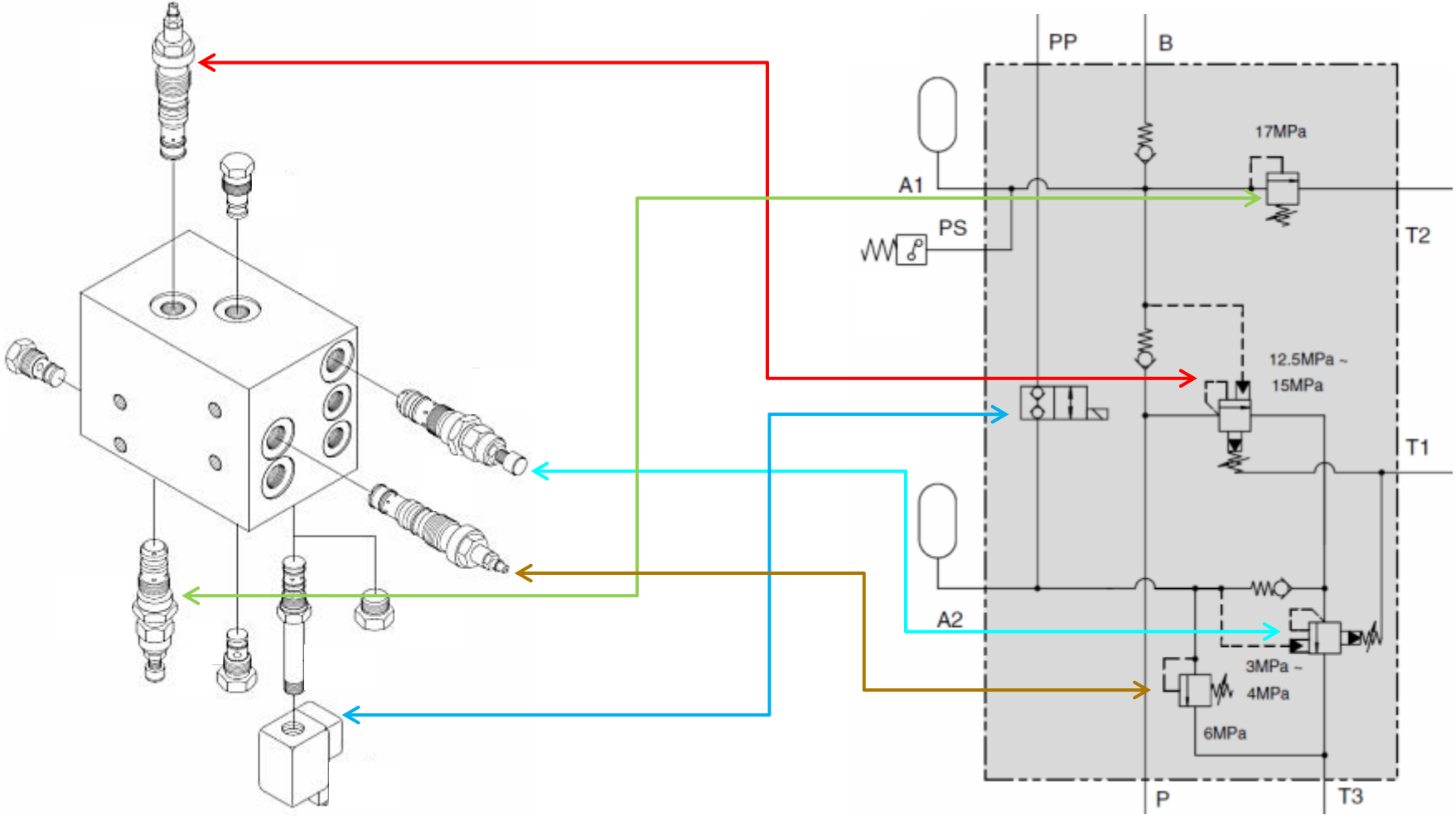
Therefore, the service brake is applied.



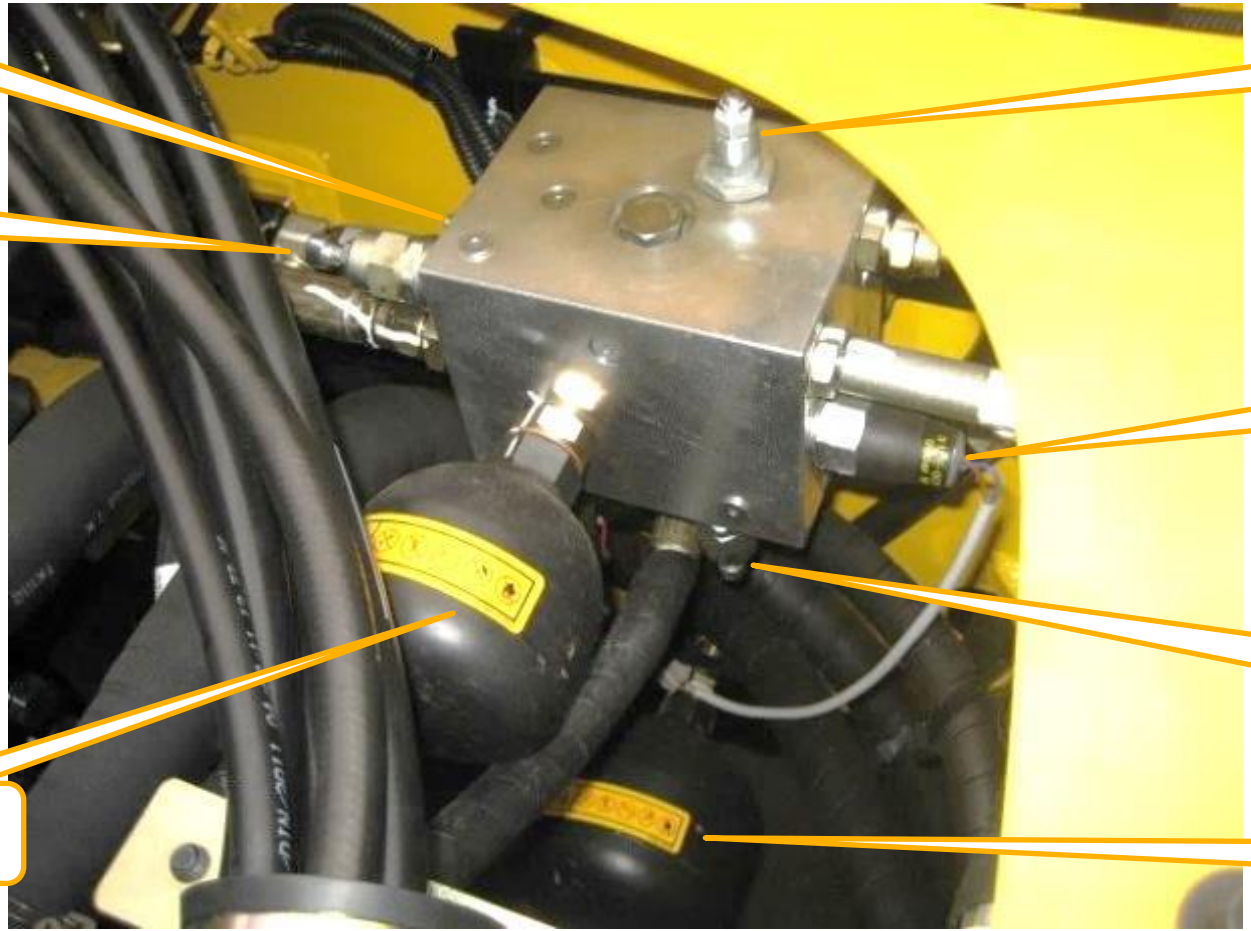
CUT-OFF VALVE – HYDRAULIC DIAGRAM



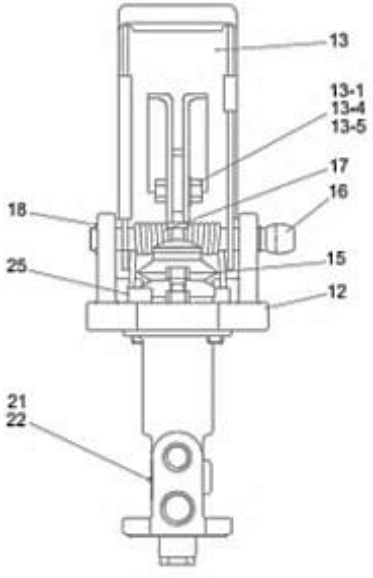
CUT-OFF VALVE – STRUCTURE

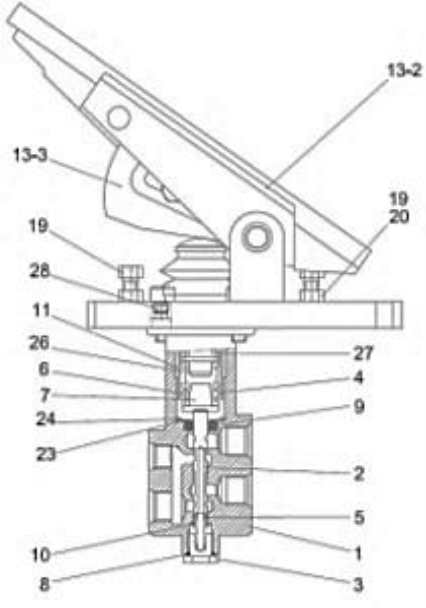


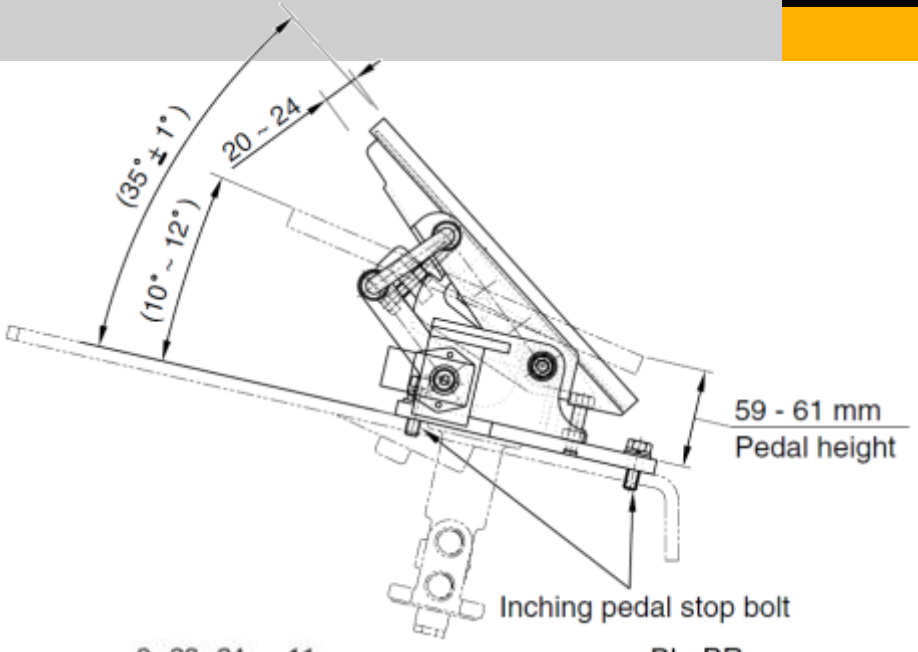
CUT-OFF VALVE – VIEW



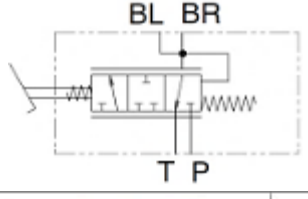
BRAKE VALVE - STRUCTURE







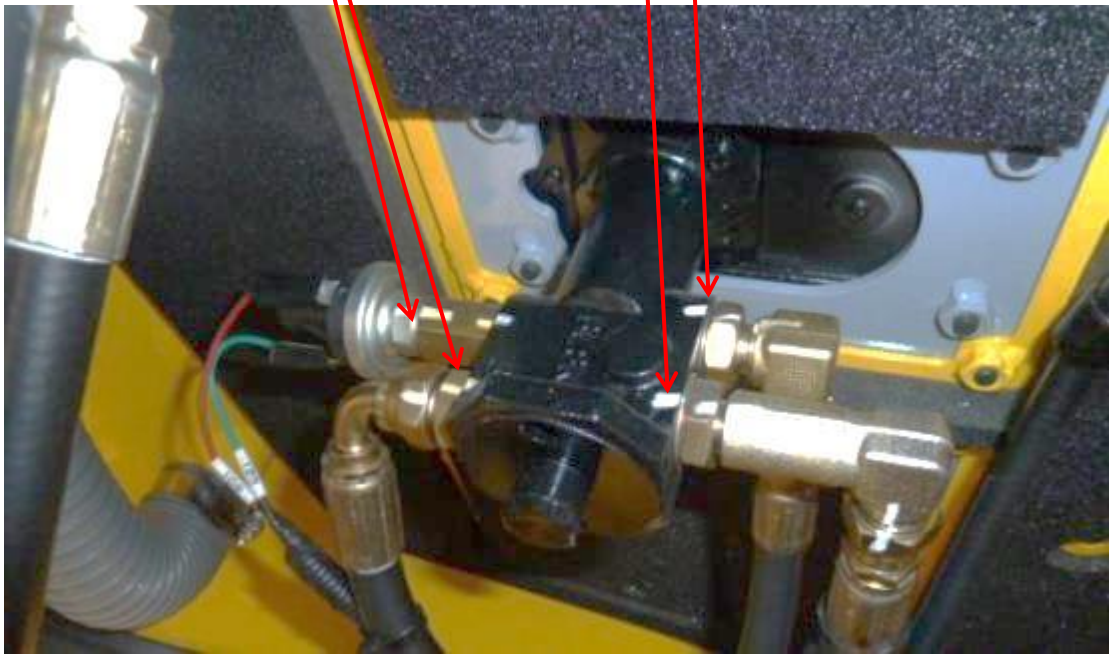
1. Body
2. Spool
3.Plug
4. Holder(piston)
5. Lower spring
6. Main spring
7. Spring retainer
8. O-ring
9 .Oil seal
10 .Snap ring
11. Du bushing
12. Pedal plate
13. Pedal assembly
13-1. Pedal
13-2. Rubber
13-3. Lock plate
13-4. Hexagon bolt
13-5. Plate washer
15. Bellows
16. Lock pin 1
17. Torsion spring
18. Snap ring
19. Hexagon bolt
20. Hexagon nut
23. Plain washer
24. Snap ring
25. Bolt
26. Taper plug

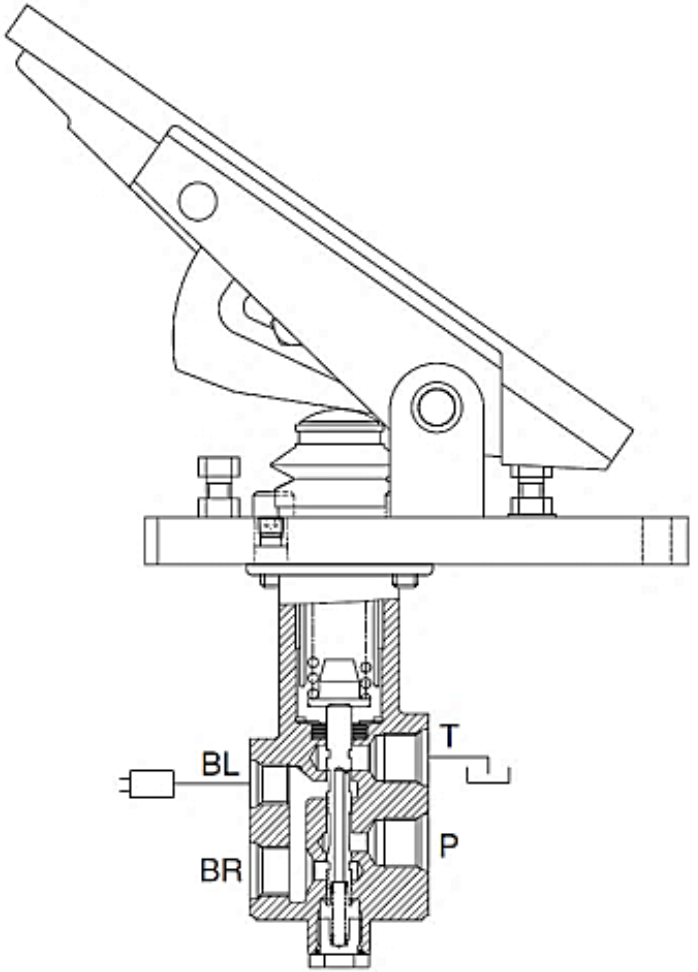


Port	Port name	Port size
P	Main pressure port	PF3/8
T	Drain port	PF3/8
BR	Brake cylinder port	PF3/8
BL	Pressure switch port	PF1/4

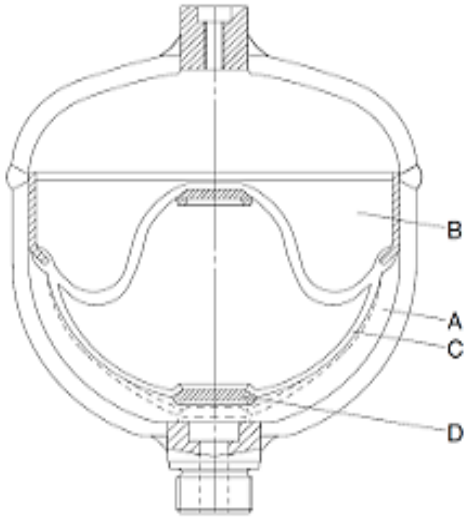
BRAKE VALVE - STRUCTURE

Port	Port name	Port size
P	Main pressure port	PF3/8
T	Drain port	PF3/8
BR	Brake cylinder port	PF3/8
BL	Pressure switch port	PF1/4



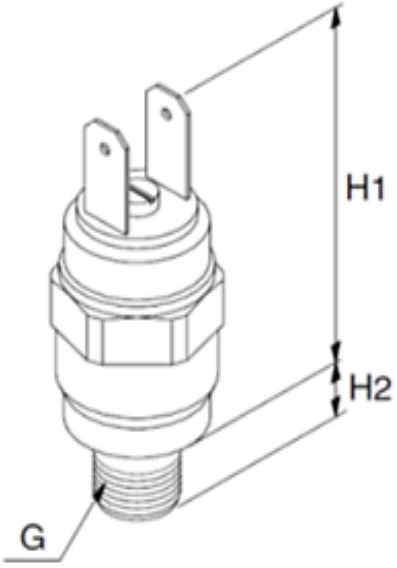


BRAKE ACCUMULATOR and PRESSURE SWITCH

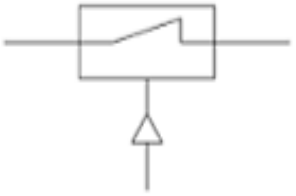


Item	81L1-0004
Diameter	110mm
Mounting height	164mm
Nominal volume	0.7 ℓ
Priming pressure	50kgf/cm²
Operating medium	Oil
Operating pressure	Max 150kgf/cm²
Thread	M18 × 1.5
Priming gas	Nitrogen

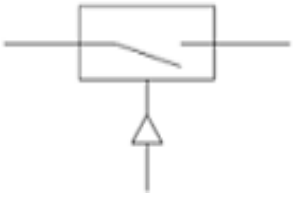
A Fluid portion C Diaphragm
B Gas portion D Valve disk



- Normally closed



- Normally open



The accumulator consists of a fluid portion (A) and a gas portion (B) with a diaphragm (C) as a gas-tight dividing element. The fluid portion (A) is connected to the hydraulic circuit, causing the diaphragm accumulator to be filled and the gas volume to be compressed as the pressure rises.
When the pressure falls, the compressed gas volume will expand, thus displacing the accumulated pressure fluid into the circuit.
The diaphragm bottom contains a valve disk (D) which, if the diaphragm accumulator is completely empty, closes the hydraulic outlet, thus preventing damage to the diaphragm.

· **Technical data**

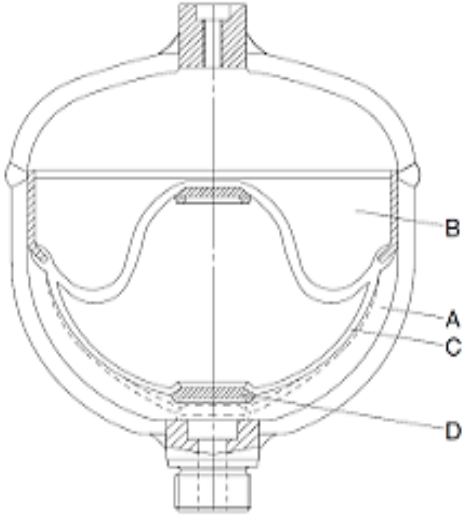
Item	Type	Medium	G	H1 mm	H2 mm	Adjusting range kgf/cm²	Adjusting pressure kgf/cm²	Voltage V
Charging	NC	Oil	M12 × 1.5	46	9	50 ~ 150	95 ± 5	Max 42
Brake stop	NO	Oil	M12 × 1.5	46	9	1~10	5 ± 1	Max 42

NC : Normally closed NO : Normally open

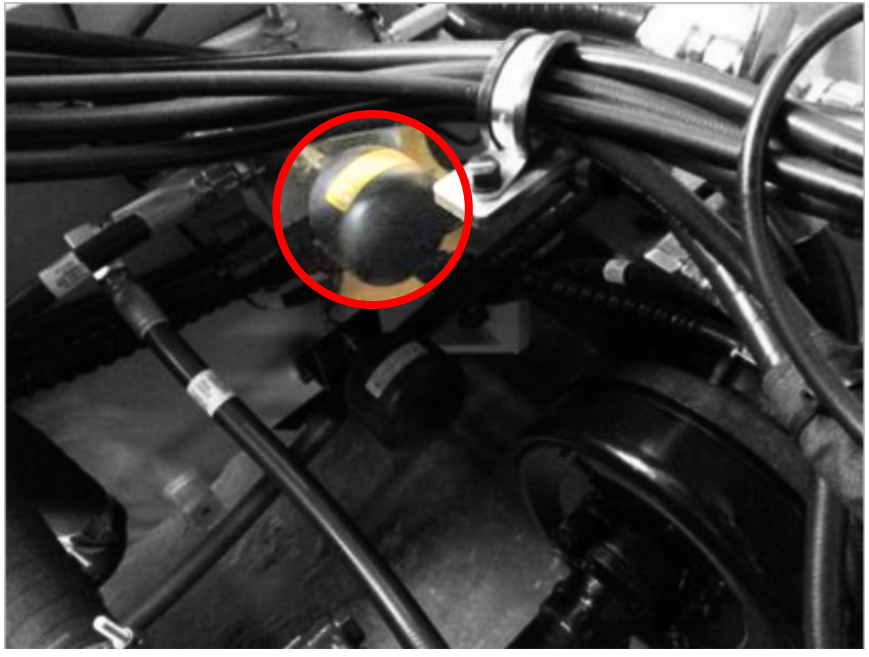
For safety reasons the accumulators need to be replaced as a whole if damaged

When working on the braking system, always make sure that there is absolutely no pressure in the system. Even when the engine is switched off there will be some residual pressure in the system.

RCV ACCUMULATOR



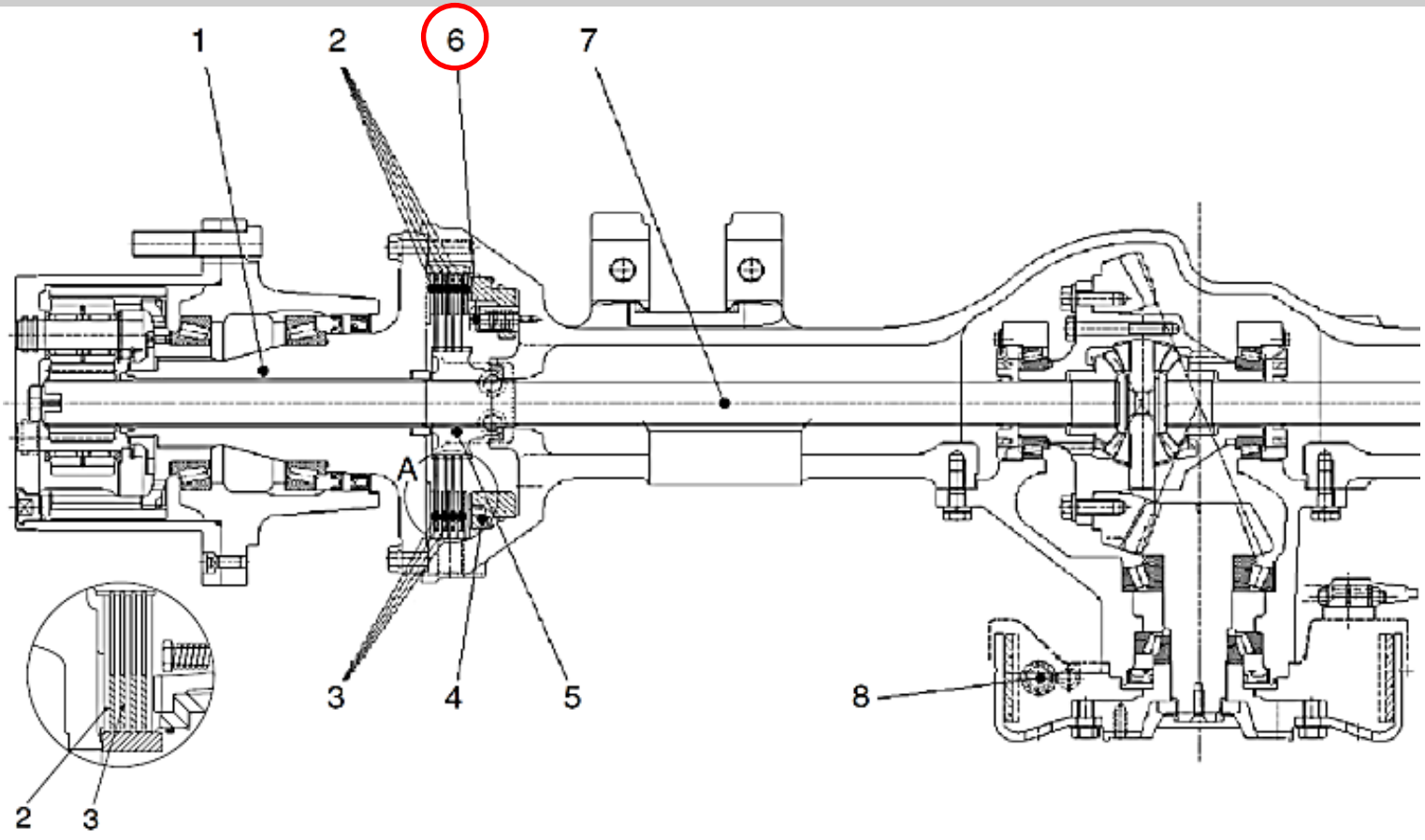
Item	31E3-3187
Diameter	90 mm
Mounting height	124 mm
Nominal volume	350 cc
Priming pressure	15 kg/cm^2
Operating medium	oil
Operating pressure	max 170 kg/cm^2
Thread	M8x1.5; G1/2
Priming gas	Nitrogen



The accumulator consists of a fluid portion (A) and a gas portion (B) with a diaphragm (C) as a gas-tight dividing element. The fluid portion (A) is connected to the hydraulic circuit, causing the diaphragm accumulator to be filled and the gas volume to be compressed as the pressure rises.
When the pressure falls, the compressed gas volume will expand, thus displacing the accumulated pressure fluid into the circuit.
The diaphragm bottom contains a valve disk (D) which, if the diaphragm accumulator is completely empty, closes the hydraulic outlet, thus preventing damage to the diaphragm.

For safety reasons the accumulators need to be replaced as a whole if damaged

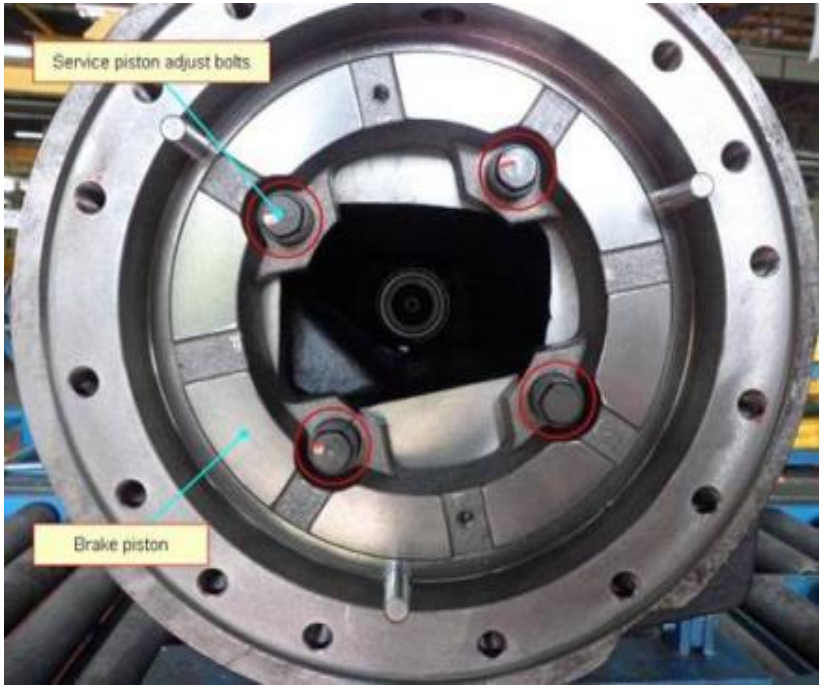
BRAKES (WHEEL)



1. Spindle
2. Steel plate
3. Disk plate
4. Service piston
5. Service collar
6. Service piston adjust bolt
7. Drive shaft
8. Parking brake

Sealed up structure of hydraulic multi-disk brake system secures good brake performance even in the high humid or dusty area.
Because it is possible to use the brake semi-permanently, there is no need to maintain its lining as drum type brake do.
Also with self-adjust of friction plate clearance, it's easy to prevent the brake performance drop due to friction material wear.

BRAKES (WHEEL)

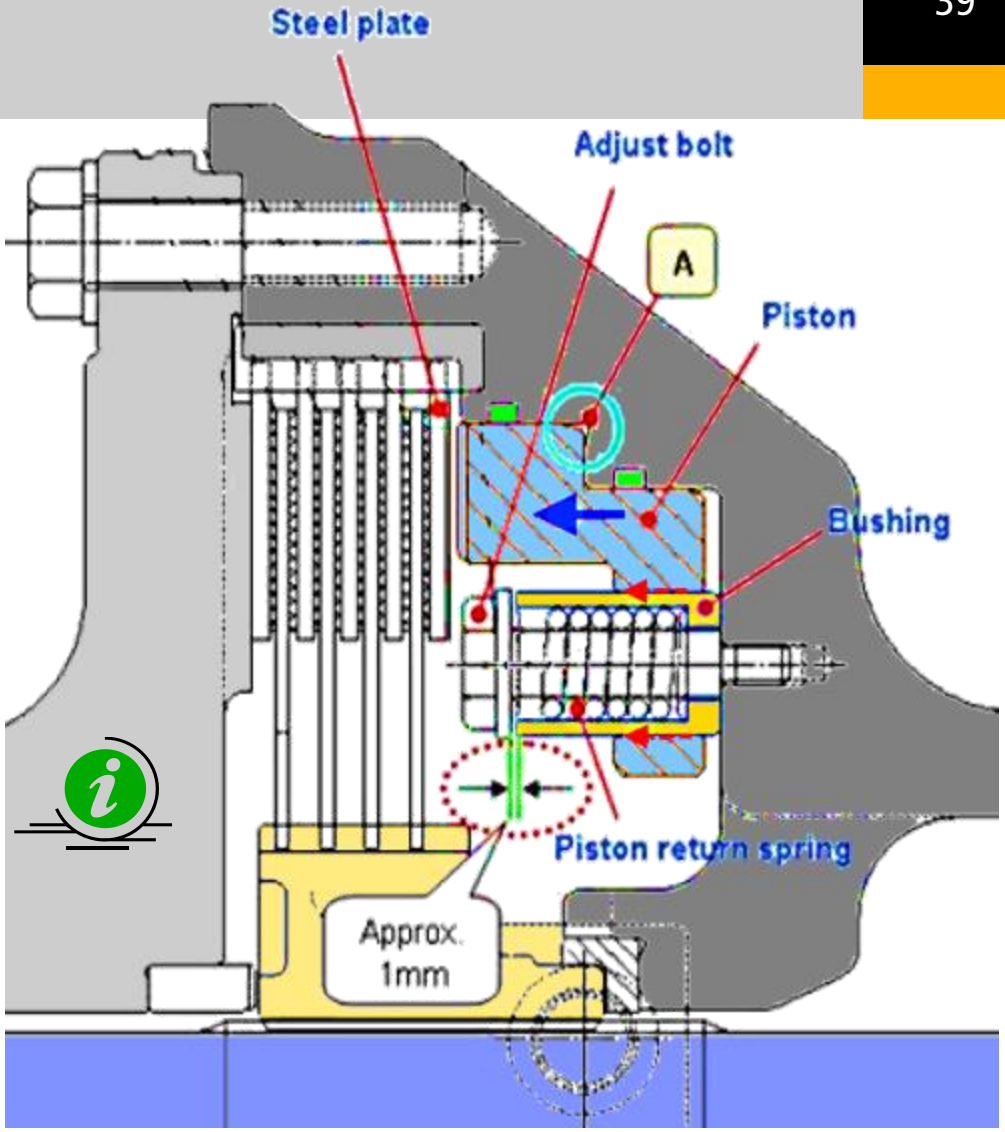


• **Condition that brake discs become worn out.**

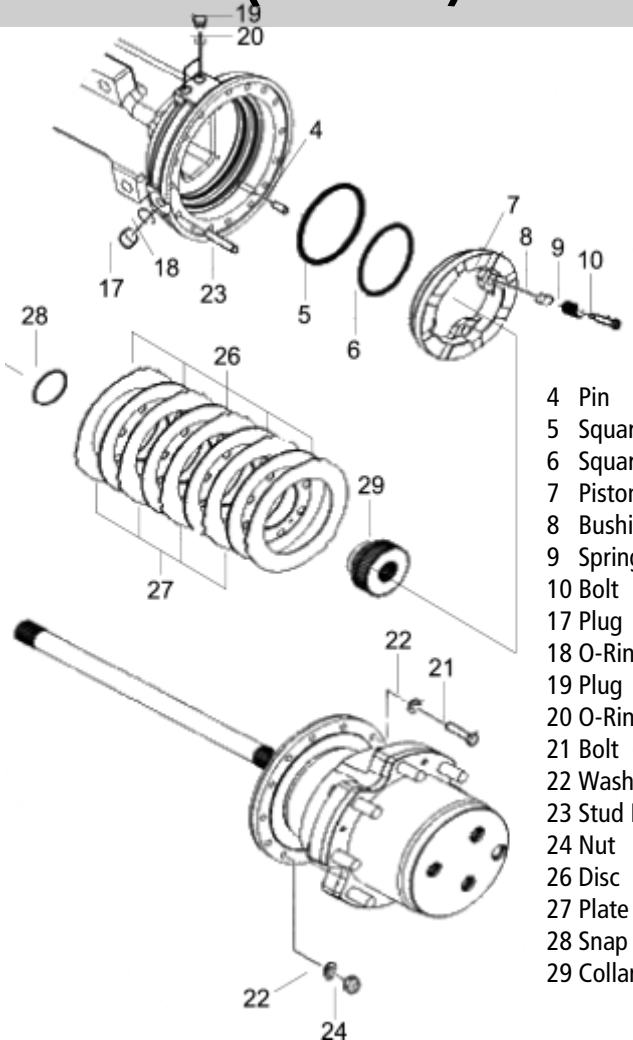
Then, the distance between disc plate and piston will be increased, which will also request piston to travel more for brake activation.

But, before piston moves to left more, travel distance for bushing is quite limited and will soon stopped.

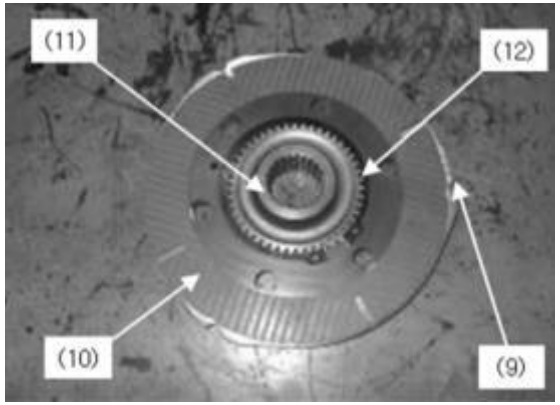
In this stage, piston will be slipped on bushing in order to move left more for brake activation thanks to brake oil pressure



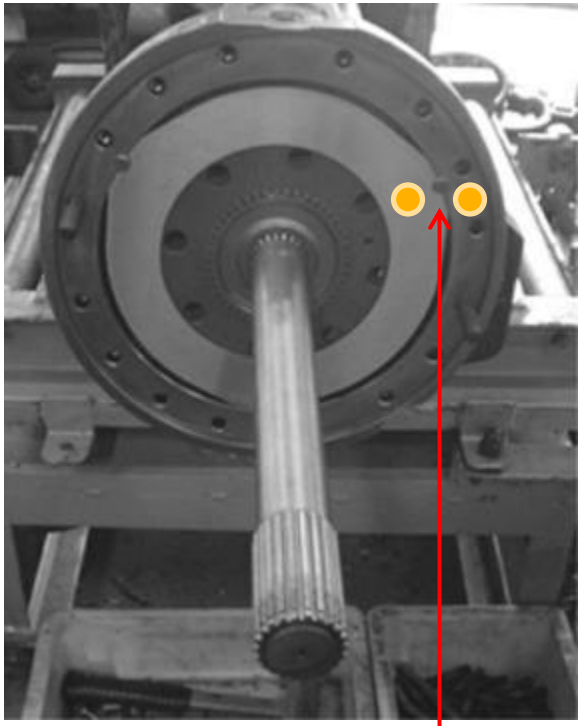
BRAKES (WHEEL)



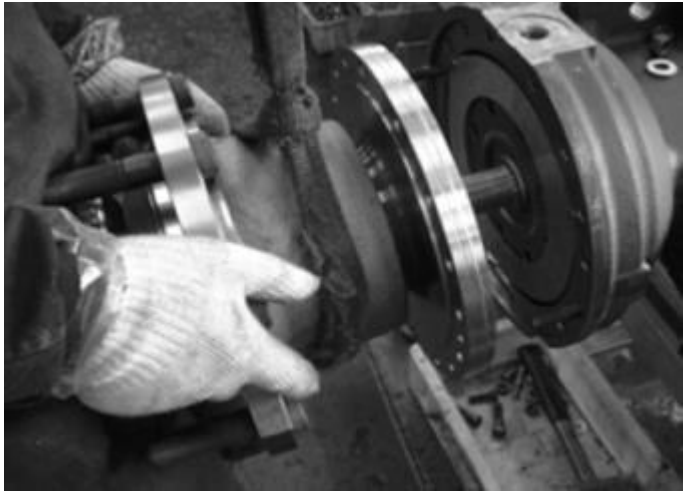
4 Pin
5 Square Ring(S)
6 Square Ring(S)
7 Piston-Brake
8 Bushing
9 Spring
10 Bolt
17 Plug
18 O-Ring
19 Plug
20 O-Ring
21 Bolt
22 Washer
23 Stud Bolt
24 Nut
26 Disc
27 Plate
28 Snap Ring
29 Collar-Spline



1. Assemble 5 plates(9) and 4 disks(10) with spline collar(11) and then lock with snap ring (12). Disc must be assembled after dipping during 12 hours in axle oil.
2. Install assembled spline collar to the axle housing with the drive shaft. Before assembling, clean all of the parts completely and remove burrs.
3. After assembling, confirm that the clearance between the outer plate and the axle housing surface is 2.1~2.6mm (0.08~0.10in).

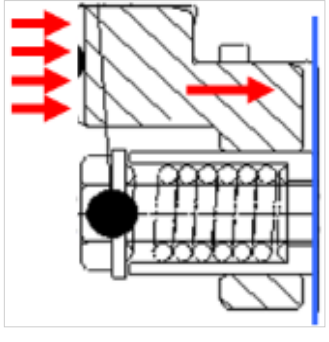


BRAKES (WHEEL) - ASSEMBLING AND INSPECTION



- Push pre-assembled wheel hub to the axle housing until contact take places.

-Tighten the torque plate until the wheel hub assembly has the same rolling resistance as before.

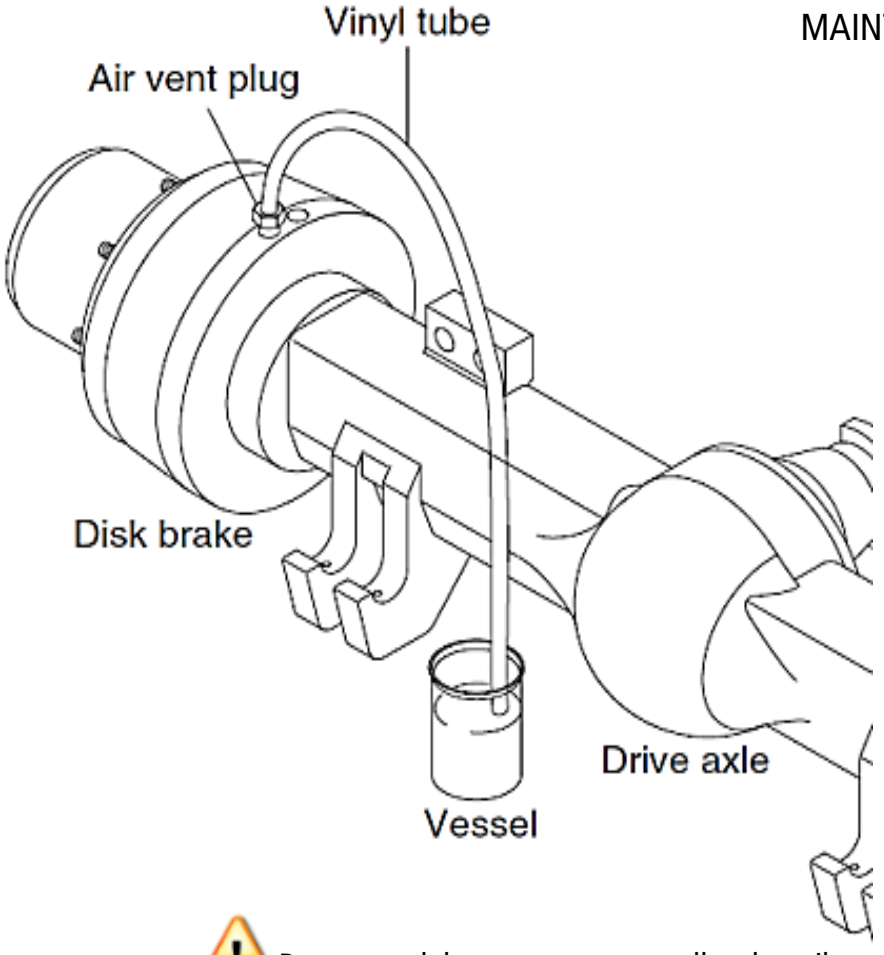


- Apply loctite #271 or #277 to thread of bolt and then assemble it with tightening torque of 18~22kgf·m(130.2~159.1lbf·ft).

Here is what we have to do for the disc replacement.
- In order to take out the piston, we have to un-tight the (4)bolts.
- Then, we have bushing and piston that are assembled together.
- We make the piston **move to the right** so that it can **be flat with bushing**. (See left pic).

If not, there will be no initial clearance between piston and plates.

BRAKES



MAINTENANCE

1. Air bleeding should be performed by two persons:
   One rides on truck for depressing and releasing brake pedal
   The other person is on the ground and removes cap from air vent plug on wheel cylinder.
2. Block the front wheel securely and apply parking brake.
3. Start the engine.
4. Attach a vinyl tube to air vent plug and immerse other end of tube into a vessel filled with hydraulic oil.
5. Loosen air vent plug by turning it 3/4 with a wrench. Depress brake pedal to drain oil mixed with air bubbles from plug hole.
6. Depress brake pedal until no air bubbles come out of air vent plug hole.
7. After completion of air bleeding, securely tighten air vent plug. Install cap on plug.
8. Same way for the opposite side.

BRAKE OIL = HYDRAULIC OIL

SERVICE INTERVALS	
2000 H	REPLACE OIL

Do not touch hot components or allow hot oil to contact your skin. Dispose of used oil in locally approved manner

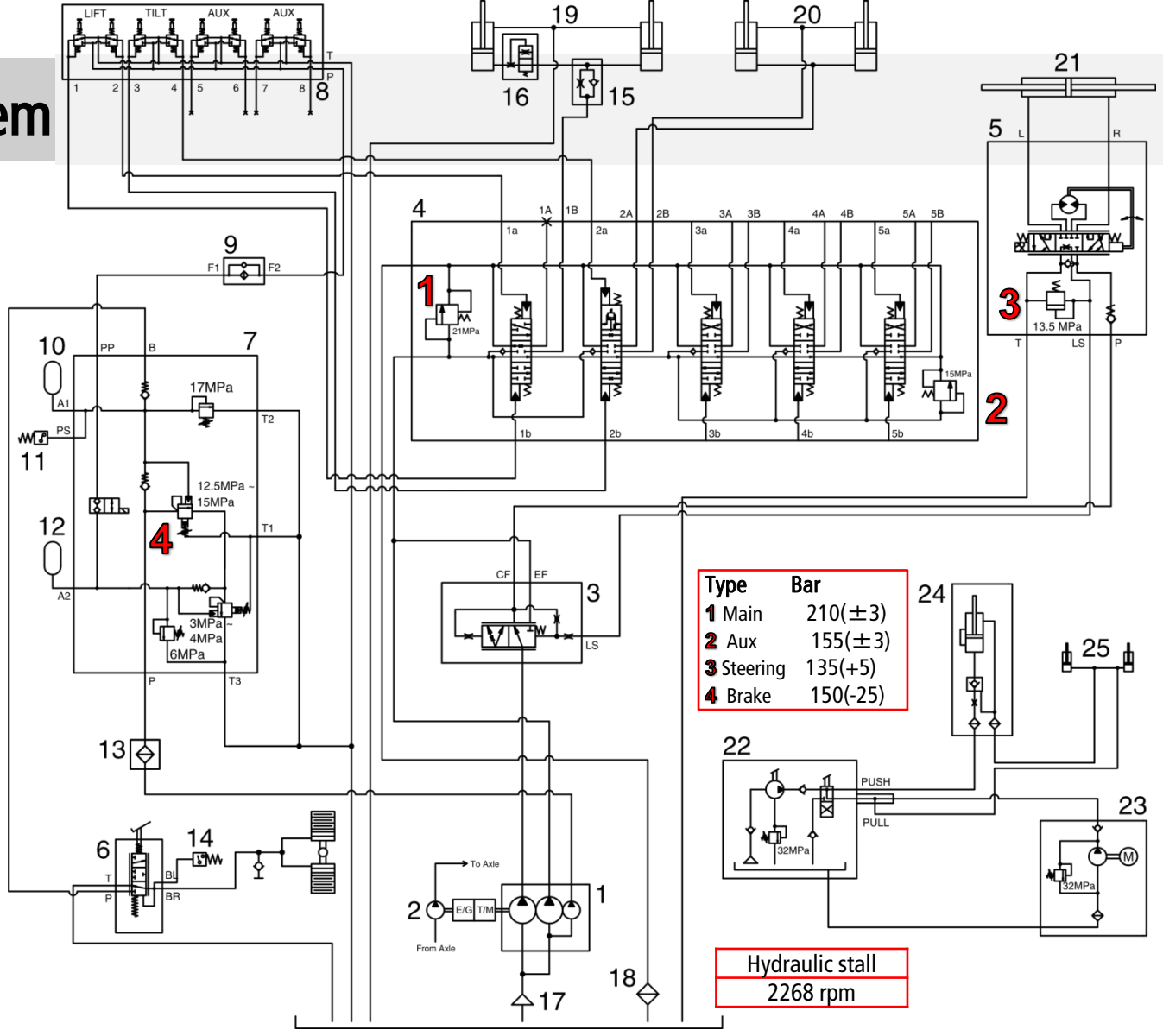
Hydraulic systems

Hydraulic Systems

- Brake circuit – see chapter Wet Brake System
- Main hydraulic circuit
  - Pilot circuit
- Power steering circuit
- Cabin tilting system

Hydraulic System

1 Hydraulic gear pump
2 Axle cooling pump
3 Priority valve
4 Main control valve
5 Steering unit
6 Brake valve
7 Cut-off valve
8 Remote control valve RCV
9 Pilot line filter
10 Brake accumulator
11 Pressure switch
12 RCV accumulator
13 Line filter
14 Pressure switch
15 Down control valve
16 Down safety valve
17 Strainer
18 Return filter
19 Lift cylinder
20 Tilt cylinder
21 Steering cylinder
22 Hand pump
23 Elec pump
24 Cab tilt cylinder
25 Latch



Type	Bar
1 Main	210(±3)
2 Aux	155(±3)
3 Steering	135(+5)
4 Brake	150(-25)

Hydraulic stall
2268 rpm

Hydraulic System - components

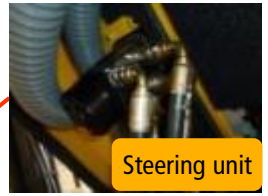

RCV


Pilot line filter


Cutt-off valve

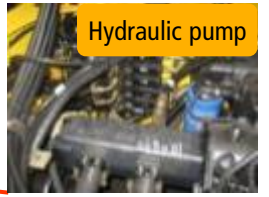

Line filter

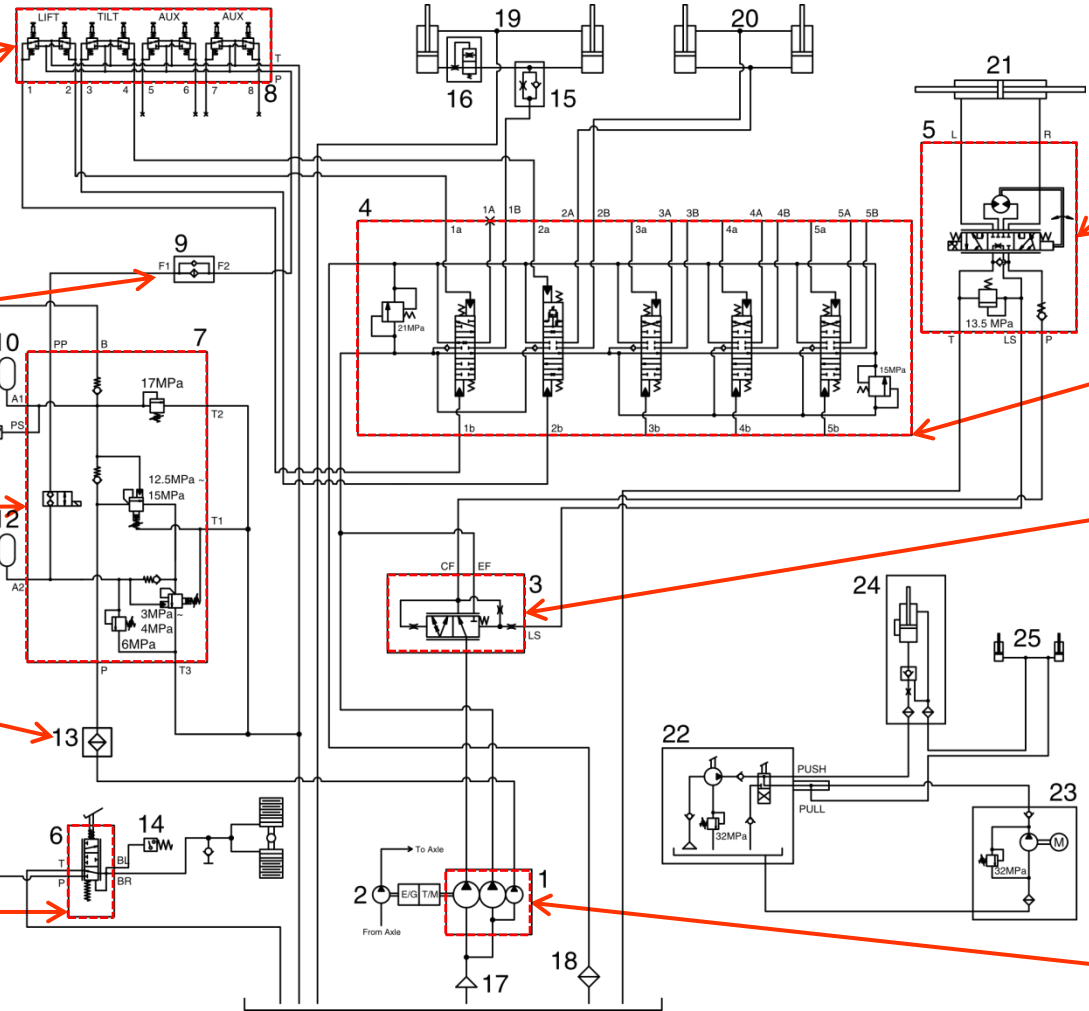

Brake valve


Steering unit

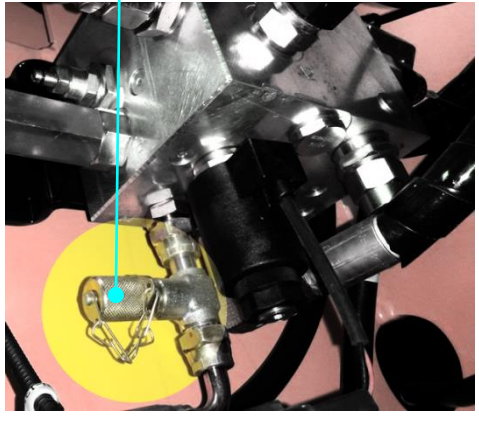

MCV

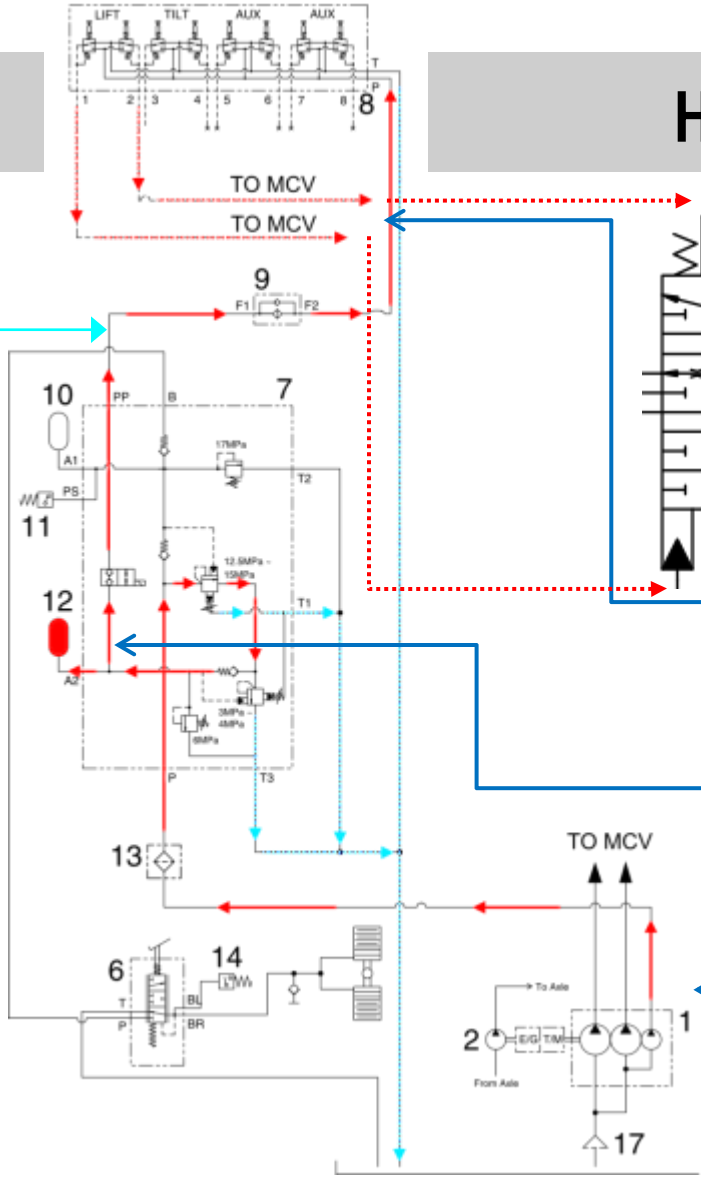

Priority valve


Hydraulic pump



Hydraulic Pilot System



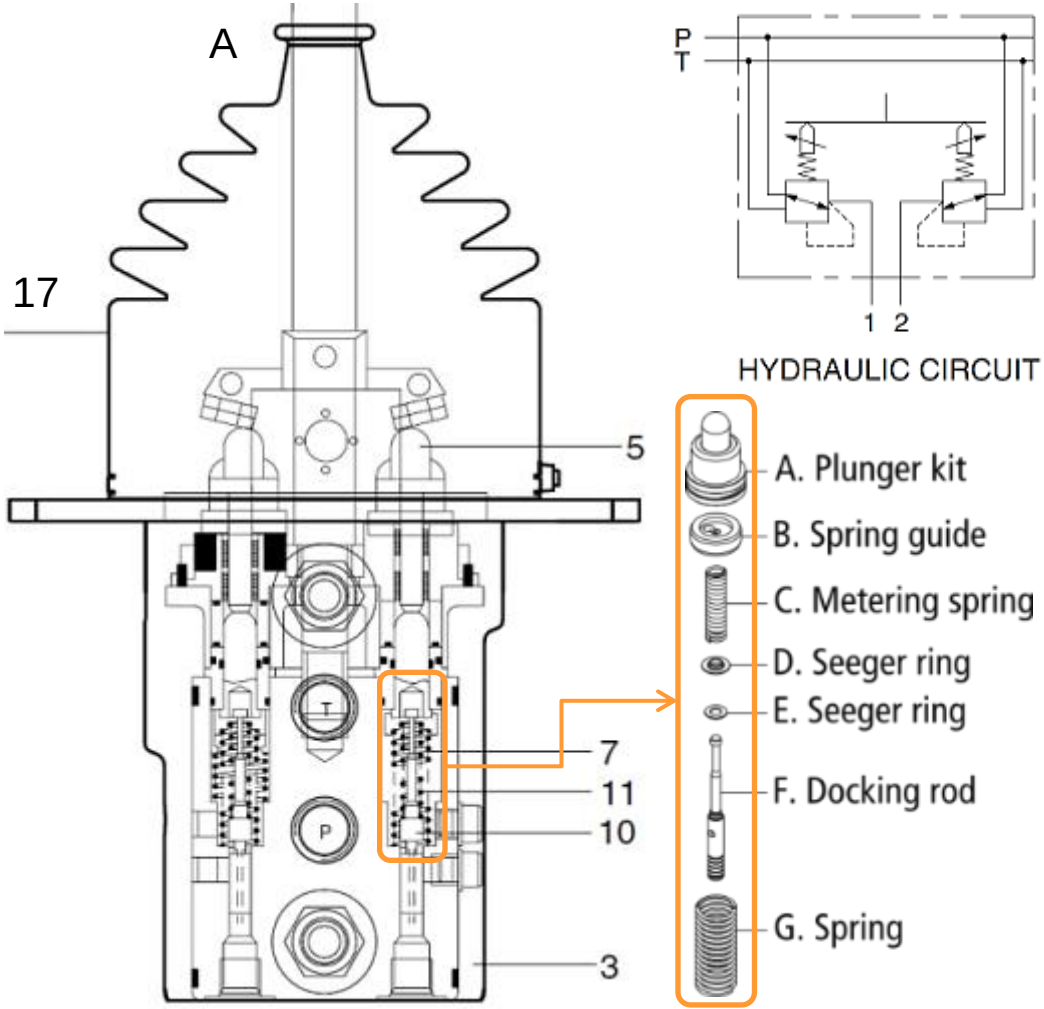


When this happens MCV spool is moving against the spring tension and directing oil to the cylinders.

The oil from accumulator line goes to RCV spool where is directed by lever movement to the MCV spool lines

The oil from hydraulic gear pump(1) flows through line filter (13) and then goes to the brake cut-off valve (120-150 bar) and RCV cut-off valve (30-40 bar) then charge the accumulator.

Hydraulic Pilot System - RCV OPERATION



HYDRAULIC CIRCUIT

Hydraulic functional principle

Pilot devices with end position locks operate as direct operated pressure reducing valves.

They basically comprise of control lever(A), two pressure reducing valves, body(3) and locks.

Each pressure reducing valve comprises of a plunger kit(5), a metering spring(7) and a spring(11).

At rest, control lever(A) is held in its neutral position by return springs(11). Ports(1, 2) are connected to tank port T.

When control lever(A) is deflected, plunger kit(5) is pressed against return spring(11) and metering spring(7).

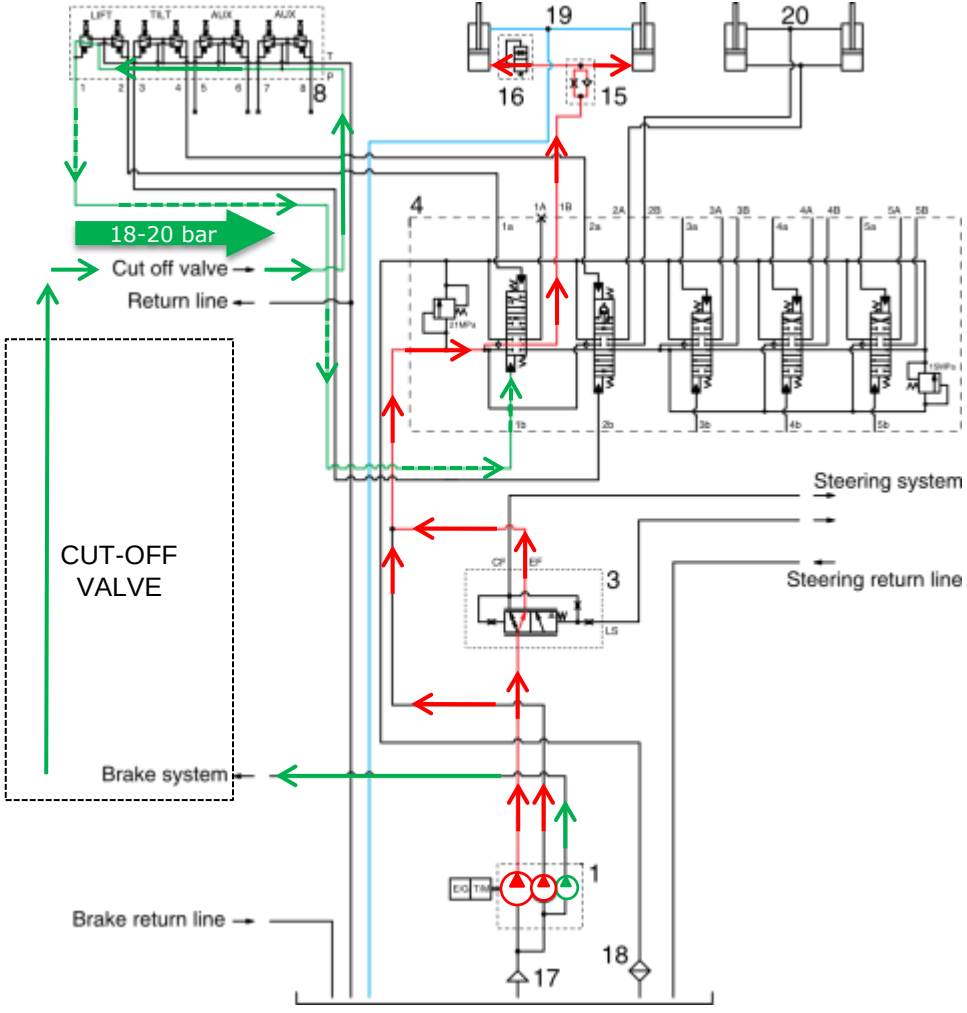
Metering spring(7) initially moves docking rod(10) downwards and closes the connection between the relevant port and tank port T. At the same time the relevant port is connected to port P. The control phase starts as soon as docking rod(10) finds its balance between the force from metering spring(7) and the force, which results from the hydraulic pressure in the relevant port(ports 1, 2).

Due to the interaction between docking rod(10) and metering spring(7) the pressure in the relevant port is proportional to the stroke of plunger(5) and hence to the position of control lever(A).

This pressure control which is dependent on the position of the control lever and the characteristics of the control spring permits the proportional hydraulic control of the main directional valves and high response valves for hydraulic pumps.

A rubber bellows(17) protects the mechanical components in the housing from contamination.

Hydraulic Pilot System - RCV OPERATION



LIFTING DIAGRAM

When the lift control lever is pulled back, the spool on the first block is moves to lift position.

The oil from hydraulic gear pump(1) flows into main control valve(4) and then goes to the large chamber of lift cylinder(19) by pushing the load check valve of the spool.

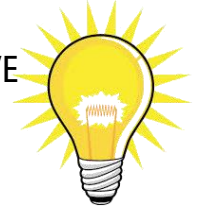
The oil from the small chamber of lift cylinder(19) returns to hydraulic oil tank at the same time.

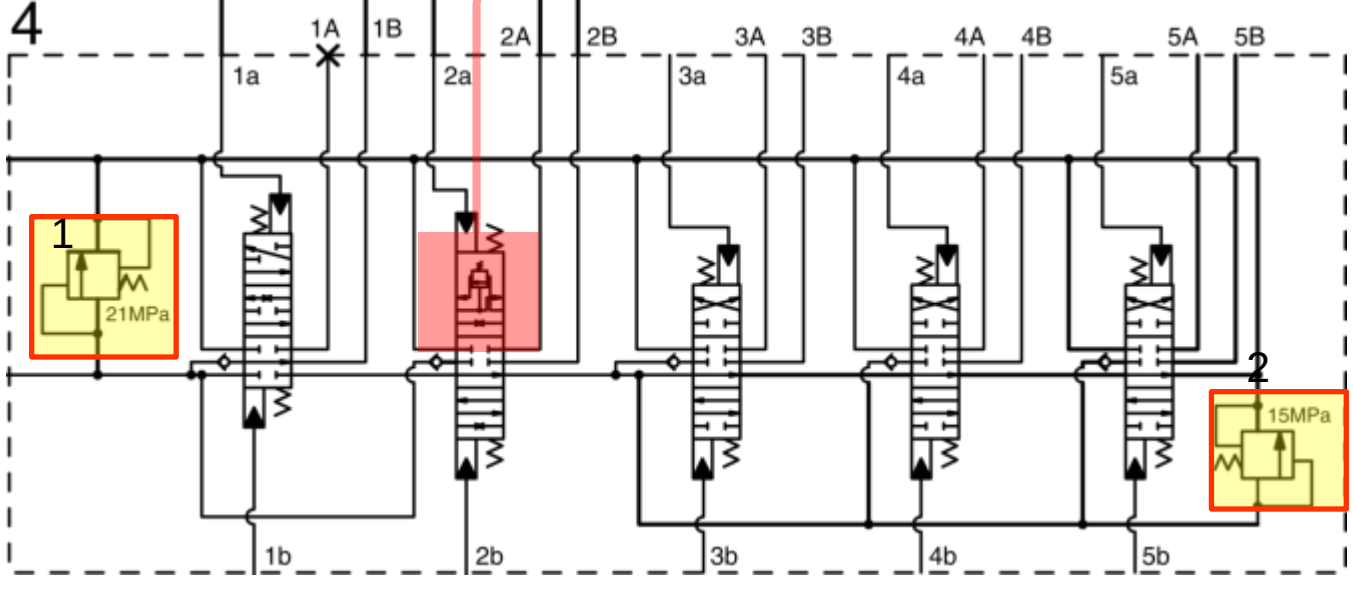
When this happens, the forks go up.

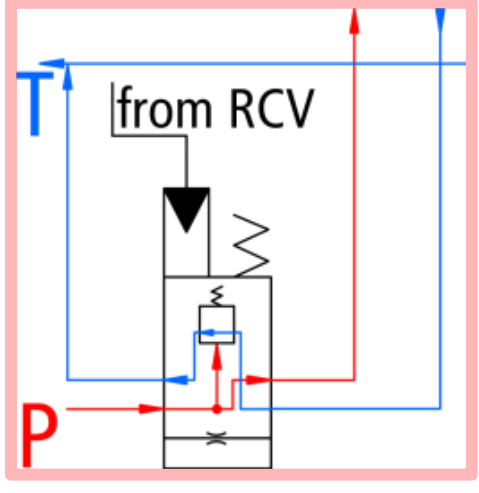
Hydraulic System – MCV Diagram

T-connector for load pressure sensor and possibility to install main pressure check point

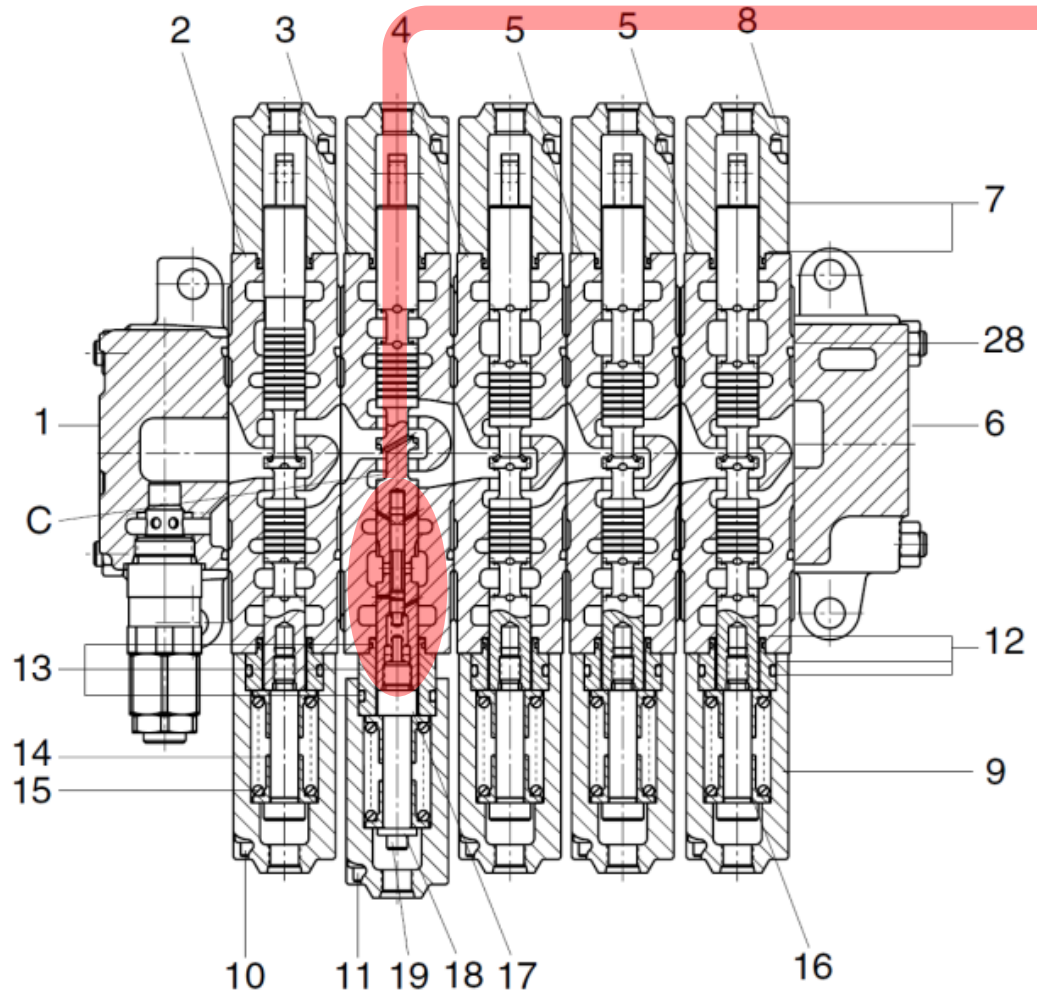
TILT LOCK VALVE

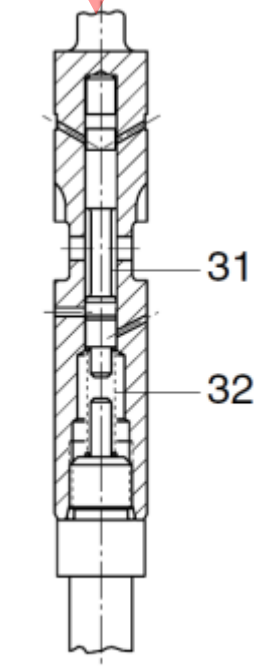




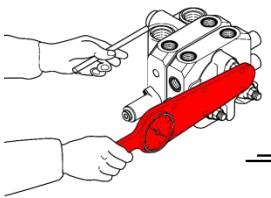


Hydraulic System – MCV





DETAIL C

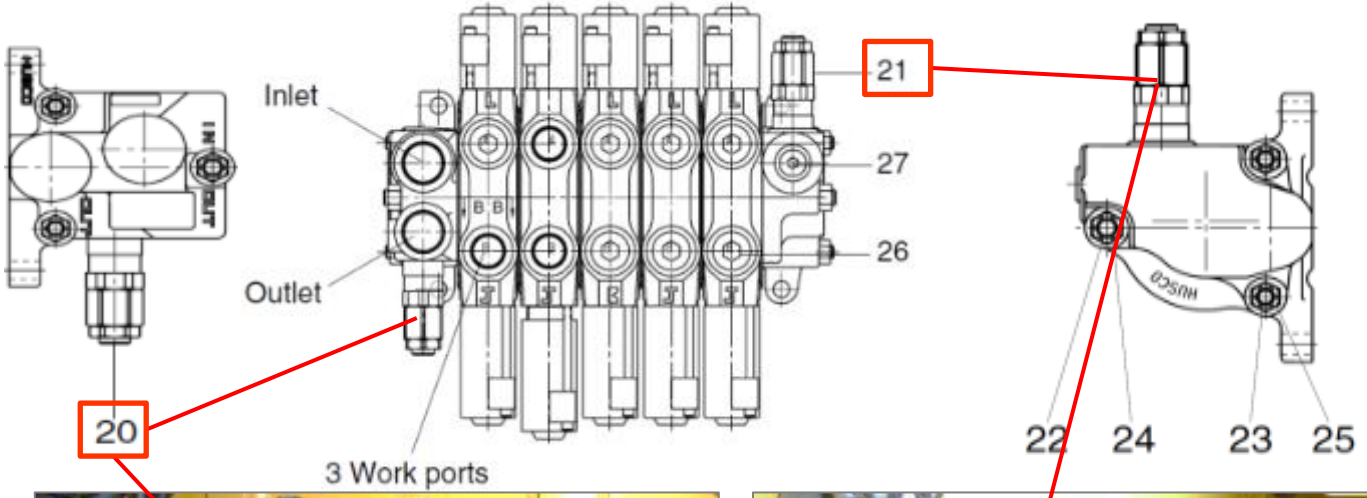


MCV STRUCTURE

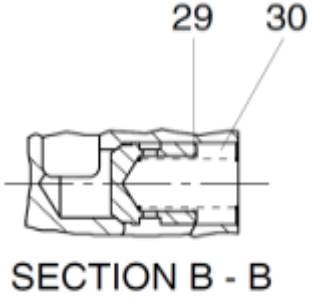
1. Inlet section assy
2. Spool section assy(Lift)
3. Spool section assy(Tilt)
4. Spool section assy(Aux)
5. Spool section assy(Aux)
6. Outlet section assy
7. Spool cap
8. Cap screw
9. Spool cap
10. Cap screw
11. Cap screw
12. Retainer
13. Retainer
14. Spring set
15. Spring
16. Screw
17. Spool end
18. Washer
19. Cap screw
28. O-ring
31. Piston
32. Spring

Tightening torque sequence:
All nuts – first 13.5 Nm
11/16" – final 65.0±6.7 Nm
3/4" – final 100±10 Nm
Check proper spools movement

Hydraulic System – MCV

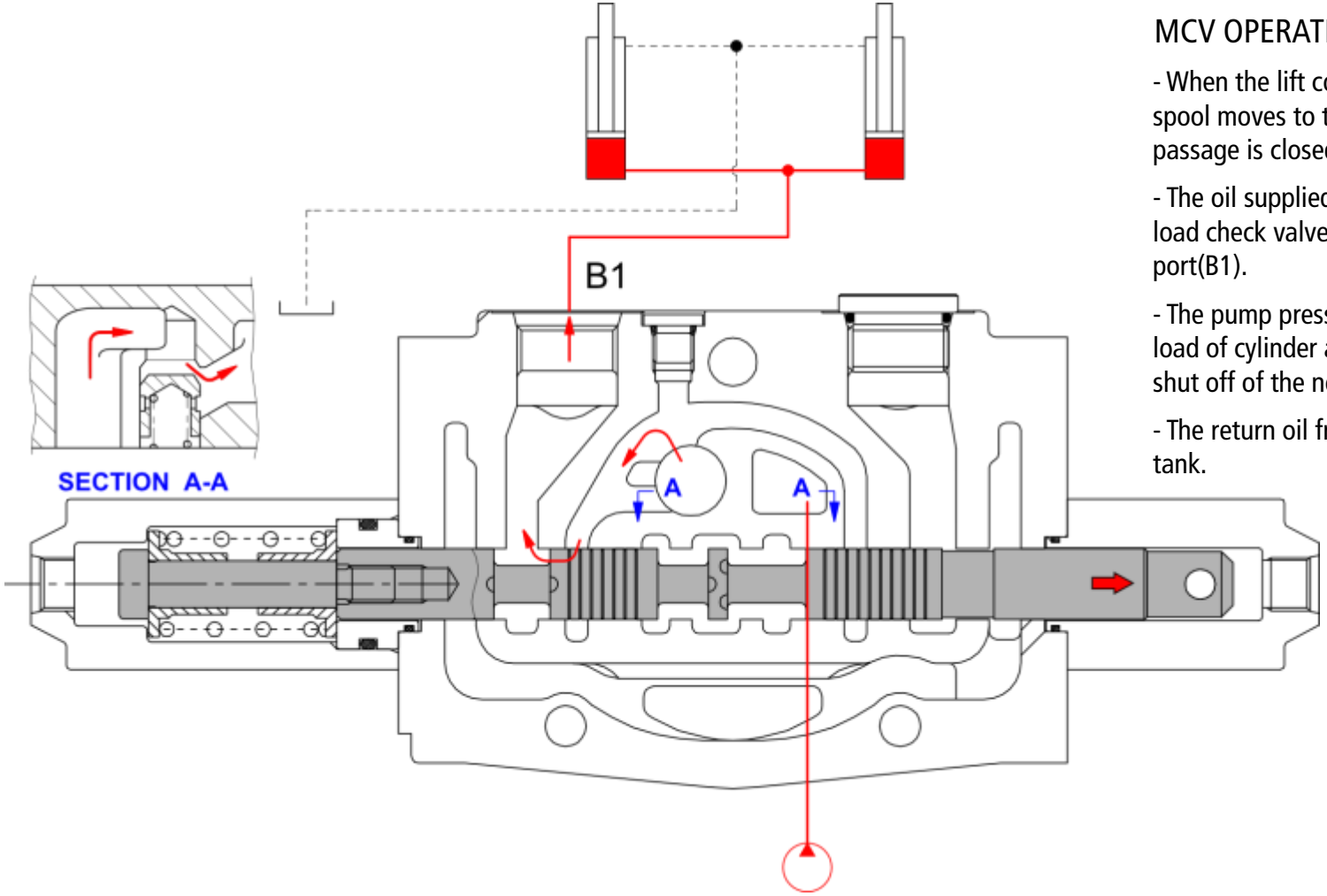


MCV STRUCTURE



20. Main relief valve assy.
21. Aux relief valve assy.
22. Tie rod
23. Tie rod
24. Special nut
25. Special nut
26. Plug
27. Plug
29. Poppet
30. Spring

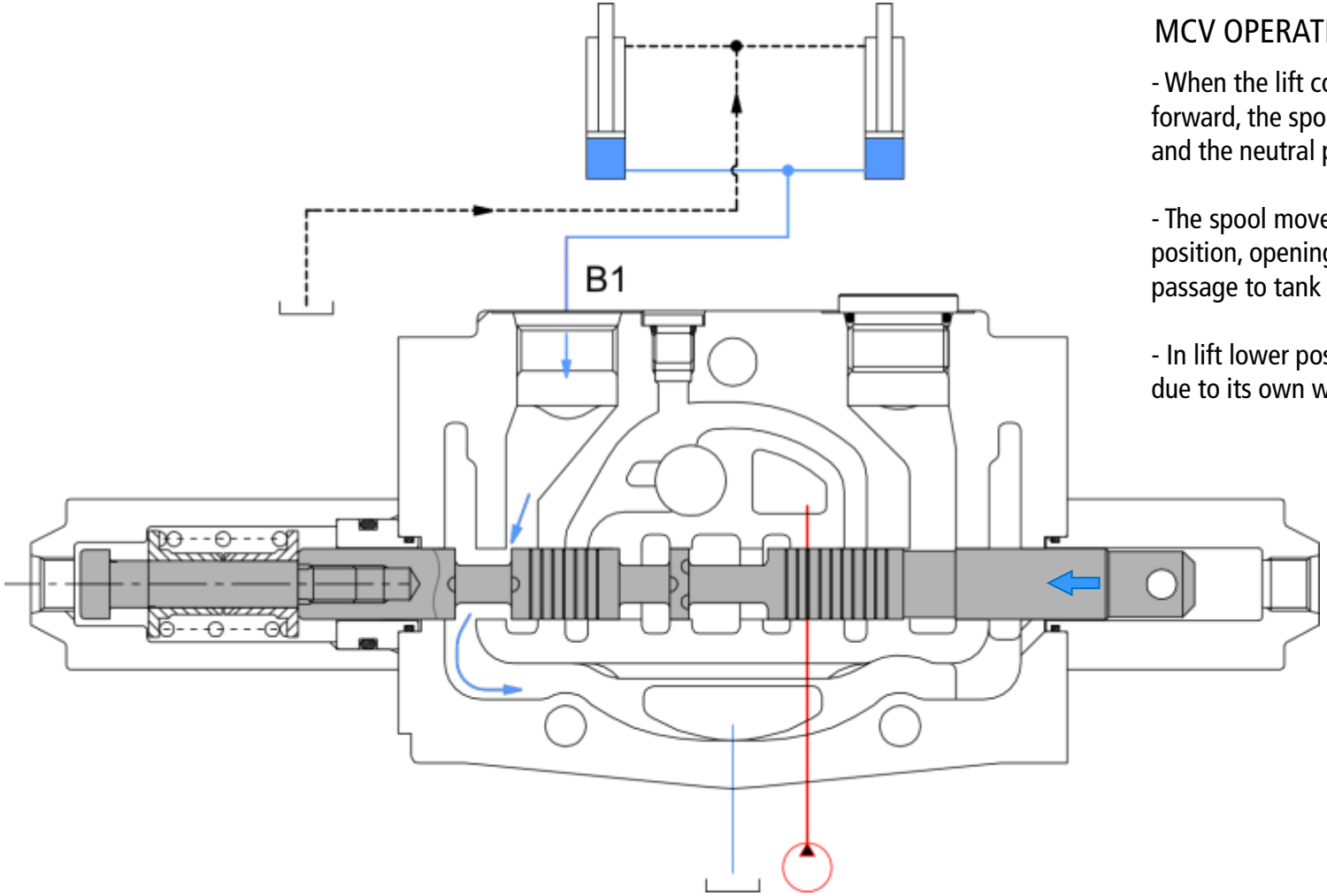
Hydraulic System – MCV



MCV OPERATION / LIFTING

- When the lift control lever is pulled back, the spool moves to the right and the neutral passage is closed.
- The oil supplied from the pump pushes up the load check valve(1) and flow into lift cylinder port(B1).
- The pump pressure reaches proportionally the load of cylinder and fine control finished by shut off of the neutral passage.
- The return oil from cylinder flows into the tank.

Hydraulic System – MCV



MCV OPERATION / **LOWERING**

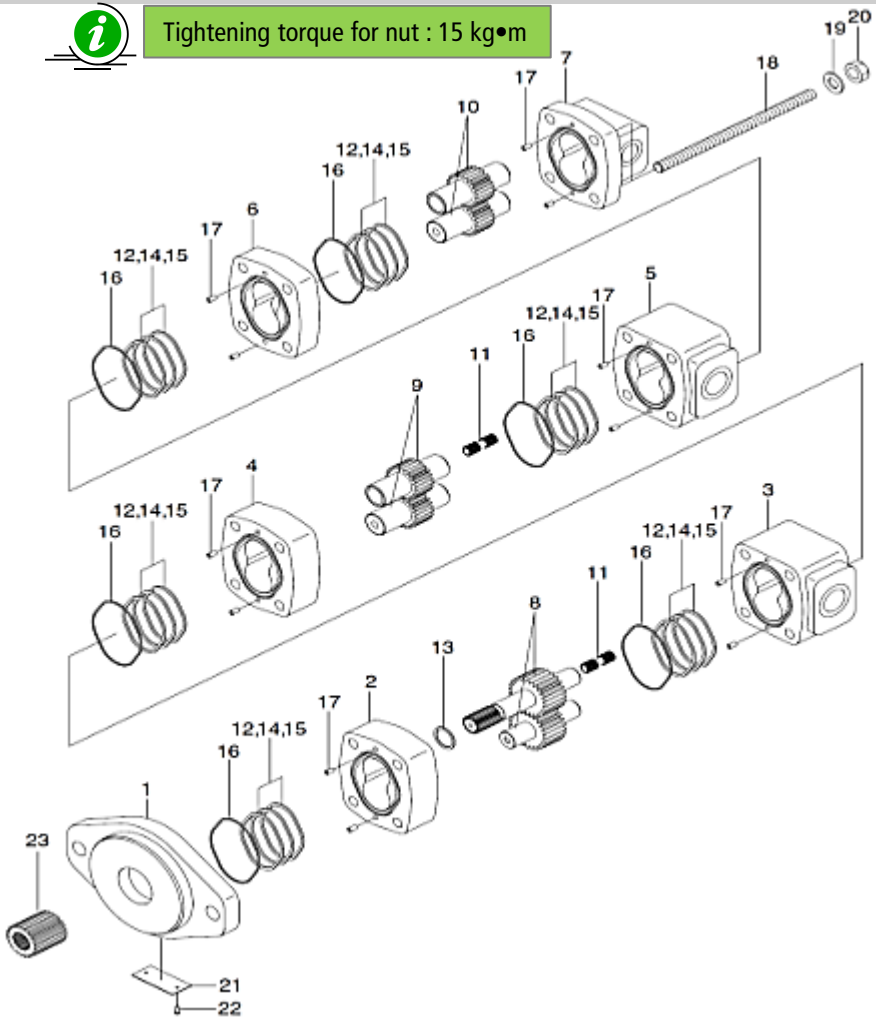
- When the lift control lever is pushed forward, the spool moves to the left and the neutral passage is closed.

- The spool moves to the lift lower position, opening up the neutral passage to tank and (B1)>T.

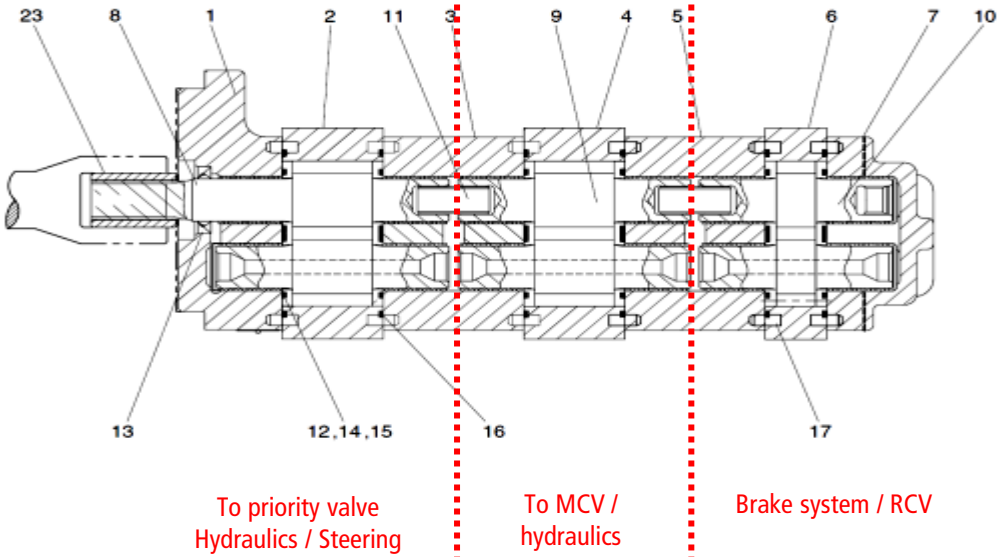
- In lift lower position the fork drops due to its own weight.

Hydraulic System – PUMP

Tightening torque for nut : 15 kg•m

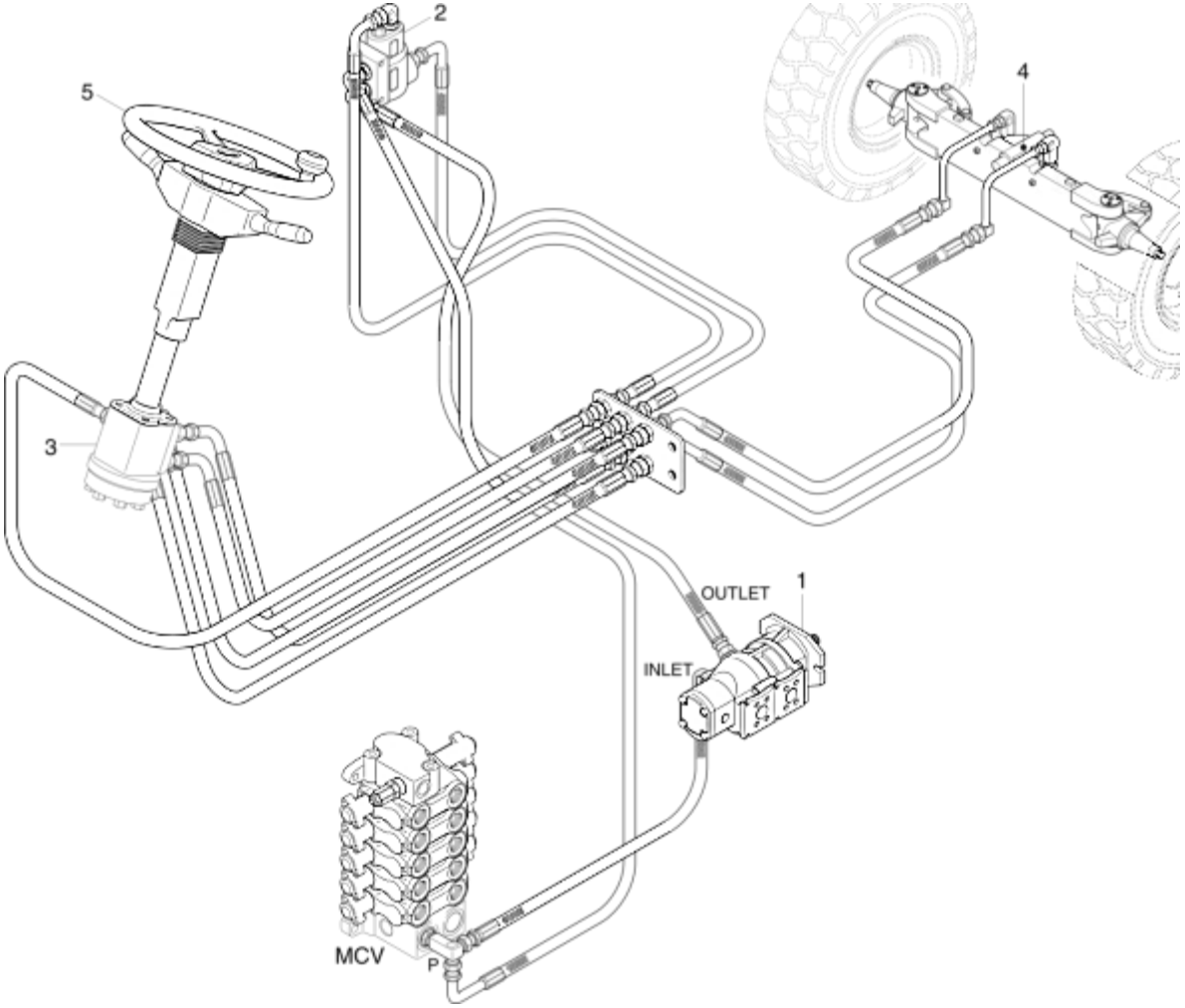


MAIN HYDRAULIC PUMP - STRUCTURE



1. Cover
2. Gear housing
3. Carrier
4. Gear housing
5. Carrier
6. Gear housing
7. Cover
8. Gear
9. Gear
10. Gear set
11. Shaft
12. Thrust plate
13. Seal
14. Seal
15. Seal
16. Seal
17. Dowel-pin
18. Stud bolt
19. Washer
20. Hex-nut
23. Shaft

Hydraulic Power Steering – overview



- The steering system for this machine is composed of steering wheel assembly, steering unit, steering cylinder, trail axle and piping.

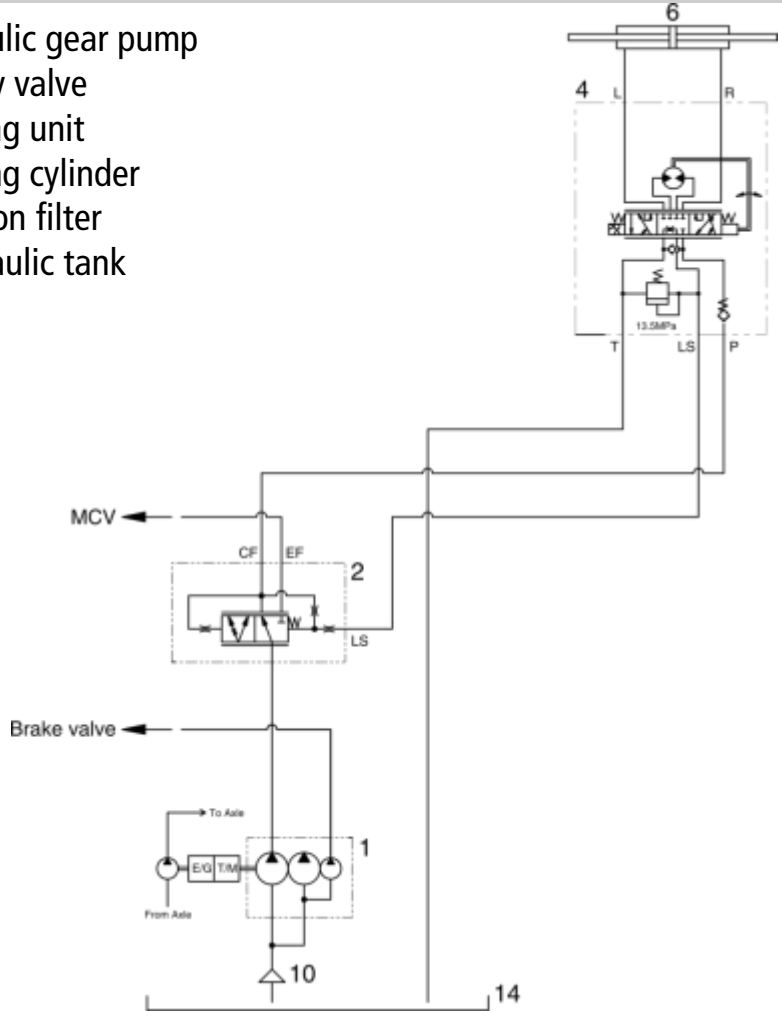
-The steering force given to the steering wheel enters the steering unit through the steering column.

- The required oil flow is sensed by the LS system of the Orbitrol , and pressurized oil delivered from the hydraulic pump flowing through the priority valve is fed to the steering cylinder.

- The force produced by the steering cylinder moves the knuckle of steering tires through the intermediate link.

Hydraulic Power Steering – diagram

1. Hydraulic gear pump
2. Priority valve
4. Steering unit
6. Steering cylinder
10. Suction filter
14. Hydraulic tank

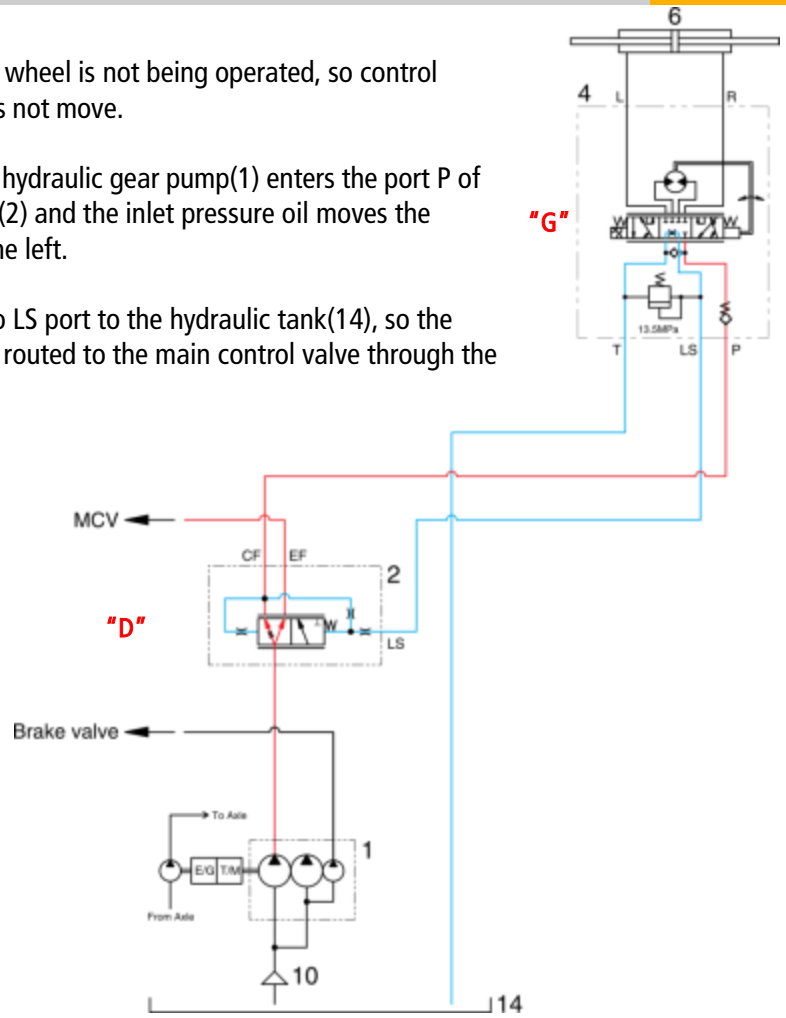


NEUTRAL:

-The steering wheel is not being operated, so control spool(G) does not move.

-The oil from hydraulic gear pump(1) enters the port P of priority valve(2) and the inlet pressure oil moves the spool(D) to the left.

- Oil flow into LS port to the hydraulic tank(14), so the pump flow is routed to the main control valve through the EF port.



Hydraulic Power Steering – diagram

LEFT TURN

When the steering wheel is turned to the left, the spool(G) within the steering unit(4) connected with steering column turns in left hand direction.

At this time, the oil discharged from the pump flows into the spool(G) the steering unit through the spool(D) of priority valve and flows the gerotor(H).

Oil flow from the gerotor flows back into the spool(G) where it is directed out the left work port(L).

Oil returned from cylinder returns to hydraulic tank(14).

When the above operation is completed, the machine turns to the left.

RIGHT TURN

When the steering wheel is turned to the right, the spool(G) within the steering unit(4) connected with steering column turns in right hand direction.

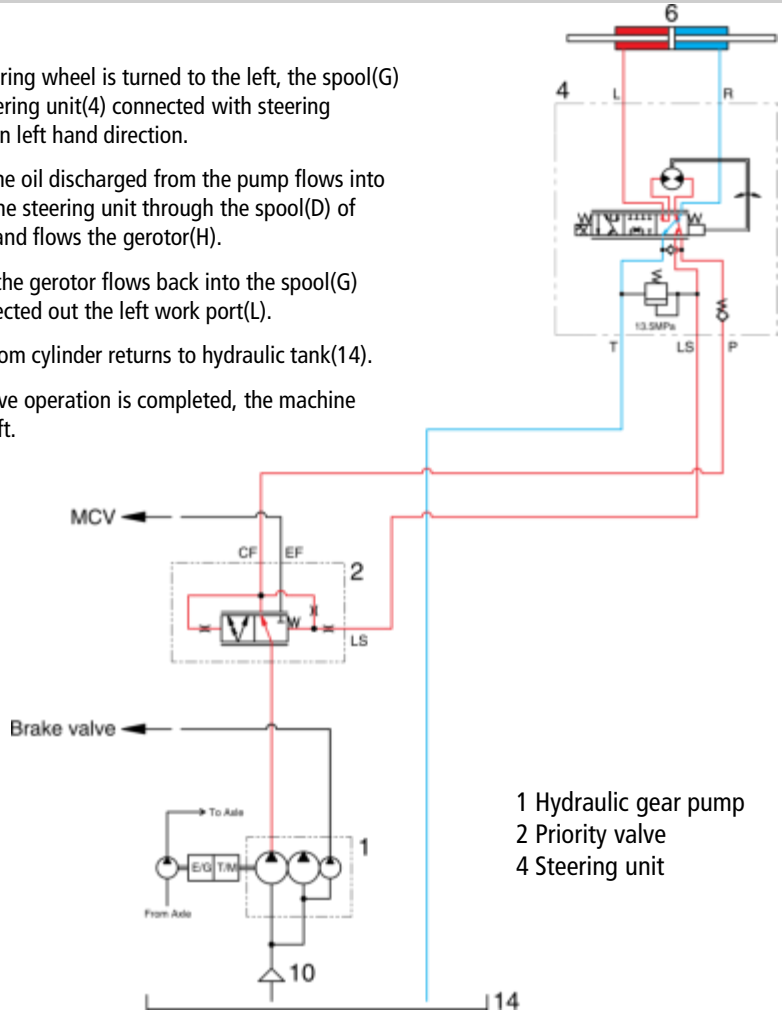
At this time, the oil discharged from the pump flows into the spool(G) the steering unit through the

spool(D) of priority valve and flows the gerotor(H).

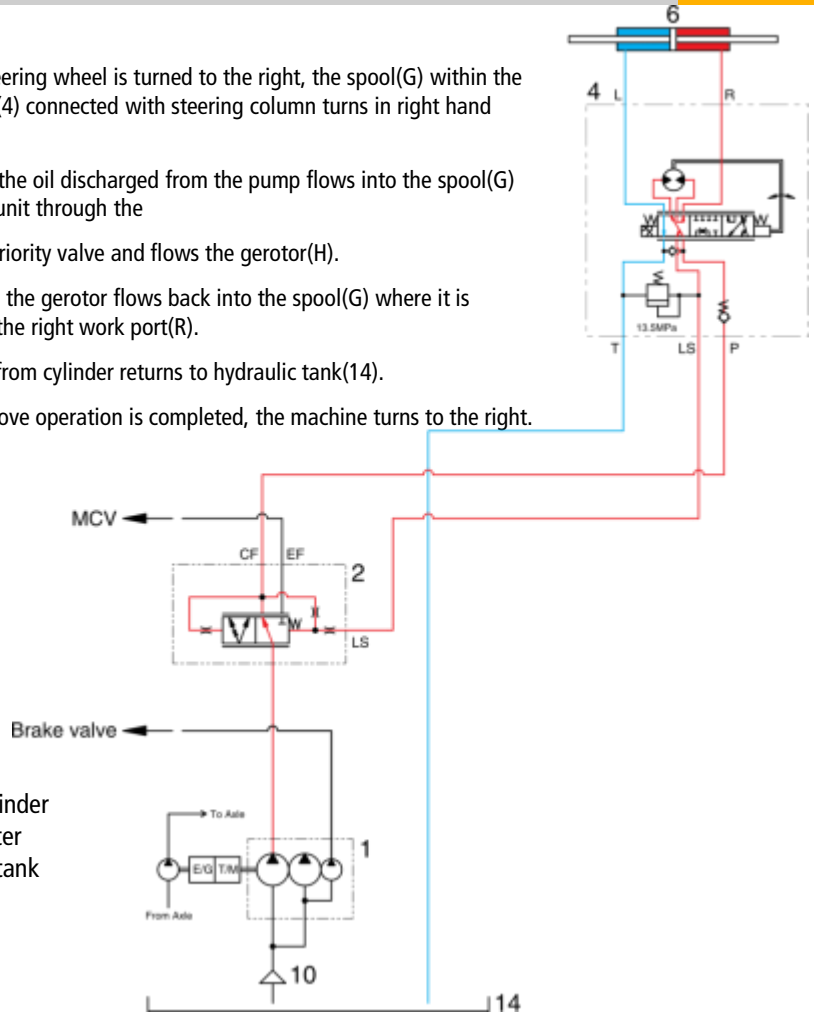
Oil flow from the gerotor flows back into the spool(G) where it is directed out the right work port(R).

Oil returned from cylinder returns to hydraulic tank(14).

When the above operation is completed, the machine turns to the right.

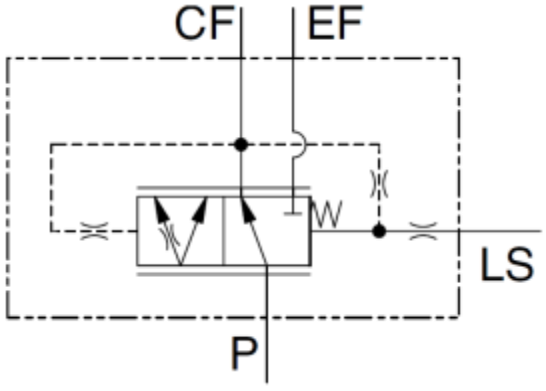


1 Hydraulic gear pump
2 Priority valve
4 Steering unit
6 Steering cylinder
10 Suction filter
14 Hydraulic tank

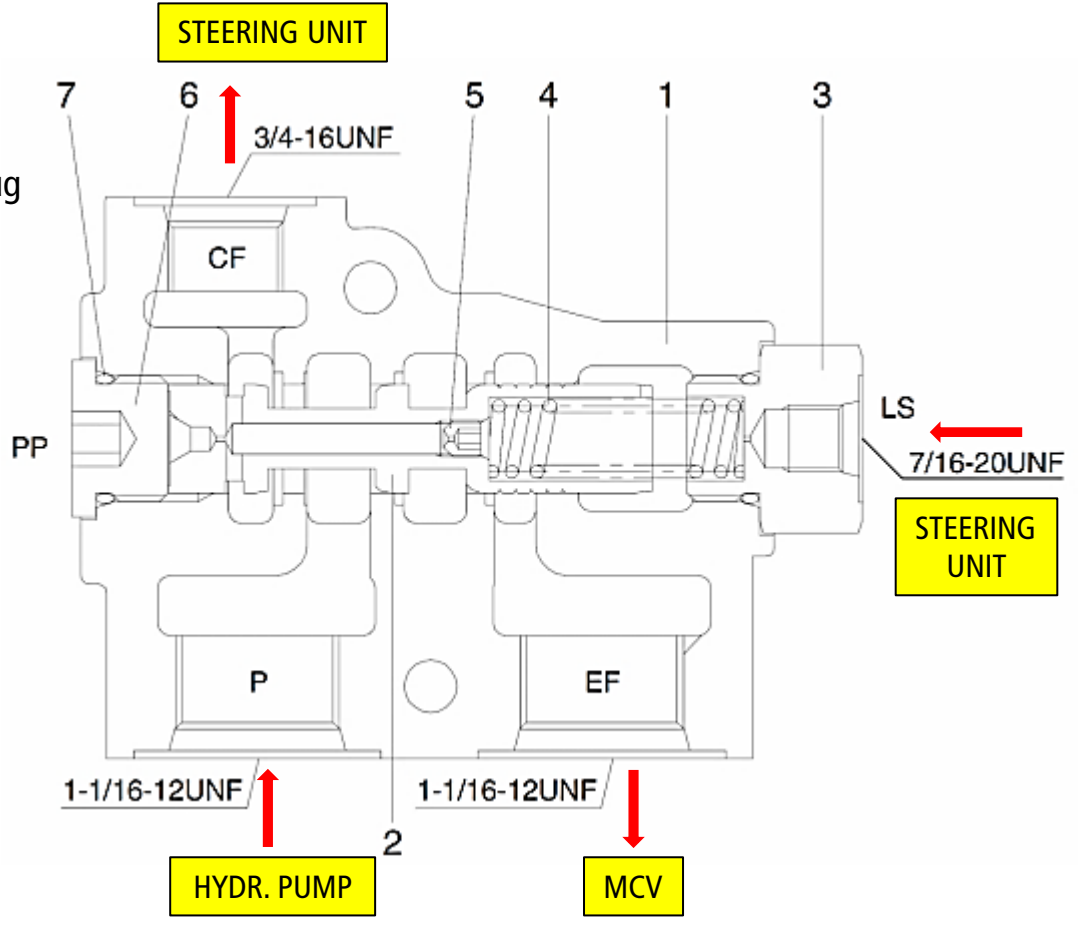


Hydraulic Power Steering – priority valve

PRIORITY VALVE STRUCTURE AND OPERATION



1. Body
2. Spool
3. Spring plug
4. Spring
5. Orifice
6. Plug
7. O-ring

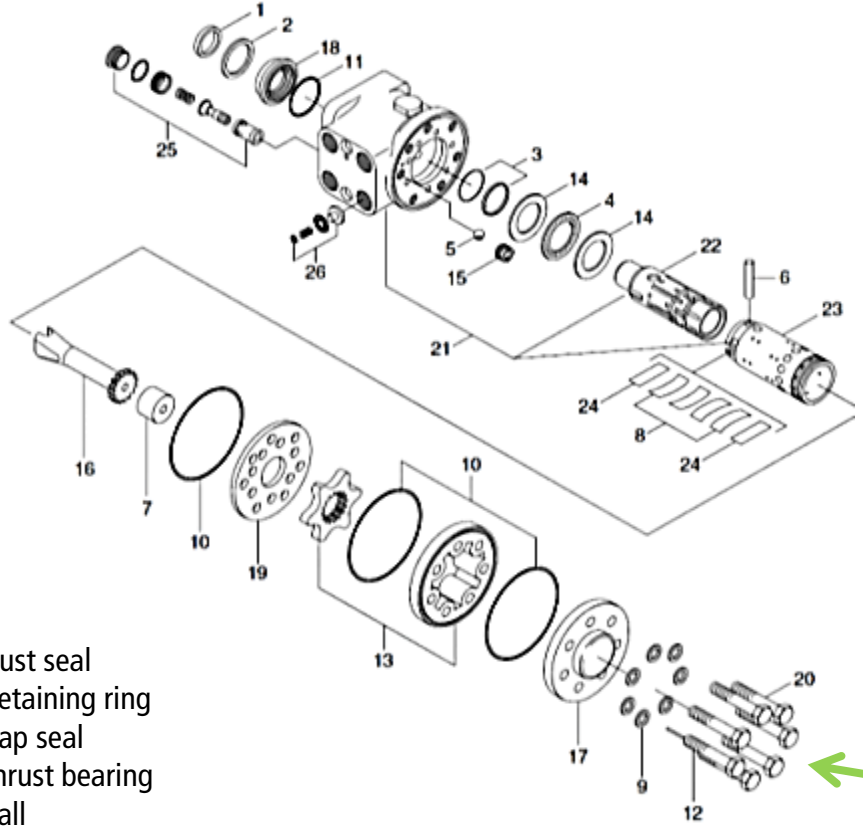


OPERATION

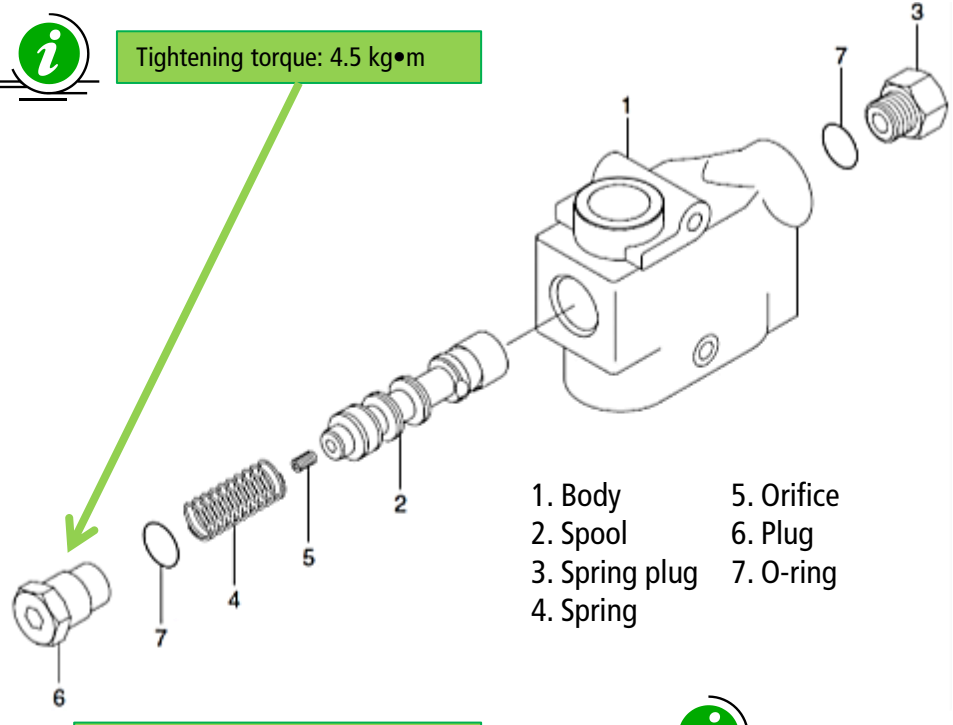
- The oil from the hydraulic gear pump flows into the priority valve.
- The priority valve supplies a flow of oil to the steering and MCV system.
- The steering flow is controlled by the steering unit to operate the steering cylinder.
- The remain oil flow from the pump flows to the main control valve (MCV).

Hydraulic Power Steering – orbitrol and priority v/v

STEERING UNIT AND PRIORITY VALVE STRUCTURE



Tightening torque: 4.5 kg•m



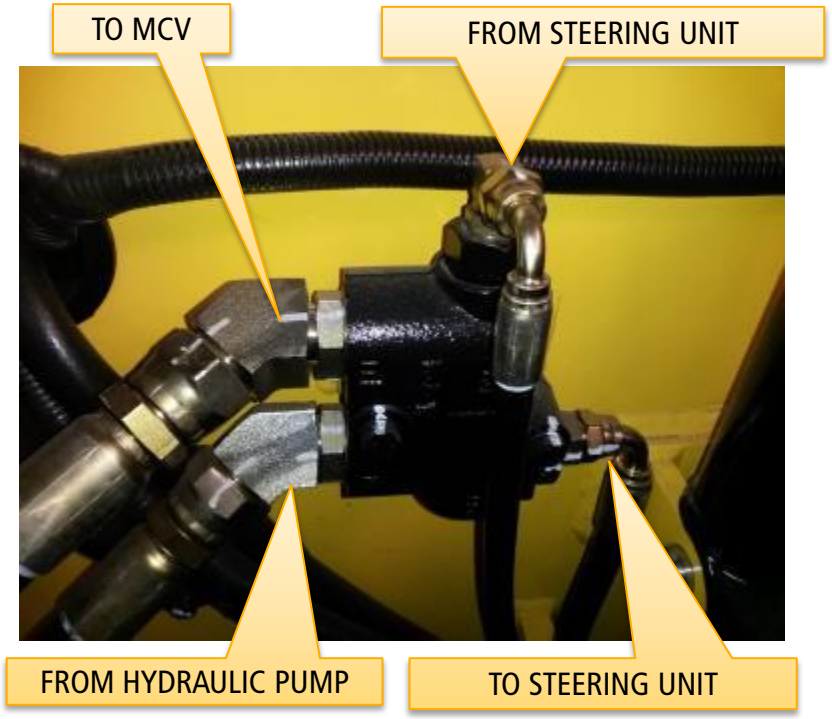
Tightening torque: 4.0 ±0.5kg•m

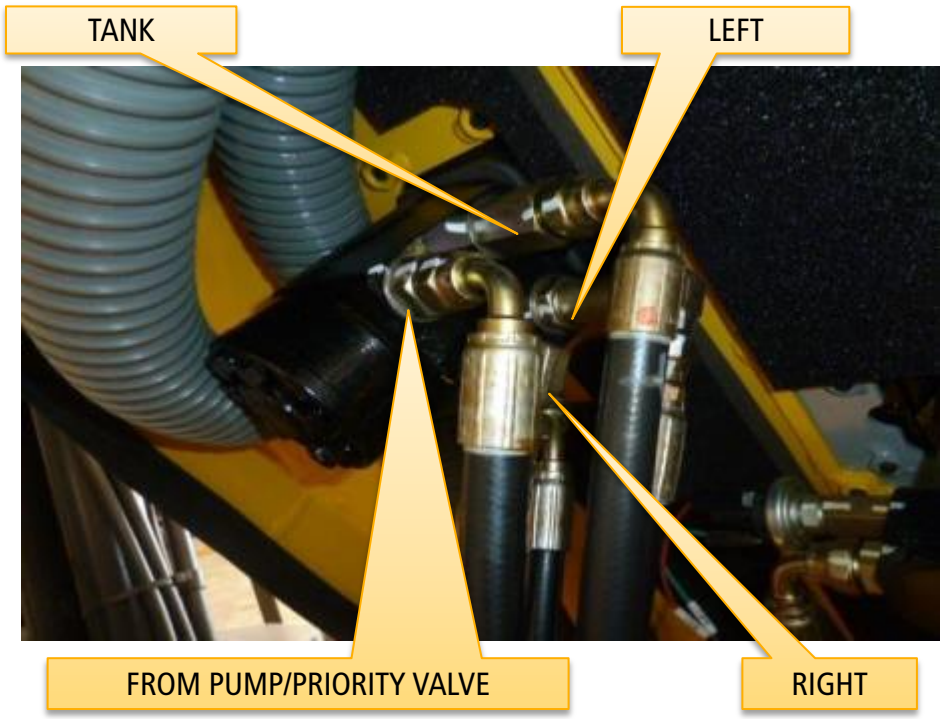
1. Dust seal
2. Retaining ring
3. Cap seal
4. Thrust bearing
5. Ball
6. Pin
7. Spacer
8. Center spring
9. Washer
10. O-ring
11. O-ring
12. Rolled screw
13. Gerotor set
14. Bearing race
15. Bore screw
16. Drive shaft
17. End cap
18. Bushing
19. Plate
20. Cap screw
21. Housing
22. Spool
23. Sleeve
24. Plate spring
25. Relief valve
26. Check valve

1. Body
2. Spool
3. Spring plug
4. Spring
5. Orifice
6. Plug
7. O-ring

Hydraulic Power Steering – orbitrol and priority v/v

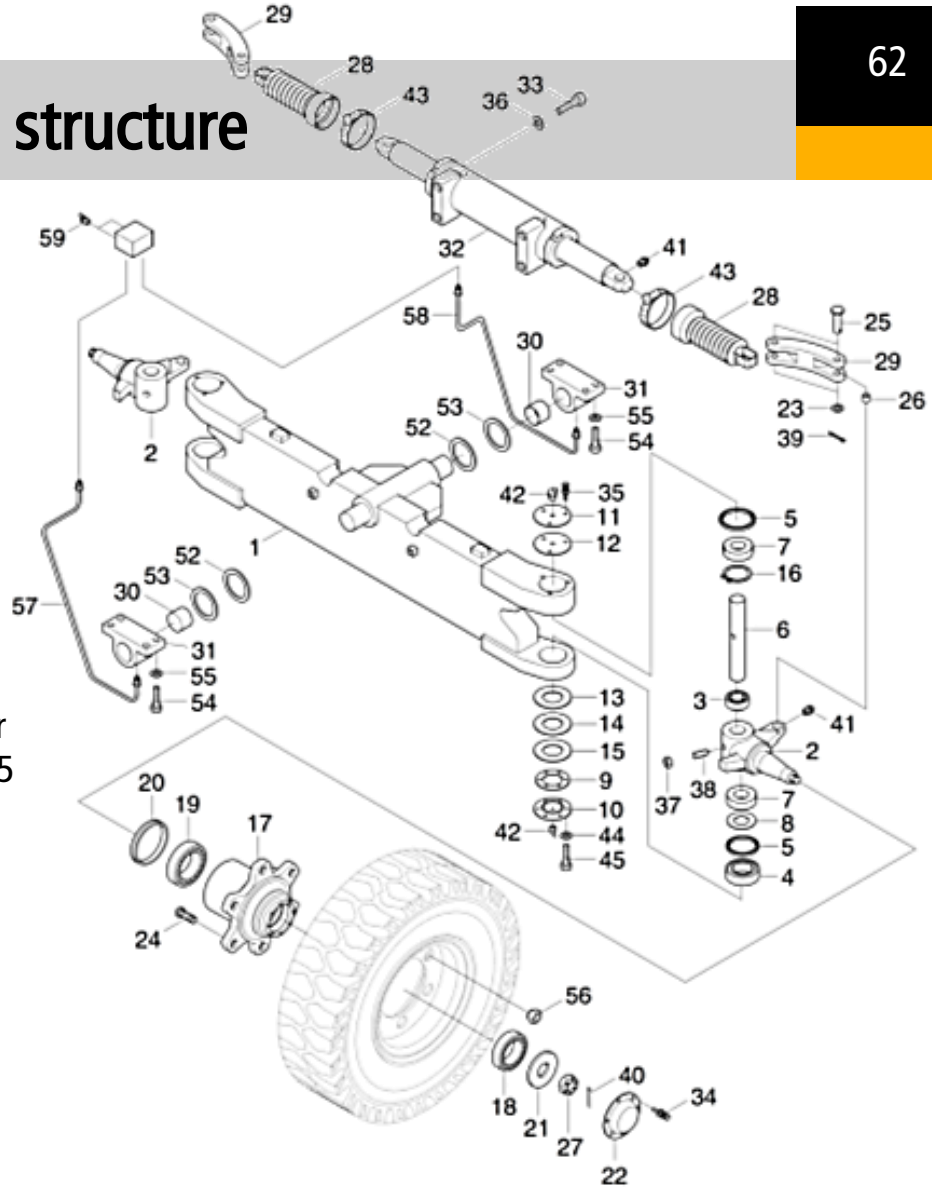
STEERING UNIT AND PRIORITY VALVE LOCATION



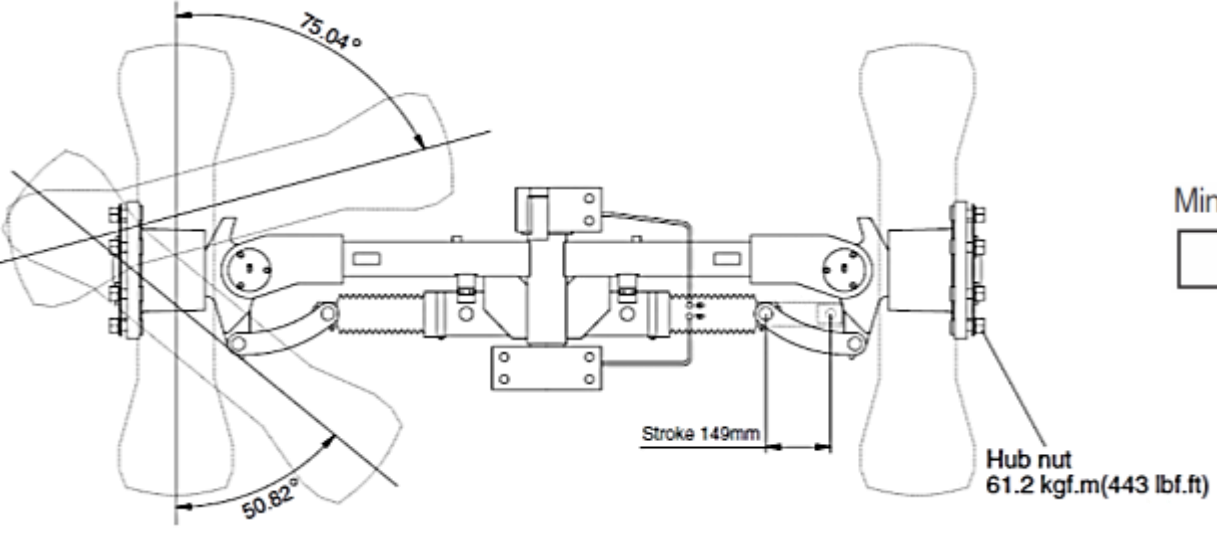


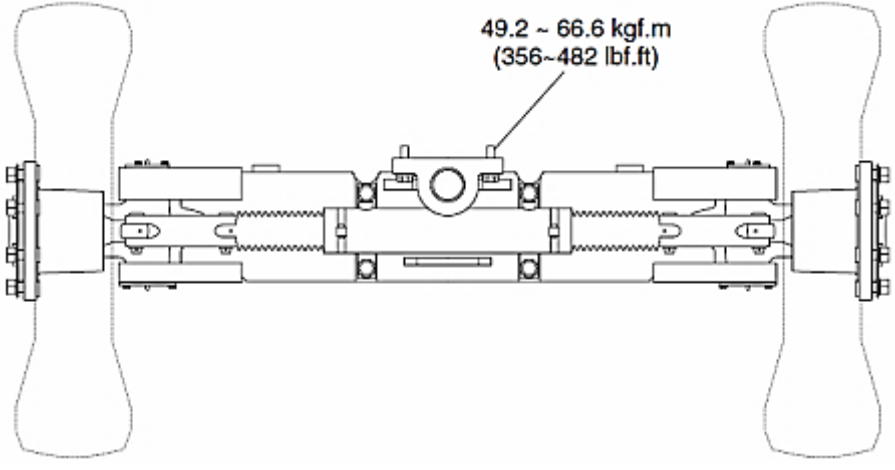
Hydraulic Power Steering – rear axle structure

1 Steering Axle Wa
2 Knuckle
3 Taper roller bearing
4 Taper roller bearing
5 Oil seal
6 King pin
7 Spacer
8 Spacer
9 Gasket
10 Cover
11 Cover
12 Gasket
13 Shim (0.5 t)
14 Shim (0.2 t)
15 Shim (0.1 t)
16 Retaining ring
17 Hub
18 Taper roller bearing
19 Taper roller bearing
20 Oil seal
21 Washer
22 Hub cap
23 Special washer
24 Hub bolt
25 Link pin
26 Bushing
27 Slotted nut
28 Steer cylinder boot
29 Intermediate link
30 Bushing
31 Support
32 Cylinder Assy
33 Hexagon bolt
34 W/Washer bolt
35 W/Washer bolt
36 Hardened washer
37 Hexagon nut
38 Set Screw
39 Split pin
40 Split pin
41 Grease nipple
42 Grease nipple
43 Hose clamp
44 Plain washer
45 Hexagon bolt
52 Thrust washer
53 Thrust washer
54 Hexagon bolt
55 Hardened washer
56 Hub nut, M22x1.5
57 Front pipe Assy
58 Rear pipe Assy
59 Grease nipple



Hydraulic Power Steering – rear axle





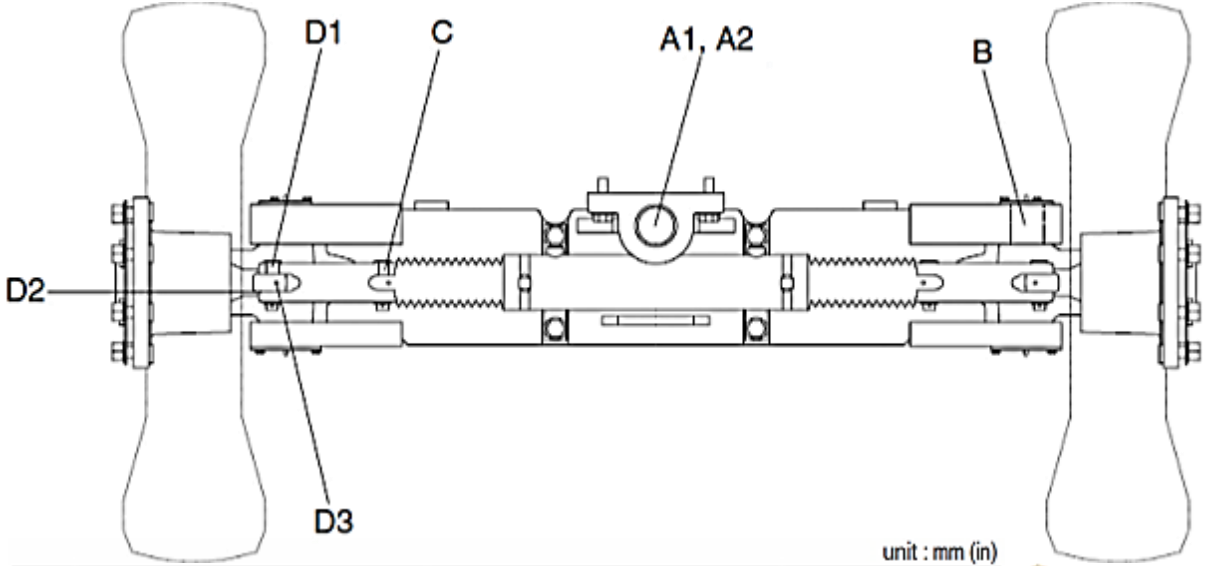
STEERING AXLE SPECIFICATION

Min turning radius (Outside)

80D-9	3700 mm (146 in)

Type	Unit	Center pin support single shaft
Structure of knuckle	-	Elliott type
Toe-in	degree	0
Camber	degree	0
Caster	degree	0
King pin angle	degree	0
Max steering angle of wheels(Inside/Outside)	degree	75.04/ 50.82
Tread	mm (in)	1700 (66.9)

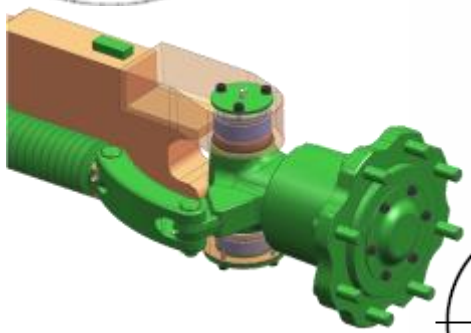
Hydraulic Power Steering – rear axle

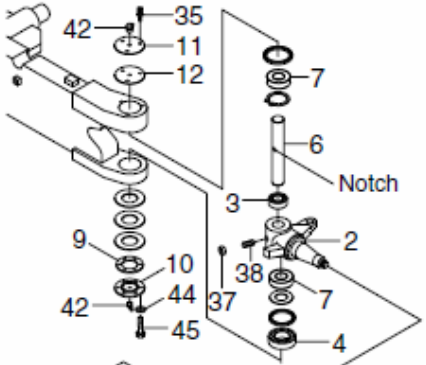


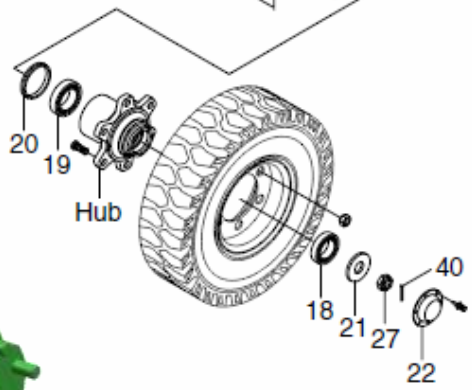
unit : mm (in)

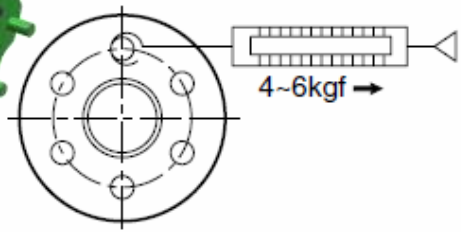
No.	Check item			Criteria		Remedy
				Standard size	Repair limit	
A	Shaft	A1	OD of shaft	60(2.4)	59.5(2.3)	Replace
		A2	ID of bushing	60(2.4)	59.5(2.3)	
B	OD of king pin			50(2.0)	49.8(2.0)	
C	OD of steering cylinder pin			22(0.9)	21.9(0.9)	
D	Knuckle	D1	OD of pin	22(0.9)	21.9(0.9)	
		D2	Vertical play	-	0.2(0.008)	Adjust shim
		D3	ID of bushing	22(0.9)	22.5(0.9)	Replace

·OD : Outer diameter
·ID : Inner diameter

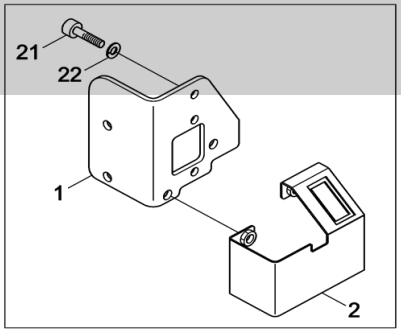








Cabin Tilting System



1. Bracket-Pump
2. Cover Wa
3. Bracket-Pump Mtg
4. Tee-B/Type,Orfs
5. Tee Wa
6. Clamp-Tube
7. Clamp-Hose
8. Tube Assy
9. Tube Assy
10. Tube Assy
11. Tube Assy
12. Hose Assy-Orfs 0x45
13. Hose Assy-Orfs 0x45
14. Hose Assy-Orfs 0x90
15. Hose Assy-Orfs 0x90
16. O-Ring
17. O-Ring
18. Bolt-W/Washer
20. Bolt-W/Washer
21. Bolt-Socket
22. Washer-Spring
23. Bolt-W/Washer
24. Cover Assy

Cooling systems

COOLING SYSTEMS

Front axle cooling system

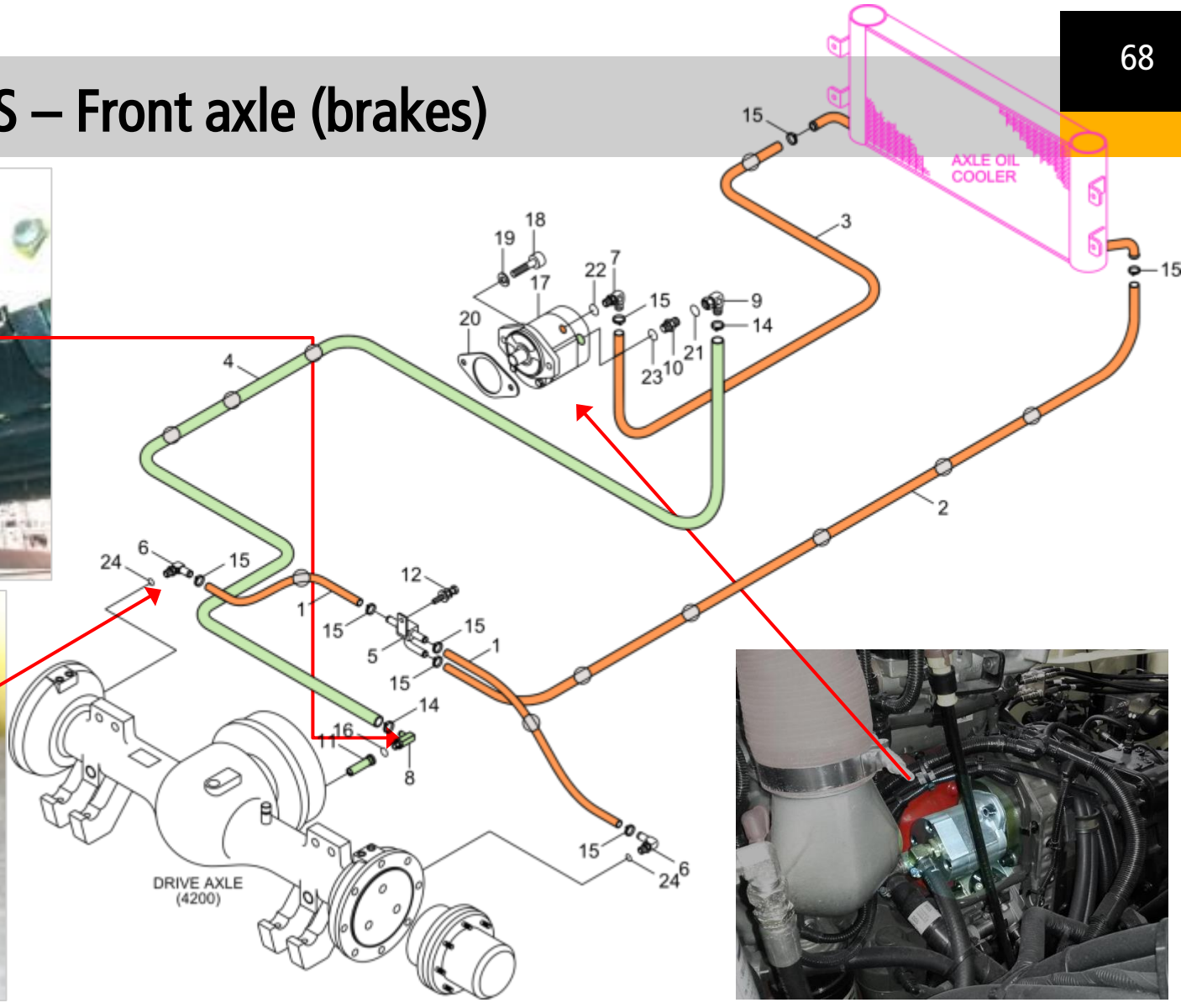
Engine cooling system

- Charger cooling system
- EGR cooling system

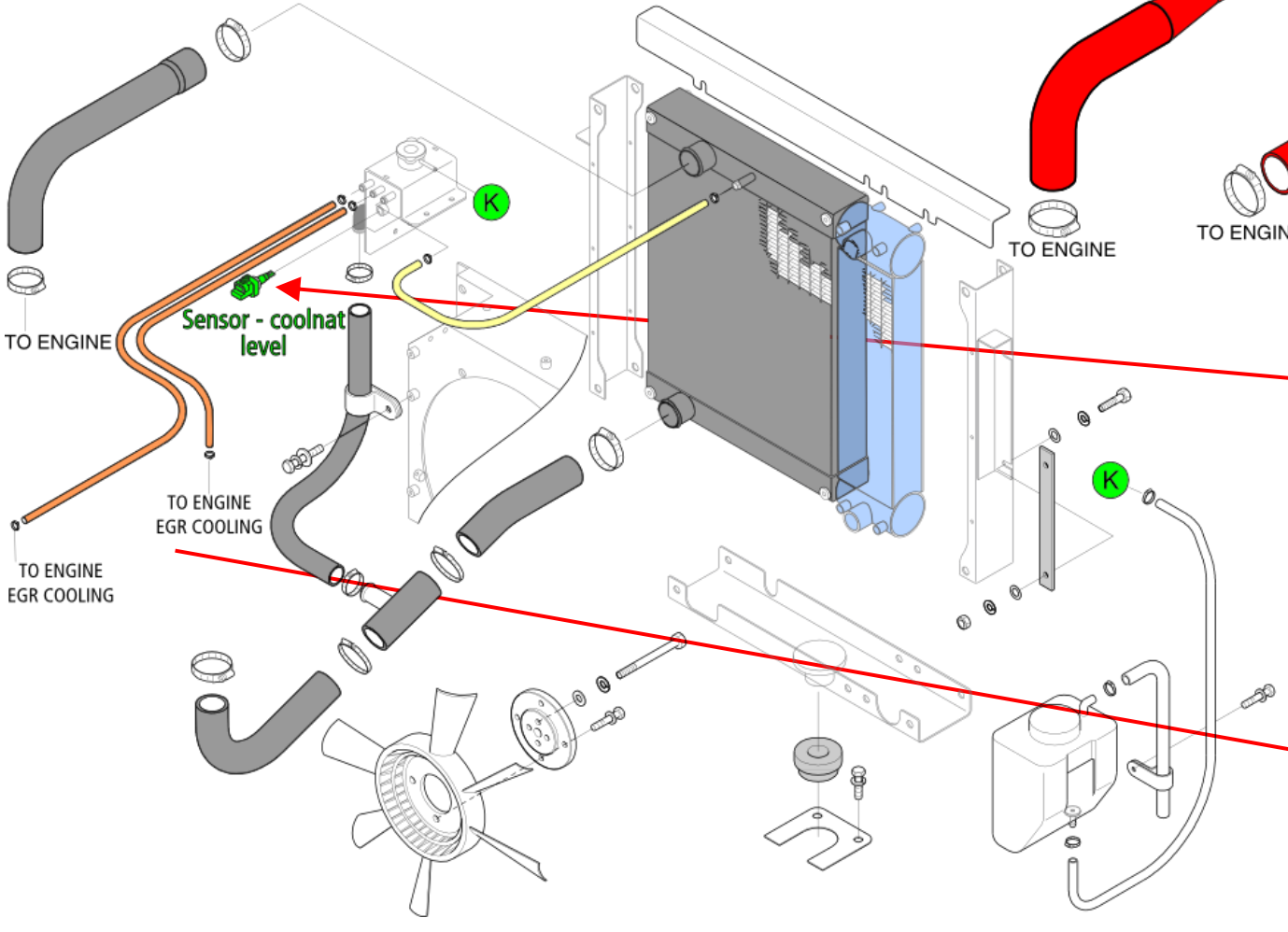
Transmission cooling system

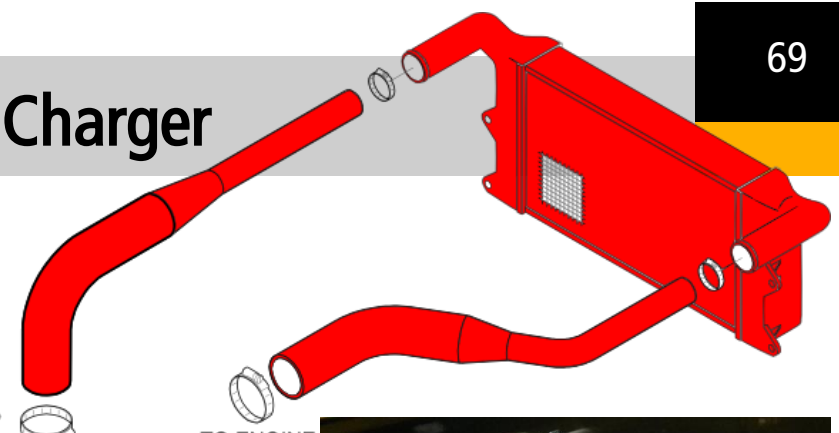
Radiators

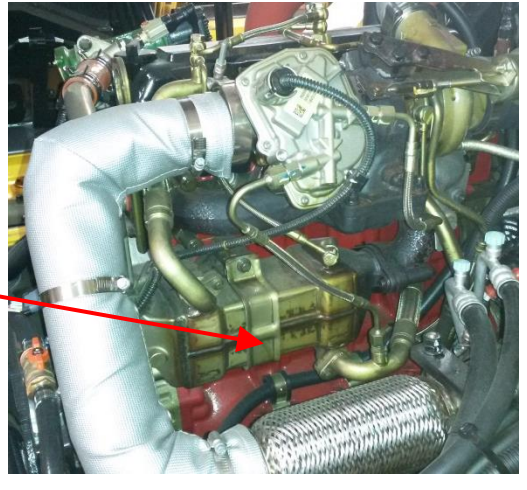
COOLING SYSTEMS – Front axle (brakes)



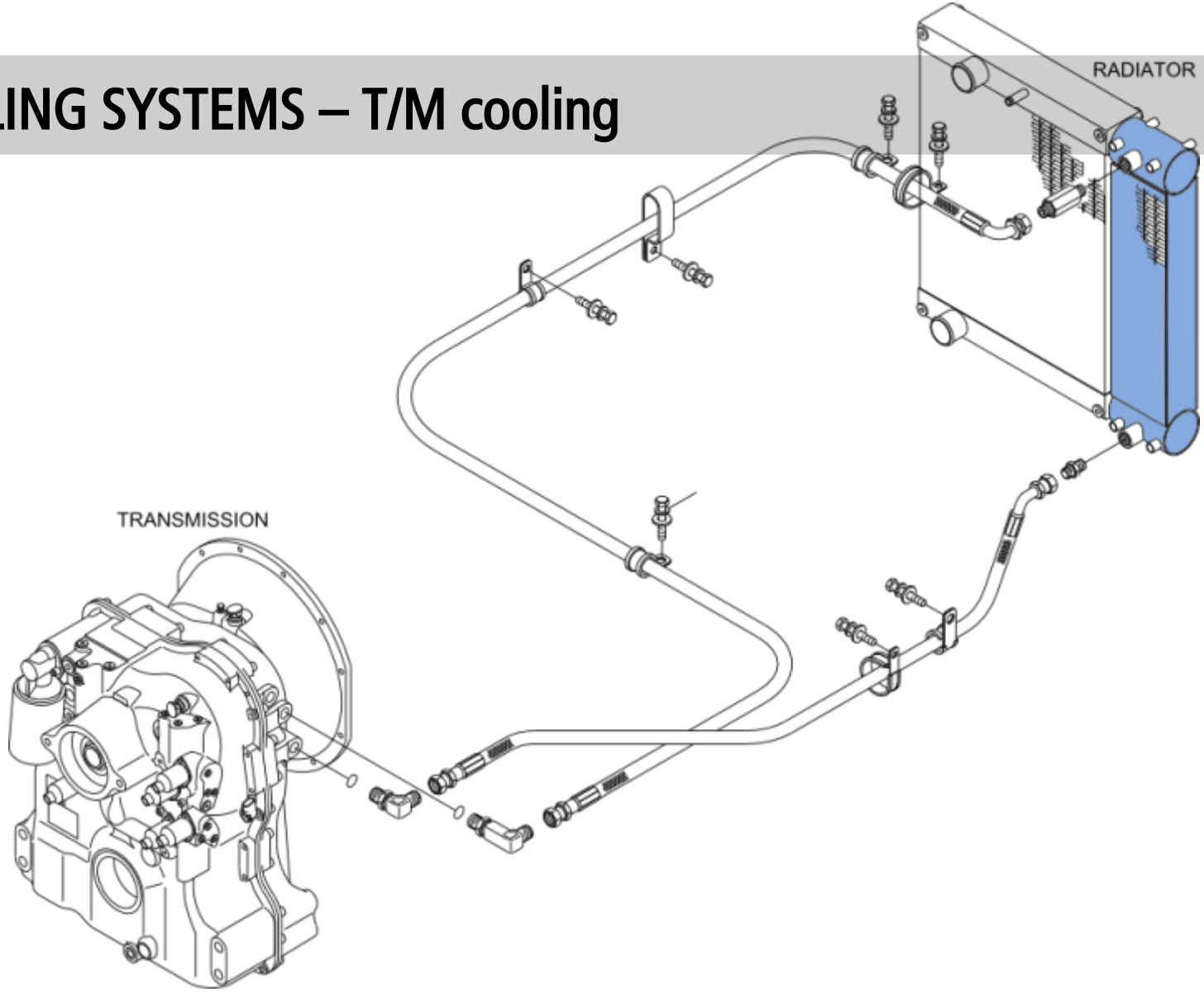
COOLING SYSTEMS – Engine and Turbo Charger



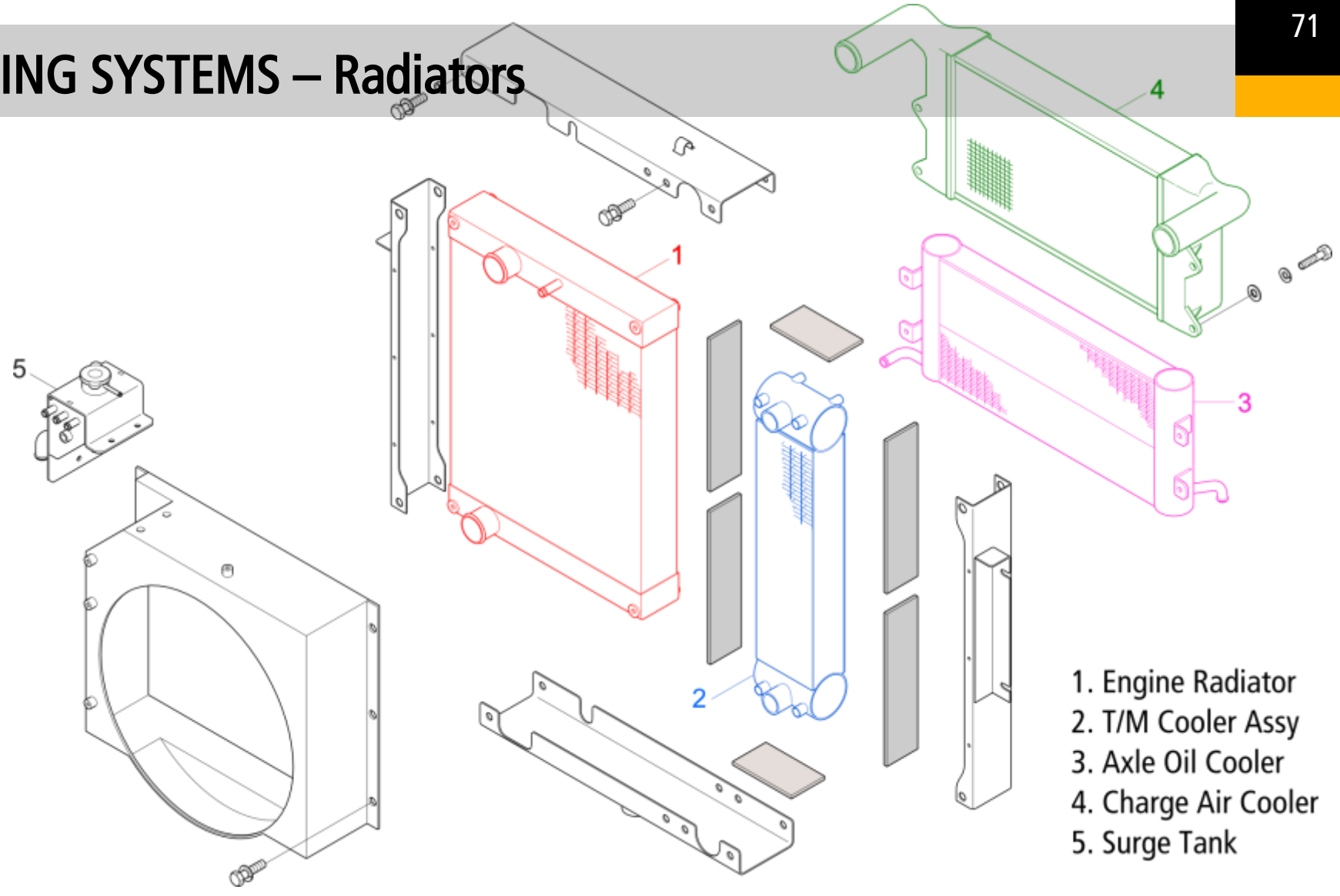




COOLING SYSTEMS – T/M cooling



COOLING SYSTEMS – Radiators

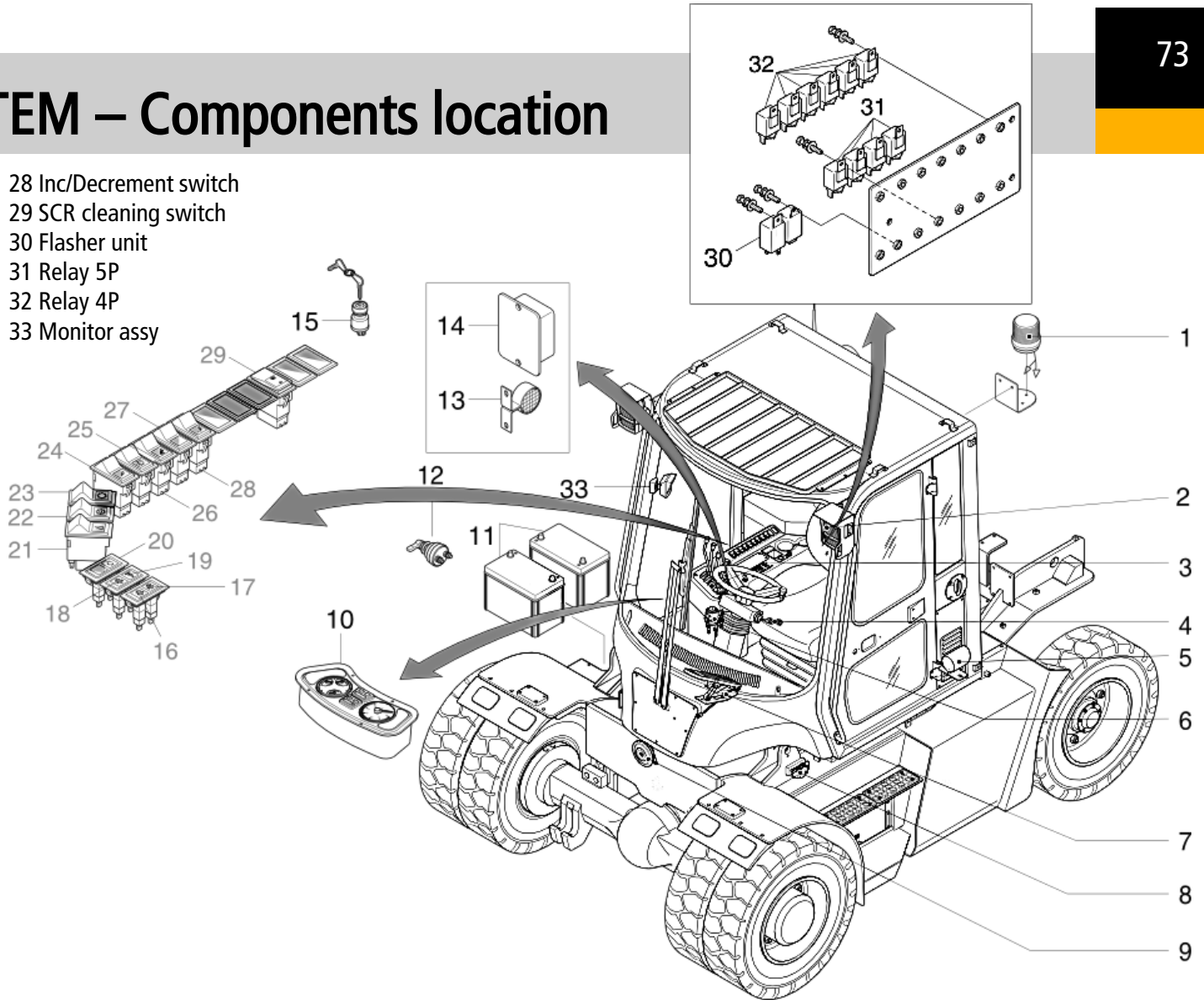


1. Engine Radiator
2. T/M Cooler Assy
3. Axle Oil Cooler
4. Charge Air Cooler
5. Surge Tank

Electric systems

ELECTRICAL SYSTEM – Components location

1 Beacon lamp
2 Work lamp
3 Combination switch
4 Gear selector
5 Backup alarm
6 Start relay
7 Accelerator pedal
8 Micro switch
9 High horn
10 Cluster
11 Battery
12 Master switch
13 Buzzer
14 OPSS unit
15 Start switch
16 SCR cleaning warning lamp
17 SCR cleaning inhibit warning lamp
18 DEF low warning lamp
19 HEST warning lamp
20 Engine stop warning lamp
21 Hazard switch
22 Inching switch
23 Auto/Manual select switch
24 Rear work lamp switch
25 Beacon switch
26 Fuel heater switch
27 Main light switch
28 Inc/Decrement switch
29 SCR cleaning switch
30 Flasher unit
31 Relay 5P
32 Relay 4P
33 Monitor assy



ELECTRICAL SYSTEM – Cluster

ELECTRICAL SYSTEM – Cluster

NO	Symbol	Name	Description
1		LEFT TURN LAMP	Illuminates when the left turn signal has been activated.
2		RIGHT TURN LAMP	Illuminates when the right turn signal has been activated.
3		HEAD LAMP	It is turned on once the driver activates the high beam mode of the headlight.
4		T/M TEMP LAMP	Illuminates when the transmission oil temperature is high (above 107℃). Turn off the forklift, and notify your supervisor immediately.
5		E/G TEMP LAMP	Illuminates when the engine coolant temperature is high (above 104℃). Turn off the forklift, and let Cool.
6		FUEL EMPTY LAMP	Illuminates when a low fuel level. Refueling is urgently required.
7		BRAKE COOLING LAMP Not used	Illuminates when the brake oil temperature is too low. Turn off the forklift, and check out the cause.
8		BRAKE LAMP Not used	Illuminates when the brake fluid level is too low. Turn off the forklift, and check the level in the brake fluid reservoir.
9		T/M FAIL LAMP	Illuminates when it indicates a transmission failure. If it is illuminated, turn off the forklift, and check out the cause.
10		ENGINE OIL PRESSURE LAMP	Illuminates when the engine oil pressure is too low. If it is illuminated with the engine running or when you are driving, this indicates a malfunction. Turn off the forklift, and check the engine oil level.

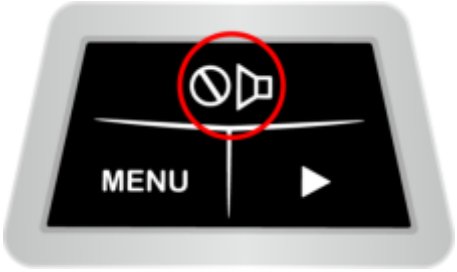
ELECTRICAL SYSTEM – Cluster

NO	Symbol	Name	Description
11		FUEL HEATER LAMP	Illuminates when the hydraulic fluid temperature is below 20℃ or engine coolant temperature is below 10℃. If the engine coolant temperature is above 60℃ or hydraulic fluid temperature is above 45℃ the ignition switch is in the ON position, automatic fuel heating is canceled.
12		WIF(WATER IN FUEL) LAMP	Illuminates when the water separator is filled with water or occur. If it is illuminated, Discharge of water from the water separator.
13		ENGINE PREHEAT LAMP	If it is illuminated when the ignition switch is in the ON position, the engine pre-heating devices is working. Depending on the engine oil temperature, warm-up is completed and the lamp will be turn off after about 15~45 seconds. If the lamp is turn off, start the engine.
14		ENGINE CHECK LAMP	If the engine warning light is illuminated, it'll be accompanied by some unusual symptoms. Turn off the forklift, and notify your supervisor immediately.
15		PARKING LAMP	Illuminates when the parking brake is engaged and the ignition is on. If it illuminates when you are driving, check that the parking brake is not engaged.
16		WORK LAMP	Illuminates when the driver pushes the work lamp switch.
17		SEAT BELT LAMP	It will illuminate to remind you to fasten your safety belt. (approximately 5 seconds)
18		OPSS LAMP	It will illuminate when the driver deviates from seat after the ignition switch is ON or START. And transmission automatically changes gear in neutral. To return to normal operation, the driver seated correctly in the driver's seat.
19		BATTERY CHARGE LAMP	If it is illuminated while driving, it indicates a malfunction. Switch off all unnecessary electrical equipment and have the system checked by your authorized dealer.
20		AIR CLEANER LAMP	Illuminates when the air cleaner is broken. If it illuminates, Check the filter and Clean or Replace a filter.
21		INCHING LAMP	Illuminates when the driver pushes the work Inching switch.

Electric system – Cluster – Display – Odometer – Error codes

Electric system – Cluster Special – Speed Limiter

1. Engage Parking brake
2. Key ON
3. Press 3 buttons the same time for ~3 sec.
4. Confirm or decline the function by



5. If YES → Change speed (loop) by:

6. Key switch OFF

Electric system – Monitor

1. Only one camera available

Rear view camera monitor manual 21HS-19240 (1).pdf

Electric system – Cluster Switches console

Work lamp pilot lamp (rear)

Beacon switch

SCR cleaning switch

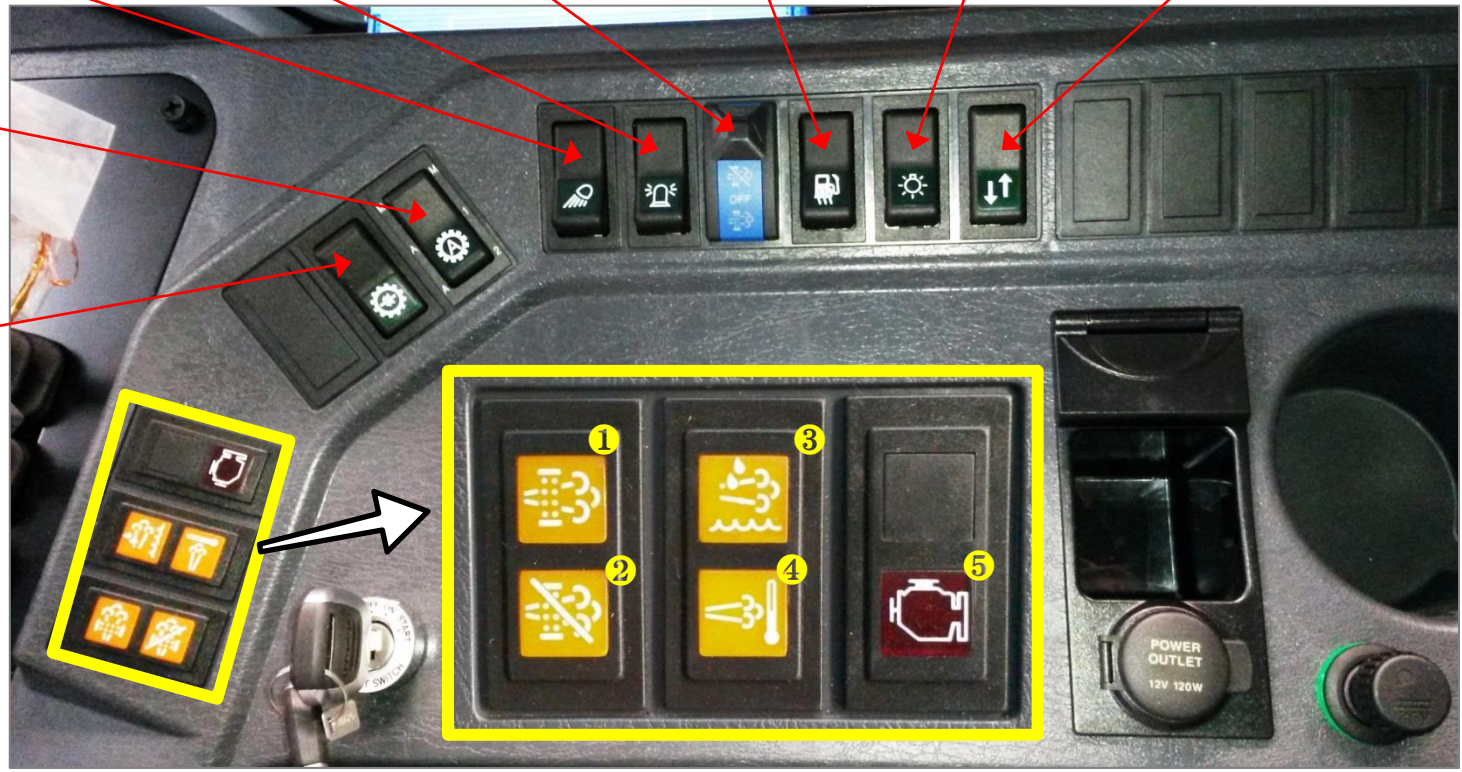
Fuel heater switch

Head lamp

Inc/Decrement switch

Auto/Manual select switch

Inching switch



1. SCR cleaning warning lamp
2. SCR cleaning inhibit warning lamp
3. DEF low warning lamp
4. HEST warning lamp
5. Engine stop warning lamp

Electric system – diagrams

ELECTRICAL DIAGRAMS
WILL NOT BE PRINTED ON A3

qsf38.pdf

electrical diagram - machine.pdf

Electric system – component and connectors spec.

No	Part name	Qty	Specification
1	Battery	2	12V×72 AH RC : 130 min CCA : 630A
2	Working lamp	1	24V, 70W
3	License lamp	1	24V, 10W
4	Rear Combination lamp	2	24V, 21/5W (Turn signal) 24V, 10W (Tail) 24V, 10W (Stop)
5	Head lamp	2	24V, 70W
6	Flasher lamp	2	24V, 25/10W
7	Room lamp	1	24V, 10W
8	Cluster	1	24V, 10W
9	Rear view camera	1	24V, 2.5W
10	12V socket	1	12V, 10A
11	Cigar lighter	1	24V, 5A
12	Converter	1	24V, 10A
13	Relay (5P)	14	24V, 8A
14	Flasher Unit	1	24V, 85±10 CM, (21W + 21W) × 2 + 3W ×2
15	Back buzzer	1	24V, 90±5 dB, 60±10 C/M, 300 mA max.
16	Warning buzzer	1	24V, 200 mA, 90±5 dB (ℓ m)
17	OPSS buzzer	1	24V, 50 mA max., 80~90 dB
18	Horn	1	24V, 1.5 A, 100 ~ 115 dB
19	Fuel level sender	1	Float indicator: E / 4/8 / F Resistance (Ω): - / 350 / 50 Tolerance (Ω): +5% -0 / 5% / +0 -5%
20	Warning lamp	3	24V
21	Master switch	1	24V, 180A
22	Work lamp switch	1	24V, 8A
23	Hazard switch	1	24V, 8A
24	Beacon switch	1	24V, 8A
25	Start switch	1	24V, 60A
26	Start relay	1	24V, 300A
27	Tilt switch (cabin)	1	24V, 8A
28	Monitor	1	24V, 15W
29	Auto/Manual switch	1	24V, 8A
30	Clutch cut-off switch	1	24V, 8A
31	Main light switch	1	24V, 8A
32	Intermittent wiper relay	1	24V, 5A
33	OPSS unit	1	24V

No	Part name	Qty	Specification
34	Increase/Decrease switch	1	24V, 8A
35	Fuel warmer switch	1	24V, 8A
36	Inching switch	1	24V, 8A
37	SCR switch	1	24V, 8A
38	Beacon lamp	1	24V

Electric system – component and connectors spec.

Connector number	Type	No. of pin	Destination	Connector part No.	
				Female	Male
CN-1	AMP	15	I/conn (Console harness-frame harness)	2-85262-1	368301-1
CN-2	AMP	12	I/conn (Frame harness-console harness)	174661-2	174663-2
CN-3	KET	1	I/conn (Frame harness-console harness)	MG640944-5	MG650943-5
CN-4	KET	1	Start cable	-	MG650943-5
CN-6	TYCO	15	I/conn (Console harness-frame harness)	2-85262-1	368301-1
CN-7	TYCO	4	Fuel filter heater	2-967325-3	-
CN-8	AMP	8	DPF harness	174982-2	-
		8	Transmission display	929504-3	-
CN-9	AMP	4	Harness monitor (CAN)	174257-2	-
CN-10	AMP	8	I/conn (Console harness-T/M harness)	174982-2	S816-108002
CN-11	AMP	15	I/conn (Console harness-T/M harness)	368047-1	S816-116002
CN-12	AMP	12	I/conn (Frame harness-console harness)	174661-2	174663-2
CN-13	MOLEX	12	I/conn (Frame harness-injector harness)	33472-1206	-
CN-16	AMP	3	Monitor power	174357-2	S816-103002
CN-17	TYCO/AMP	12	I/conn (Cabin harness-console harness)	174661-2	174663-2
CN-19	KET	2	Output check	MG610320	-
CN-20	KET	4	Aircon harness (Cabin)	MG641744-5	-
	AMP	6	Diagnostic	480704-0	-
CN-21	AMP	6	Wiper motor (Cabin)	936257-2	-
CN-22	KET	2	Washer tank (Cabin)	MG640605	-
CN-23	KET	2	LH speaker (Cabin)	MG610070	-
CN-24	KET	2	RH speaker (Cabin)	MG610070	-
CN-25	MOLEX	2	Horn	35825-0211	-
CN-26	KET	1	Tilt alarm	ST730018-3	ST750836-3
CN-27	KUM	16	CD/MP3 radio (Cabin)	PK145-16017	-
CN-36	-	-	Fuse box	21HF-10500	-
CN-37	-	-	Fuse box	21HF-10500	-
CN-45	KET	1	Start motor	S820-205000	-
CN-50	AMP	68	Transmission control unit	963598-1	-
CN-51	AMP	6	Diagnostic	-	926682-3
CN-54	AMP	36	Load indicator control unit	344111-1	-
CN-55	KET	14	OPSS unit	MG610350	-
CN-56	AMP	20	Cluster	174047-2	-
CN-57	AMP	20	Cluster	175967-2	-
CN-65	KET	1	Back buzzer	ST730018-3	-
CN-71	DEUTSCH	6	Seat switch	DT06-6S	-
CN-74	KET	1	Alternator	S820-105000	-
CN-95	KET	2	Fusible link	-	MG620558

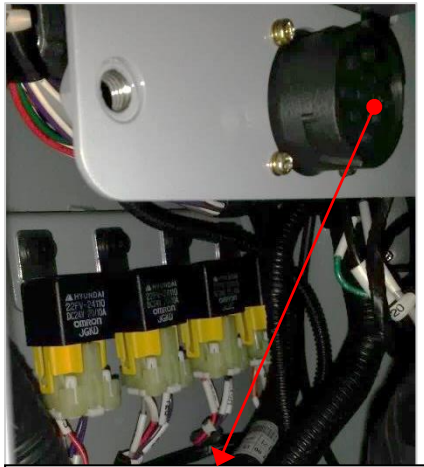
Connector number	Type	No. of pin	Destination	Connector part No.	
				Female	Male
CN-98	DEUTSCH	3	Resistor	DT06-3S-EP06	-
CN-101	FRAMATOME	4	ENG TBAP	54200415	-
CN-113	KET	2	OPSS buzzer	MG610320	-
CN-124	AMP	6	Accelerator pedal	174262-2	-
CN-129	KET	2	12V socket	MG610043	-
CN-131	DEUTSCH	2	Attach cut solenoid	DT06-2S	-
CN-134	DEUTSCH	9	ECU service port	-	HD10-9-19399
CN-138	KET	3	Converter	MG610045	-
CN-147	KET	2	Cabin tilting pump motor	MG640188-4	-
CN-151	DELPHI	96	ECU J2	13964577	-
CN-169	DEUTSCH	4	RS232C	DT06-4S-EP06	DT04-4P-E005
CN-J1	FIC	24	ECU J1	F934000	-
CN-J6	DEUTSCH	4	DEF quality sensor	DT06-4S	-
CN-J7A	AMP	4	NOX sensor (Gray)	2-1418390-1	-
CN-J7B	AMP	4	NOX sensor	1-1418390-1	-
CN-J10	AMP	4	SCR thermo control	3-1418390-1	-
CN-J26	AMP	12	DEF supply module	2-1703639-1	-
CN-J27	AMP	4	DEF tank heater valve	1-967325-1	-
CN-J28	DEUTSCH	2	DEF pressure line	DT06-2S	-
CN-J29	DEUTSCH	2	DEF backflow line	DT06-2S	-
CN-J30	DEUTSCH	2	DEF suction line	DT06-2S	-
CN-J31	BOSCH	2	DEF dosing module	1928403874	-
Switch					
CS-2	KET	2	Start switch	MG610281	MG620282
CS-5	KET	2	Horn switch	MG640322	-
CS-5A	KET	2	Horn switch	MG610320	-
CS-5B	KET	1	Horn switch	S820-10500	-
CS-6	KET	1	Multi function switch	ST730018-3	-
CS-10	DAEDONG	10	Fuel warmer switch	250-10PRG	-
CS-11	KET	6	Combination switch	MG610335	-
CS-12	KET	8	Combination switch	MG610339	-
CS-14	PACKARD	4	Gear selector switch	-	12010974
CS-15	PACKARD	4	Gear selector switch	12015797	-
CS-17	KET	3	Parking brake switch	MG610045	-
CS-23	DAEDONG	10	Beacon switch	250-10PRG	-
CS-39	DAEDONG	10	Main light switch	250-10PRG	-
CS-41	DAEDONG	10	Hazard switch	250-10PRG	-
CS-42	DAEDONG	10	Inching switch	250-10PRG	-
CS-59	DAEDONG	10	Auto/Manual switch	250-10PRG	-
CS-64	DAEDONG	10	Increase/Decrease switch	250-10PRG	-

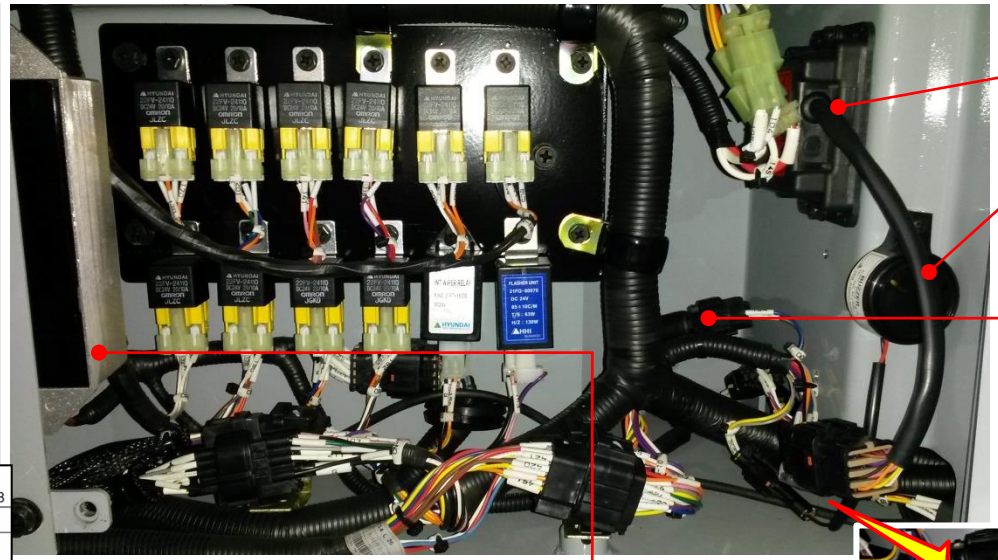
Electric system – component and connectors spec.

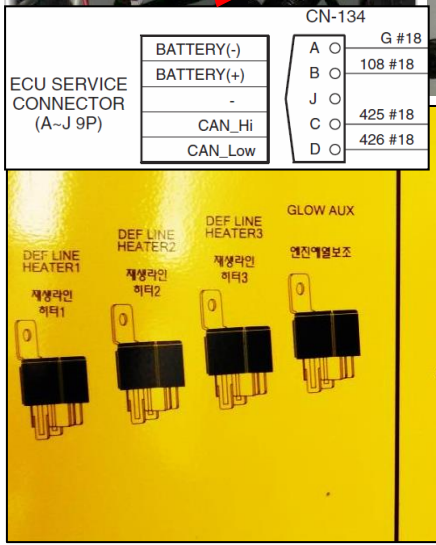
Connector number	Type	No. of pin	Destination	Connector part No.	
				Female	Male
CS-69	DAEDONG	10	Rear work switch	250-10PRG	-
CS-72	DEUTSCH	4	Tilt alarm switch	DT06-4S	DT04-4P
CS-74	DEUTSCH	4	Cabin tilting supply switch	DT06-4S	DT04-4P
CS-77	SWF	10	Cabin tilting switch	593757	
CS-100	SWF	12	SCR switch	589790	-
Lamp					
CL-2	KET	1	Cigar light	ST730018-3	ST750036-3
	AMP	1	Cigar light	172128-1	-
CL-7	KET	2	Beacon lamp	-	DT04-2P
CL-15A	AMP	3	ILLUM/Stop lamp (Black)	282087-1	-
CL-15B	DAEDONG	3	Turn/back up lamp	282087-2	-
CL-16A	AMP	3	ILLUM/Stop lamp (Black)	282087-1	-
CL-16B	AMP	3	Turn/back up lamp (Gray)	282087-2	-
CL-21	KET	1	License lamp	ST730018-3	ST750036-3
CL-23	KET	1	Rear work lamp	S822-014000	S822-114000
CL-24	DEUTSCH	6	Work lamp-LH	DT06-6S	-
CL-25	DEUTSCH	6	Work lamp-RH	DT06-6S	-
CL-40	SWF	2	Engine stop lamp	913328	-
CL-41	SWF	2	HEST lamp	913328	-
CL-42	SWF	2	SCR cleaning lamp	913328	-
CL-43	SWF	2	SCR cleaning inhibit lamp	913328	-
CL-50	SWF	2	DEF low lamp	913328	-
CL-51	KET	2	Room lamp (Cabin)	MG610392	-
Relay					
CR-4	KET	5	Wiper relay (Cabin)	MG640927	-
CR-5	KET	5	Neutral relay	MG640927	-
CR-6	KET	4	Intermittent wiper relay (Cabin)	MG610047	-
CR-11	-	3	Flasher unit relay	312-GIHUNG	-
CR-23	KET	4	Start relay	172134-1	-
CR-24	KET	1	Pre-heater relay	ST730018-3	-
CR-26	KET	5	Wiper pump relay (Cabin)	MG640927	-
CR-34	KET	5	Parking relay	MG640927	-
CR-35	KET	5	Back up relay	MG640927	-
CR-36	KET	5	Start lock relay	MG640927	-
CR-39	KET	5	Wiper high relay	MG640927	-
CR-44	AMP	2	Cabin tilting relay	174352-2	-
CR-45	KET	5	Glow aux relay	MG640927	-
CR-50	KET	5	Tilt/Lift cut-off relay	MG640927	-
CR-58	KET	5	DEF supply module relay	MG640927	-
CR-59	KET	5	DEF & sensor relay	MG640927	-

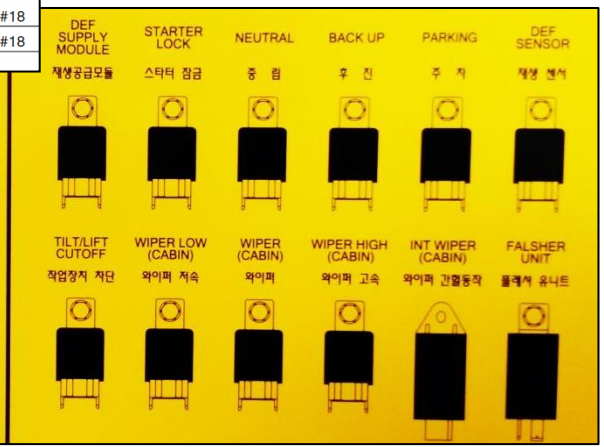
Connector number	Type	No. of pin	Destination	Connector part No.	
				Female	Male
CR-61	KET	5	DEF line heater-1 relay	MG640927	-
CR-62	KET	5	DEF line heater-2 relay	MG640927	-
CR-63	KET	5	DEF line heater-3 relay	MG640927	-
Sensor and pressure switch					
CD-2	KET	3	Fuel sendor	MG610045	-
CD-3	DEUTSCH	2	Brake fail pressure	-	DT04-2P
CD-4	AMP	1	Stop lamp switch	171809-2	-
CD-27	AMP	2	Turbin speed input	963040-3	-
CD-38	DEUTSCH	2	Water in fuel switch	DT06-2S	-
CD-71	AMP	6	Inching sensor	1-967616-1	-
CD-72	AMP	2	Gear train speed sensor	963040-3	-
CD-73	AMP	3	Output speed sensor	282087	-
CD-80	PACKARD	2	KV Solenoid	12162197	-
CD-81	PACKARD	2	KR Solenoid	12162197	-
CD-82	PACKARD	2	KD Solenoid	12162197	-
CD-83	PACKARD	2	KE Solenoid	12162197	-
CD-84	PACKARD	2	KC Solenoid	12162197	-
CD-90	AMP	2	Temp sensor	963040-3	-
CD-J22	DELPHI	3	Coolant level	12110293	-
DO-01	-	2	Diode	21EA-50550	-

Electric system – electrical compartment - relays





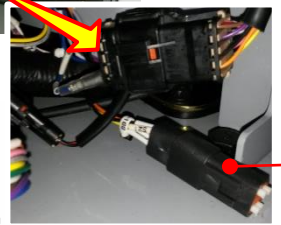




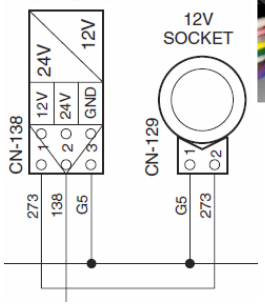
ECU SERVICE CONNECTOR (A~J 9P)

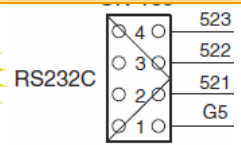
CN-134

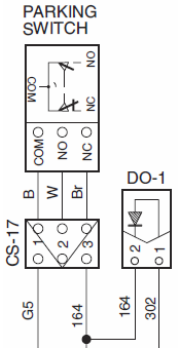
BATTERY(-)	A	G #18
BATTERY(+)	B	108 #18
-	J	
CAN_Hi	C	425 #18
CAN_Low	D	426 #18



CONVERTOR







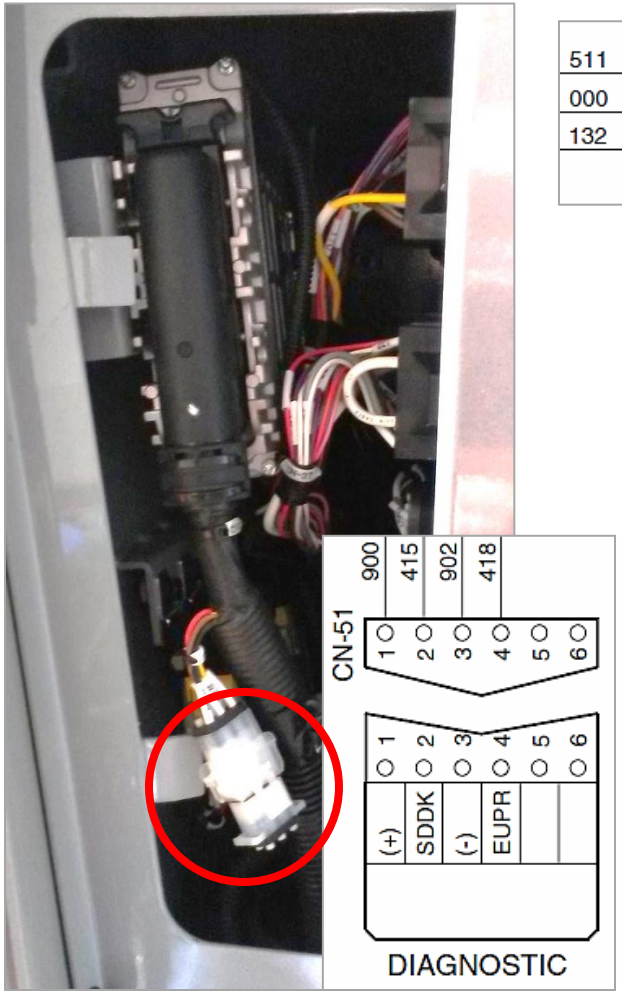
OPSS unit and buzzer

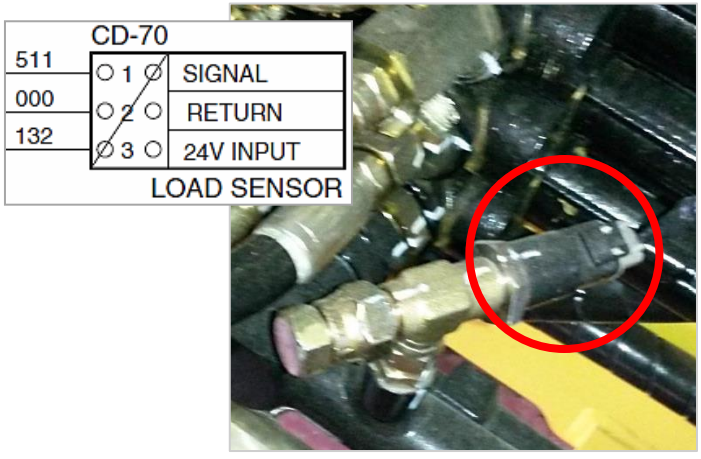
DO1 – parking switch

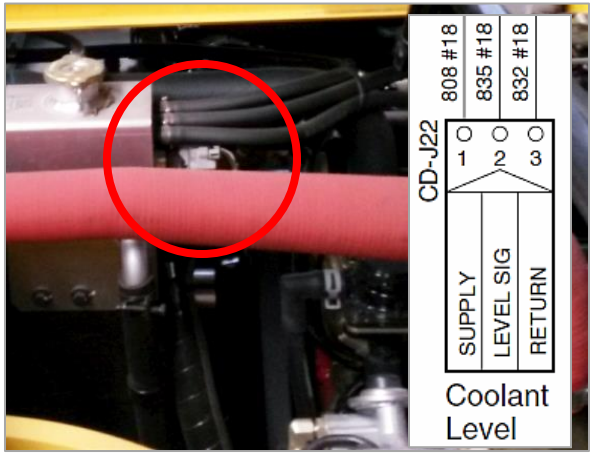
RS232C – Cluster update

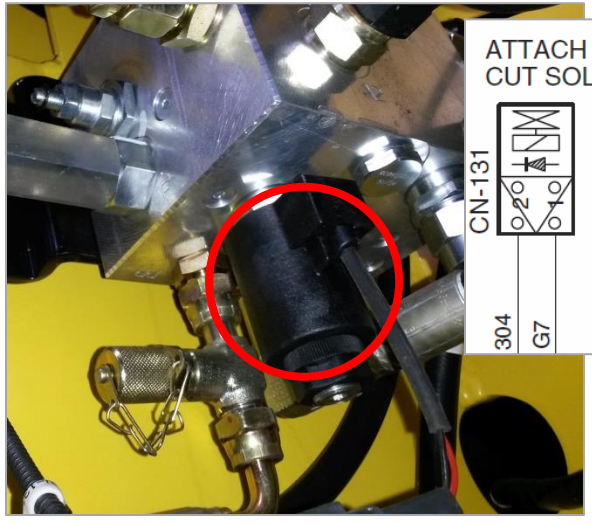
DC/DC converter

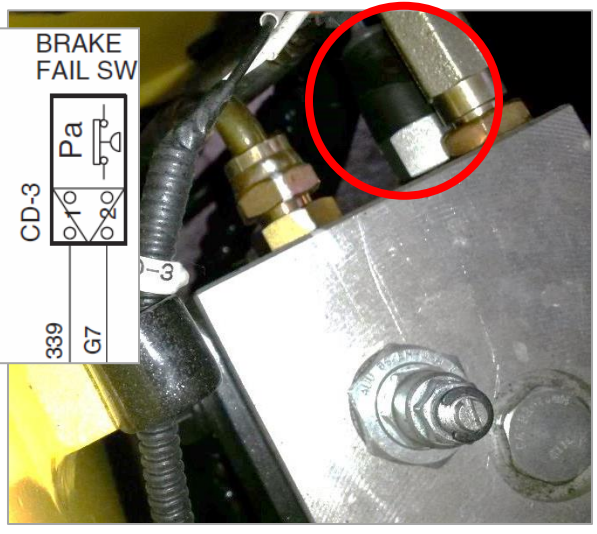
Electric system – electrical compartment - examples



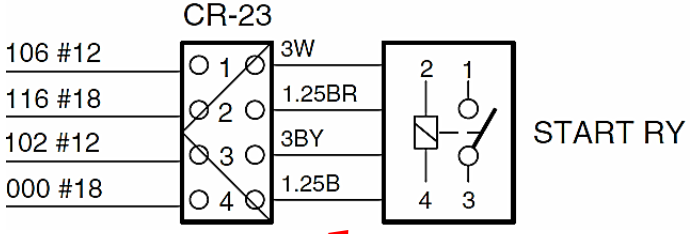


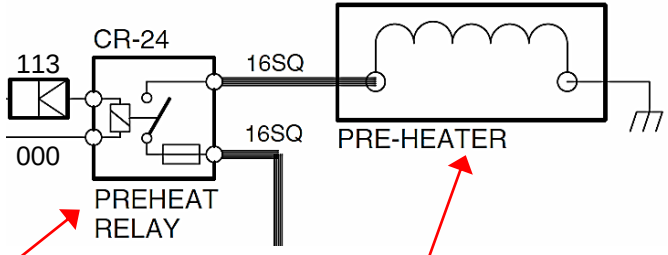


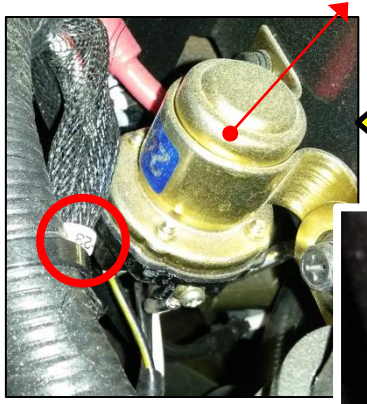




Electric system – electrical compartment - examples

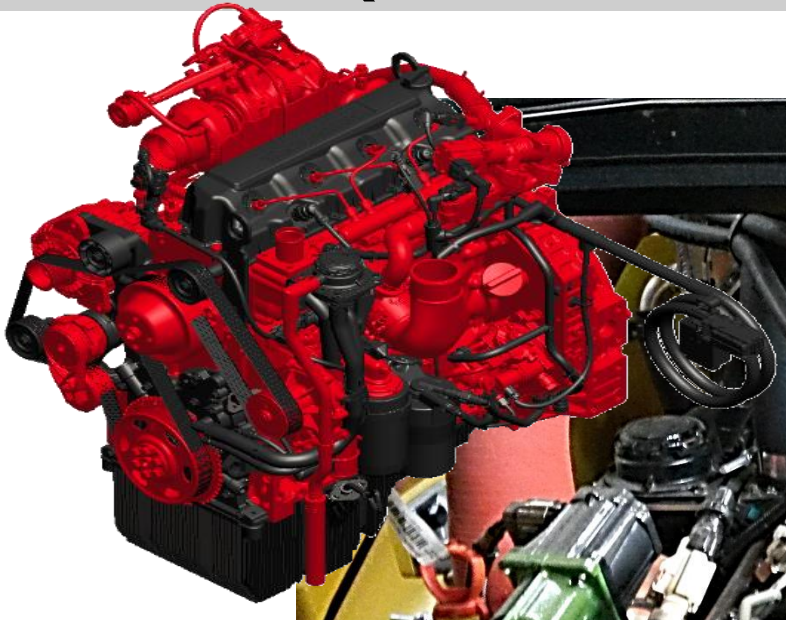






Engine

CUMMINS QSF3.8 CM2350 F107



CUMMINS QSF3.8 - Specifications

Specifications

Listed below are the general specifications for this engine.

Horsepower	Refer to engine dataplate
Bore and Stroke	102 mm [4.02 in] x 115 mm [4.53 in]
Firing Order	1-3-4-2

Engine Weight (with standard accessories):

Dry Weight for 3.8 liter engine [231 C.I.D.]	348 kg [767 lb]
Crankshaft Rotation (viewed from the front of the engine)	Clockwise

Valve Clearance:

Intake	0.330 mm [0.013 in]
Exhaust	0.584 mm [0.023 in]
Maximum Overspeed Capability (15 seconds maximum)	3750 rpm
Minimum Ambient Air Temperature for Unaided Cold Start	- 12.2°C [10°F]
Minimum Engine Cranking Speed	120 rpm
Engine Idle Speed	700 rpm

Altitude Maximum Before Derate Occurs

3.8 liter engine	1676 m [5500 ft]

Oil Carryover:

Open crankcase ventilation system	Less than 2 grams/hour [0.07 oz/hr]

Engine Blowby (with orifice size 5.61 mm [0.221 in]):

New	101.6 mm H2O [4.0 in H2O]
Used	431.8 mm H2O [17.0 in H2O]

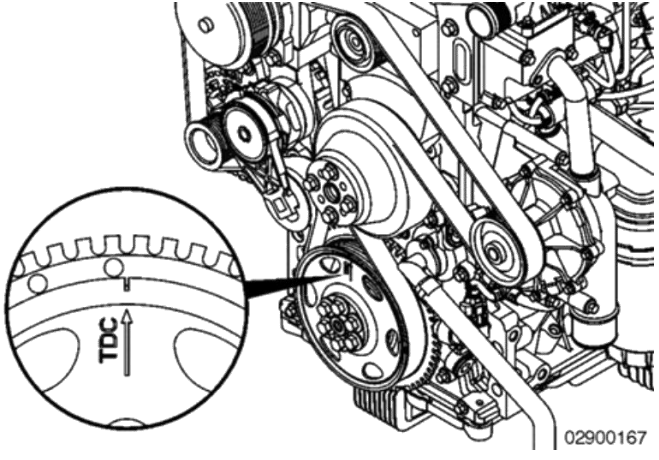
Full stall
1260 rpm

Review procedure 003-004

NOTE:

Engine coolant temperature must be less than 60° C [140° F].

Finding Top Dead Center Cylinder #1



NOTE: The engine features a no-adjust overhead. ***Adjustment of the valve lash is not required for normal service during the first 5000 hours***. The valve train operates acceptably within the limits of 0.229 to 0.457 mm [0.009 to 0.018 in] intake valve lash and 0.457 to 0.838 mm [0.018 to 0.033 in] exhaust valve lash. It is recommended that the valve lash be checked at 5000 hours and every 2000 hours thereafter.

CUMMINS QSF3.8 - Specifications

Fuel system

Specifications

For performance and fuel rate values, see the Engine Data Sheet.

Maximum Fuel Inlet Restriction - With gear pump **only** (at gear pump inlet)	14 kPa [12 in-Hg]
Rail Pressure	250 to 2,000 bar [3,626 to 29,008 psi]
Maximum Fuel Pressure Range at Fuel Filter Outlet (engine cranking) - With gear pump **only**	3.3 kPa [1 in-Hg] Maximum
Fuel Pressure Range at Fuel Filter Inlet (engine running) - With gear pump **only**	400 to 810 kPa [58 to 117 psi]
Maximum Fuel Drain Line Restriction	20 kPa [5.9 in-Hg]
Maximum Fuel Inlet Temperature	70°C [158°F]

Cooling system

Specifications

Engine Coolant Capacity	7.3 liters [7.7 qt]
Standard Modulating Thermostat - Range	82 to 95°C [180 to 203°F]
Maximum Allowed Operating Temperature	107°C [225°F]
Minimum Recommended Operating Temperature	70°C [158°F]
Minimum Recommended Pressure Cap at Sea Level	90 kPa [13 psi]

CUMMINS QSF3.8 - Specifications

Lubrication system

Specifications

Oil Pressure

Low idle (minimum allowed)	69 kPa [10 psi]
At rated speed (minimum allowed)	275 kPa [40 psi]
Oil-regulating valve-opening pressure range	525 kPa to 600 kPa [76 psi to 87 psi]
Oil filter differential pressure to open bypass	345 kPa [50 psi]
Lubricating oiil filter capacity	0.85 liters [0.9 qt]

Oil Capacity of Standard Engine

Low Capacity Rear Sump Oil Pan

Pan **only**	8 liters [8.4 qt]
Total system	10.6 liters [11.2 qt]
High to low (on dipstick)	1.5 liters [1.6 qt]
Maximum Oil Temperature	135°C [275°F]

NOTE: If the type/oil capacity of the oil pan is not known:

Contact a Cummins® Authorized Repair Location.

Determine the capacity of the oil pan option for the engine being serviced. Use QuickServe™ Online and the engine serial number.

Fill the lubricating oil pan to the smallest oil pan capacity listed for the engine being serviced.
Then add 0.95 liters [1 qt] of oil at a time until it reaches the high mark on the dipstick.
Record the number of quarts added, so that the capacity is known the next time the oil is drained.

CUMMINS QSF3.8 - Specifications

Intake system

Specifications

Maximum Intake Restriction:

Clean Air Filter Element	3.71 kPa / 378 mm H2O [15 in H2O]
Dirty Air Filter Element	6.2 kPa / 632 mm H2O [25 in H2O]

Charge-Air Cooler Temperature Differential:

Maximum Differential	30°C [86°F]

Charge-Air Cooler Pressure Differential:

Maximum Charge-Air Cooler Pressure Drop	13.5 kPa [1.96 psi]
Recommended Intake Piping Size	76 mm [3 in]

Exhaust system

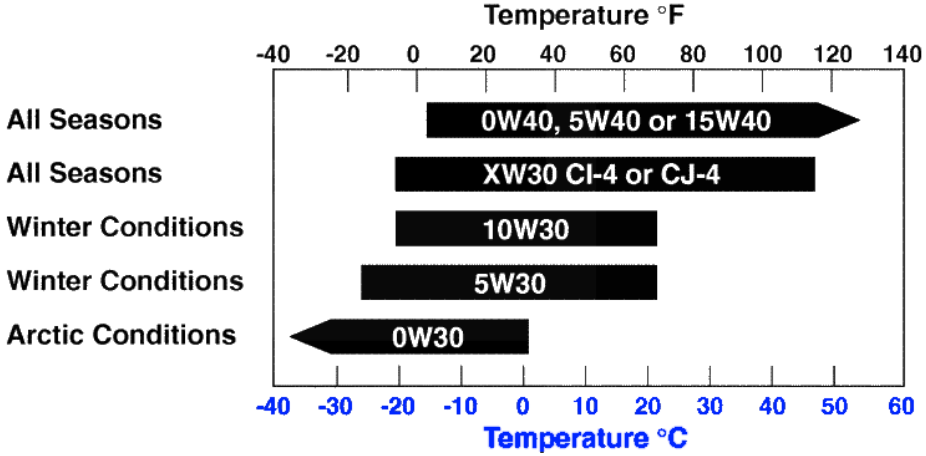
Specifications

Maximum Back Pressure (imposed by complete exhaust system)	18 kPa [5.3 Hg]
Exhaust Pipe Size (normally acceptable inside diameter)	75 mm [3 in]

CUMMINS QSF3.8 - Specifications

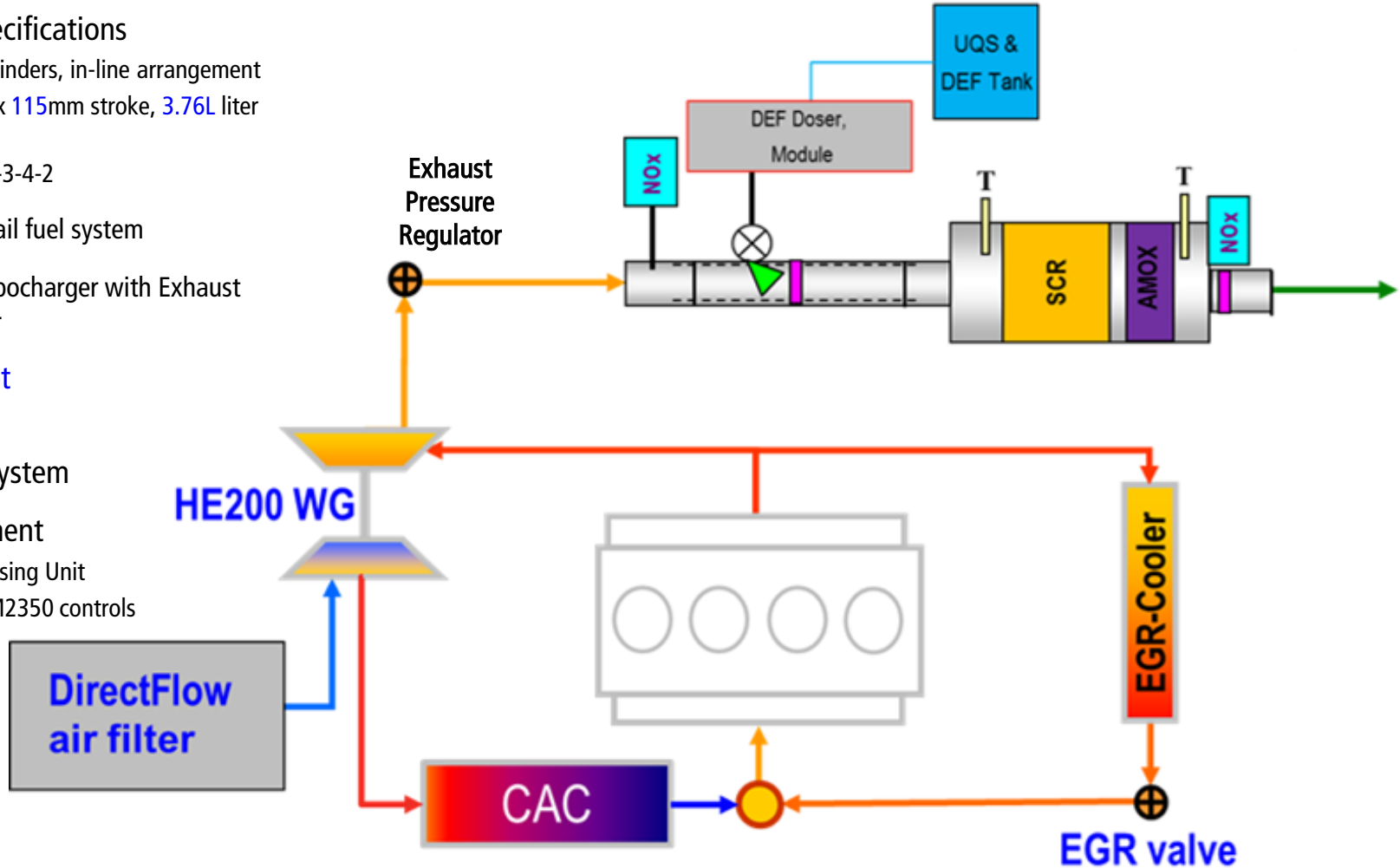
Table 1: Cummins Inc. Required Diesel **Fuel** Specifications1	
Viscosity	1.3 to 4.1 centistokes at 40°C [104°]
Cetane Number	42 minimum above 0°C [32°F]; 45 minimum below 0°C [32°F][2]
Sulfur Content	Maximum sulfur content of 15 ppm in the United States and Canada and 10 ppm in the EU
Active Sulfur	Copper strip corrosion **not** to exceed number 3 rating after 3 hours at 50°C [122°F].
Water Sediment	**Not** to exceed 0.05 volume-percent
Carbon Residue	**Not** to exceed 0.35 mass-percent on 10 volume-percent residuum
Density	0.816 to 0.876 grams per cubic centimeter (g/cc) at 15°C [59°F]
Cloud Point	6°C or 11°F below lowest ambient temperature at which the fuel is expected to operate
Ash	Not to exceed 0.02 mass-percent. For vehicles equipped with exhaust aftertreatment, there shall be no detectable ash in the fuel
Distillation	10 volume-percent at 282°C [540°F] maximum, 90 volume-percent at 360°C [680°F] maximum, 100 volume-percent at 385°C [725°F]maximum. The distillation curve **must** be smooth and continuous
Lubricity (HFRR)or (SLBOCLE)	High Frequency Reciprocating Rig (HFRR): Maximum of 0.52 mm[0.020 in] Wear Scar Diameter (WSD) at 60°C [140°F].Scuffing Load Ball-on-Cylinder Lubricity Evaluator (SLBOCLE):Minimum of 3100 grams

Table 2: Cummins Inc. Required Diesel **Oil** Specifications	
Cummins® Engineering Standard (CES) Classifications	CES-20081
American Petroleum Institute (API) Classification	API CJ-4
Association des Constructeurs Européen d'Automobiles (ACEA) Classification	ACEA E-9

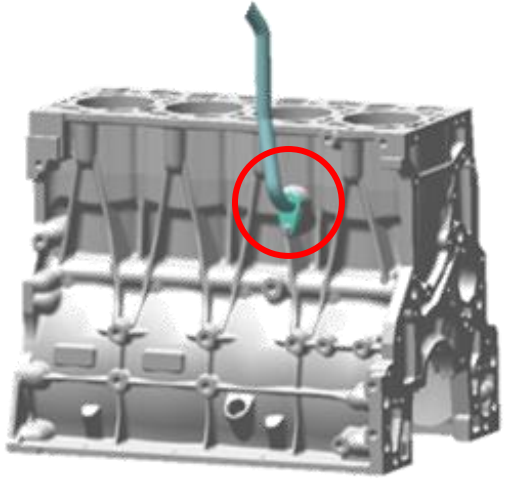


CUMMINS QSF3.8 - Architecture

- Base engine specifications
  - 4 stroke, 4 cylinders, in-line arrangement
  - 102mm bore x 115mm stroke, 3.76L liter displacement
  - Firing order 1-3-4-2
- Denso common rail fuel system
- Wastegated Turbocharger with Exhaust Pressure Regulator
- Emissions Target
  - Tier 4 Final
- Cold side EGR system
- SCR Aftertreatment
  - Bosch DEF Dosing Unit
  - Integrated CM2350 controls



CUMMINS QSF3.8 – Mechanical – Cylinder block & Crankshaft



Cast grey iron

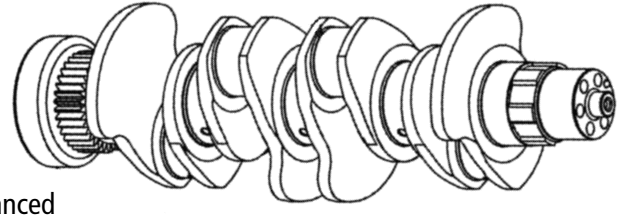
Sculpted design

- Less material & Greater Strength

Bored cylinders in parent material

Block Stiffener Plate

Water supply port for EGR cooler.



Ductile cast iron

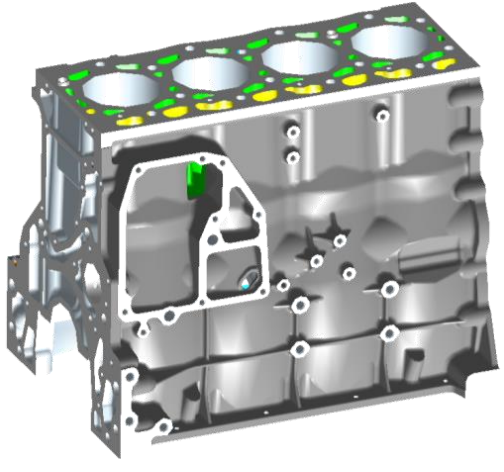
- Integrally balanced

The front gear is used to drive only the oil lubrication pump.

The rear gear is used to drive the camshaft, the fuel pump and accessories.

Neither gear is serviceable.

- If damaged, the entire crankshaft assembly must be replaced.



Main Bearing and Main Bearing Cap

The upper and lower main bearing shells are not interchangeable.

- The backs of the main bearings are marked with the proper orientation.
- The upper bearings have one hole that receives lubricating oil from the main oil rifle.

This engine only have a thrust bearing for the upper main bearing (180 degree).

- The crankshaft thrust bearing must be installed in the number 4 main bearing position.
- The flanges on this main bearing control the end thrust of the crankshaft.

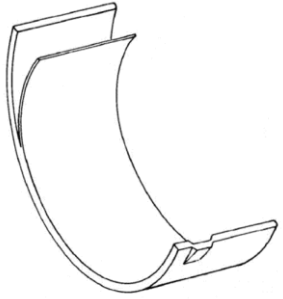
CUMMINS QSF3.8 – Mechanical – Connecting Rod and Bearings

Angle split rod

- The connecting rod is fractured during the manufacturing process to separate the connecting rod cap from the connecting rod.
- Angle split creates a narrower rod profile.

The surface between the connecting rod and the cap is not machined.

- Unique surface on every connecting rod and cap.
- Surface must be protected.
- Improper mating will cause rod damage.



Aluminum alloy lining bonded onto a steel strip. Lower and upper bearing use different material.

- Lower connecting rod bearings:

Good embedability

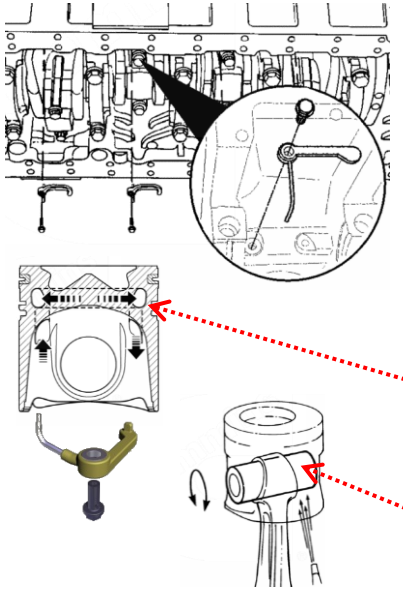
- Upper connecting rod bearings:

Good fatigue strength

Reference the appropriate Part Information resources when replacing the connecting rod bearings, so the correct connecting rod bearings are installed.

CUMMINS QSF3.8 – Mechanical – Piston & Rings

- One piece aluminum alloy piston.
- Front of piston is marked an arrow.

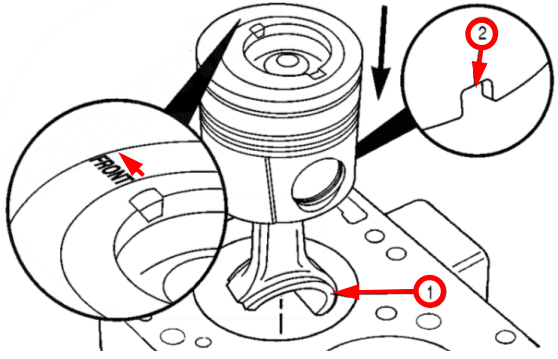


J-jet piston cooling nozzles are located between the main bearing saddles on the exhaust side of the engine.

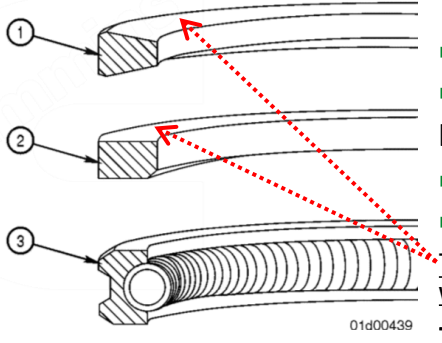
Oil is supplied from an oil gallery in the block.

The nozzles supply lubricating oil to the underside of the pistons.

- The pistons have an oil passage cast into the top of the piston for cooling purposes.
- Lubrication for the piston pin and journal is supplied by residual spray from the nozzles.



- Align the "Front" marking on the top of the piston so that it points towards the front of the engine.
- The long end of the connecting rod (1) and the notch in the piston skirt (2) will be on the exhaust side of the engine.



Top Piston Ring

- Hard particle chrome plating
- Keystone shape

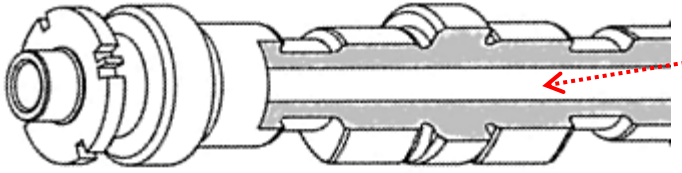
Intermediate piston ring

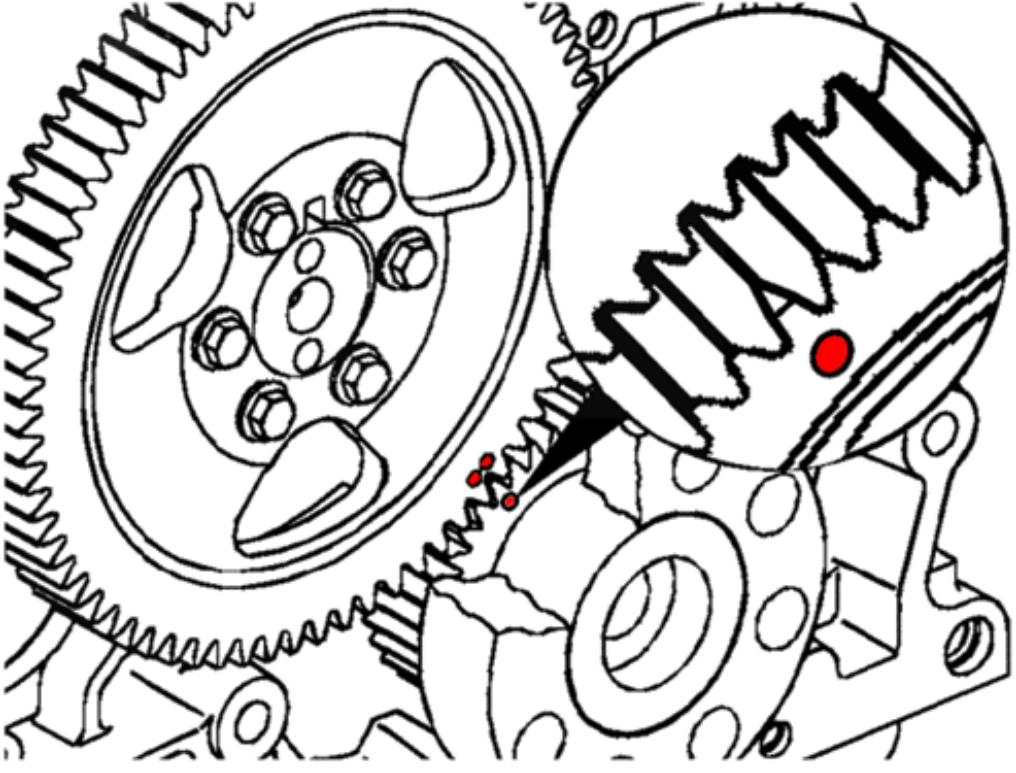
- The material is changed for higher wear resistance.
- Square cut shape

The top surface of the upper and intermediate rings are identified either with the word "TOP" or "O". Assemble with the word "TOP" or "O" facing upward.

The bottom ring, or oil control ring, can be installed with either side up.

CUMMINS QSF3.8 – Mechanical – Camshaft





The camshaft is hollow to allow crankcase gases to flow through it to the front of the engine.

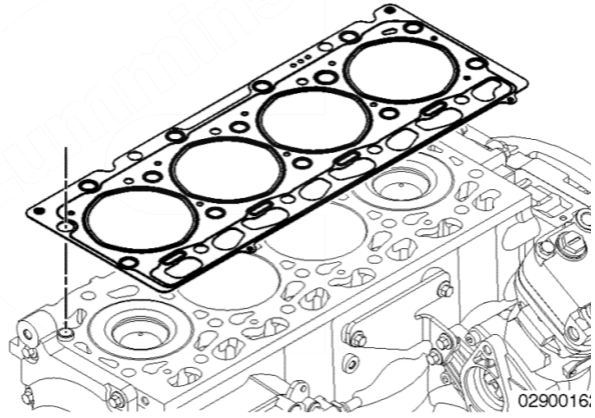
The camshaft speed indicator ring is mounted to the end of the camshaft at the front of the engine.

Only one camshaft bushing on flywheel end.

The camshaft must be timed to the crankshaft.

- The crankshaft gear has a special edge beveled gear tooth.
- The camshaft gear has a drilling between two teeth.

CUMMINS QSF3.8 – Mechanical – Cylinder Head and Gasket



The cylinder head gasket is a specialized metal design with a printed o-seal on both sides around the water holes.

- An embossment in the gasket seals the cylinder bores.

Head gasket grading is not required for these engines.

- No head gasket with an increased thickness, is available for cylinder head or block combustion deck resurfacing.

A new gasket **must** be installed. Do **not** reuse an old gasket.

One-piece

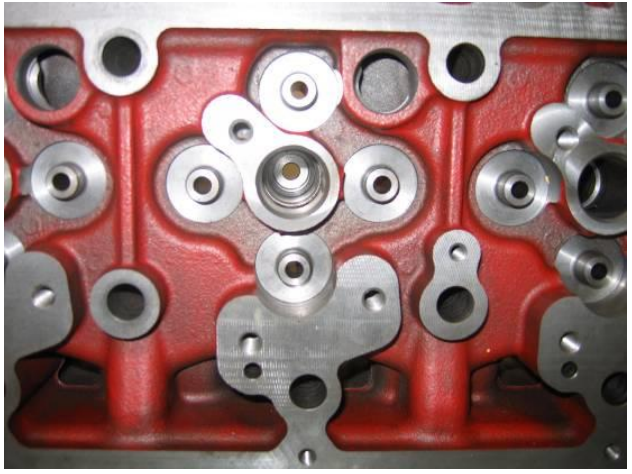
Cross flow design

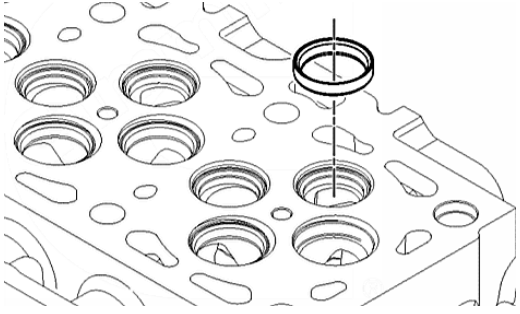
Four valve per cylinder design

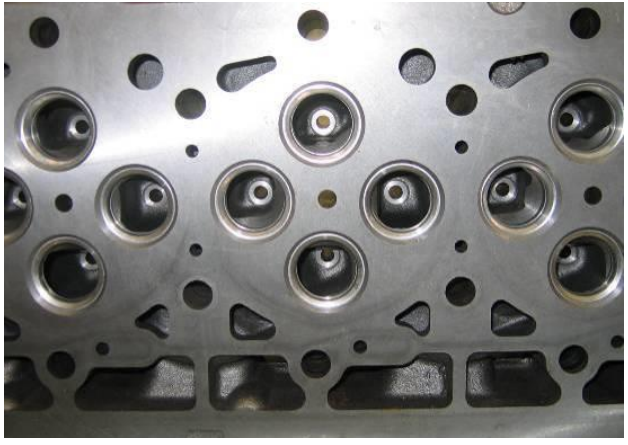
- Allows for a centered injector in the cylinder head

Replaceable valve seats

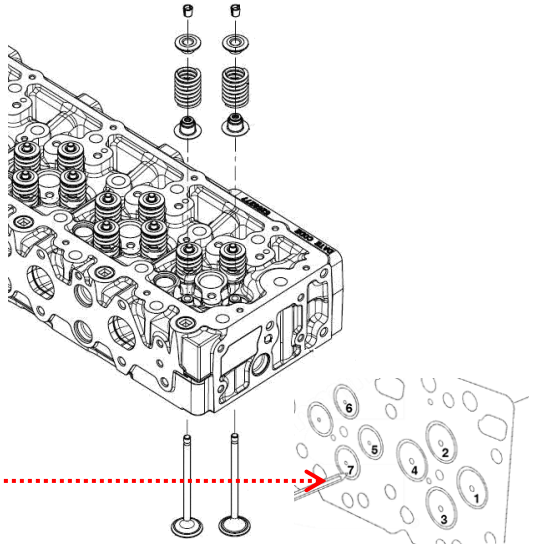
The cylinder head has integrally cast valve guides which are not serviceable.







CUMMINS QSF3.8 – Mechanical – Valves, tappets and rockers



The intake and exhaust valves are made of heat resistant steel, and have chrome plated stems to prevent scuffing.

- Intake and exhaust valves have similar design, but are not interchangeable.

If installing the same valves as previously removed, make sure to install the valves in the same locations from which the valves were removed.

- Both valves have a dimple on the valve head.

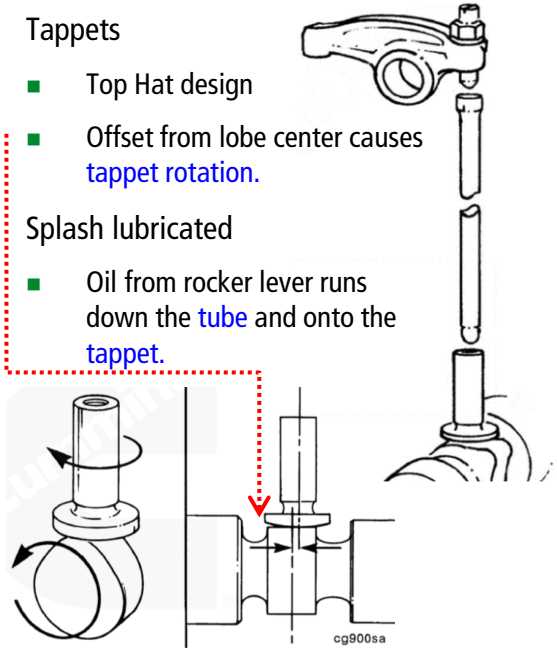
Transfers movement of the camshaft lobe to the rocker lever.

Tappets

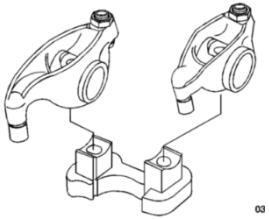
- Top Hat design
- Offset from lobe center causes tappet rotation.

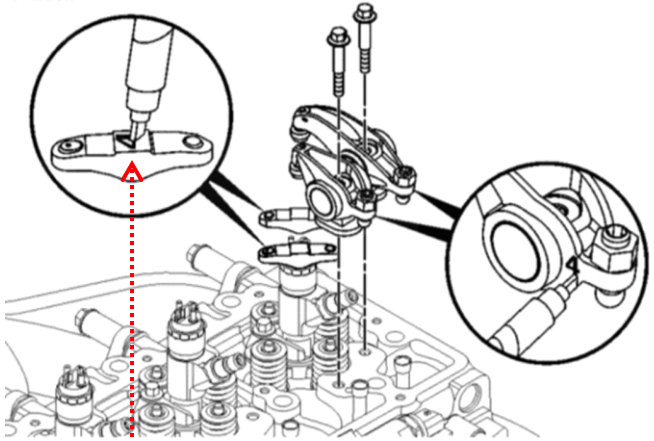
Splash lubricated

- Oil from rocker lever runs down the tube and onto the tappet.



Intake	0.330 mm	0.013 in
Exhaust	0.584 mm	0.023 in





The exhaust and intake rocker levers are mounted on a common pedestal, but rotate on separate shafts.

Crosshead allows one lever to depress two valves.

- The crosshead has a round and oval hole.

If installing new crossheads, it is not required to place the holes in a particular position.

If crossheads are being reused, make sure to install them in their original location and orientation.

CUMMINS QSF3.8 – Mechanical – Rocker cover, front gear cover, seal

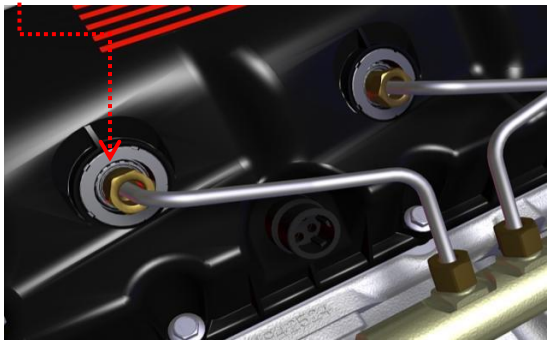
New valve cover to match with the new injectors.

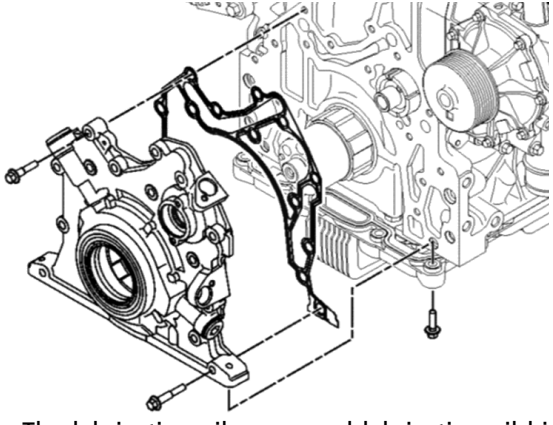
High Pressure Fuel Supply lines and Injector wires pass-through connectors.

- Critical to clean before loosening or removing high pressure supply lines.

The rocker lever cover uses a molded rubber gasket.

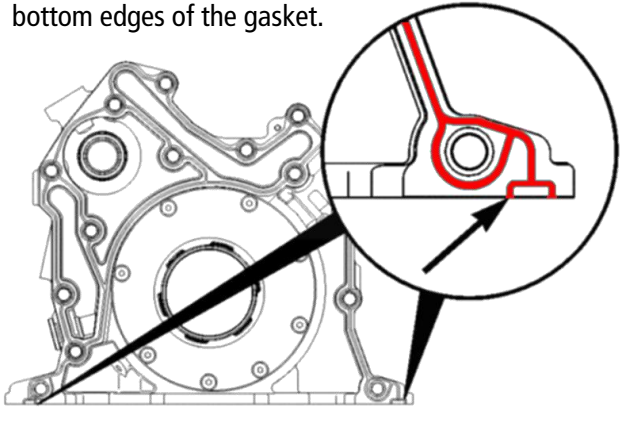
- The gasket is inserted into a groove along the perimeter of the rocker lever cover.

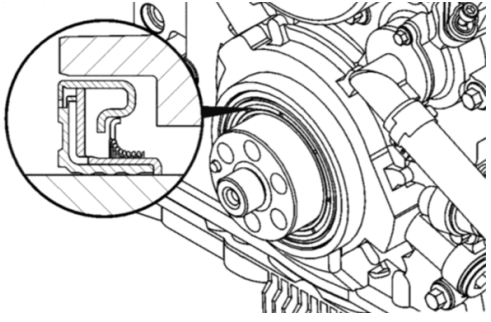




The lubricating oil pump and lubricating oil high pressure valve are a part of the front gear cover.

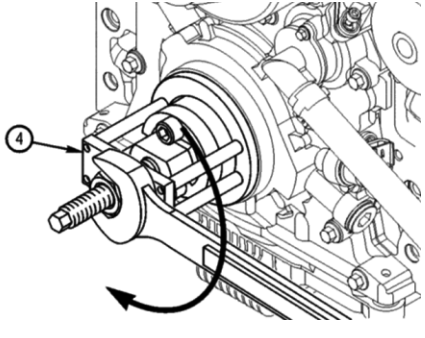
When installing the front gear cover gasket, take care not to damage the rubber seal on the bottom edges of the gasket.



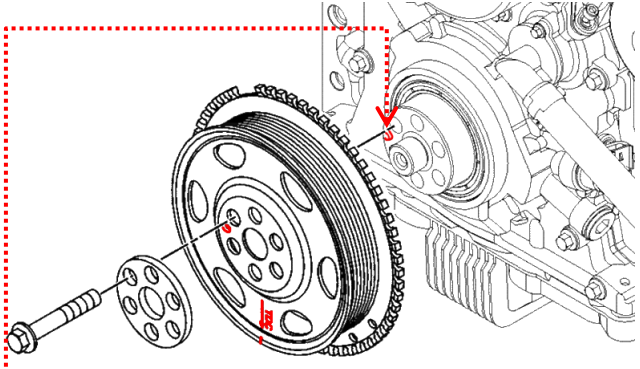


This engine is equipped with a Unitized/Cartridge seal which utilizes a built-in wear sleeve and a concealed sealing lip.

The inner and outer diameters are press-fit onto the crankshaft and the front gear cover respectively. The sealing point is internal to the seal.



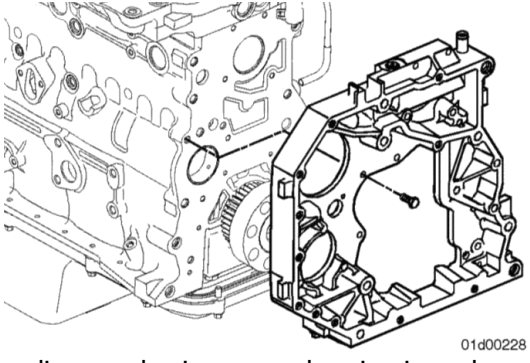
CUMMINS QSF3.8 – Mechanical – Pulley, gear housing, accessory drive



The crankshaft pulley and the crankshaft speed indicator ring are a permanent assembly.

No vibration damper.

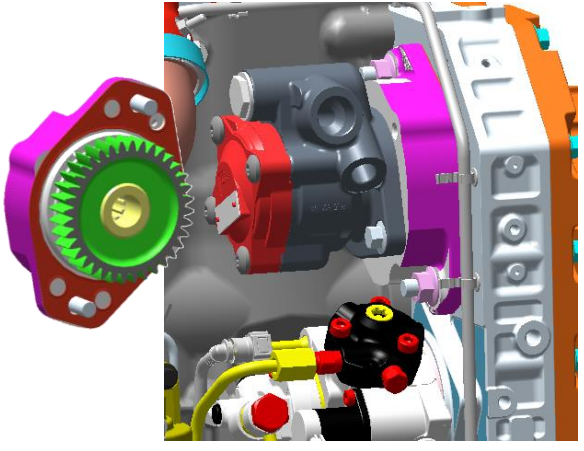
Align the crankshaft pulley with the index pin located on the nose of the crankshaft.

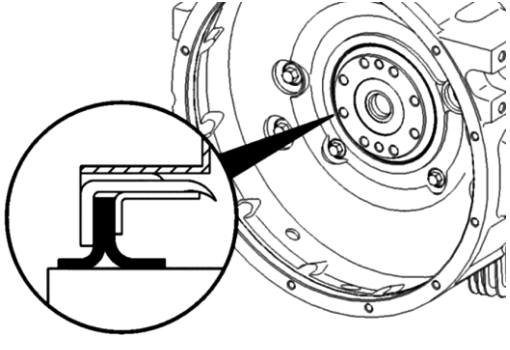


The die cast aluminum gear housing is at the rear of the engine between the block and flywheel housing.

The rear gear housing is used to mount the fuel pump and a gear driven accessory driven accessory drive.

The rear gear housing also contains an internal oil passage to feed oil to the accessory drive.

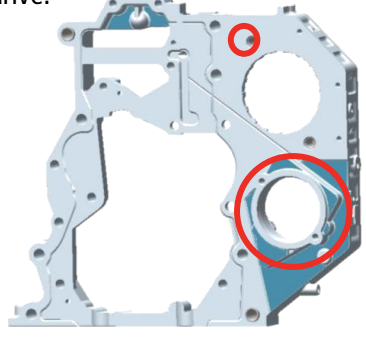




This engine is equipped with a lip style rear crankshaft seal.

- The rotating portion of the sealing occurs at the contact surface between the lip of the rear crankshaft seal and the crankshaft.

The seal is installed in the flywheel housing bore.



Rear gear train can drive a hydraulic pump through accessory drive, or drive a air compressor.

CUMMINS QSF3.8 – Fuel System

WARNING !

The fuel pump, high-pressure fuel lines, and fuel rail contain very high-pressure fuel. Do not loosen any fittings while the engine is running. Wait at least 10 minutes after shutting down the engine before loosening any fittings in the high-pressure fuel system to allow pressure to decrease to a lower level.

Fuel can be returned at highly elevated temperatures. Wear safety goggles and protective gloves and clothing when performing this test. To reduce the possibility of personal injury, avoid contact with returned fuel.

WARNING !

- Wear your safety glasses
- Use cardboard or paper for identifying/troubleshooting high-pressure leaks ... Never use your hands or fingers
- 2 000 Bar = 29 000 PSI
- 2 Bar (30 PSI) is enough to penetrate human skin and cause a pressure injection.

What can high pressure fluids do?

- Industrial water jets (abrasive jets) are used to cut wood, steel, rock, and various metals
- The water pressure is typically between 1400 to 3800 bar. The water is forced through a 0.25 to 0.4 mm in diameter orifice in a jewel and can cut 12 mm thick titanium at the rate of 180 mm per minute

CAUTION !

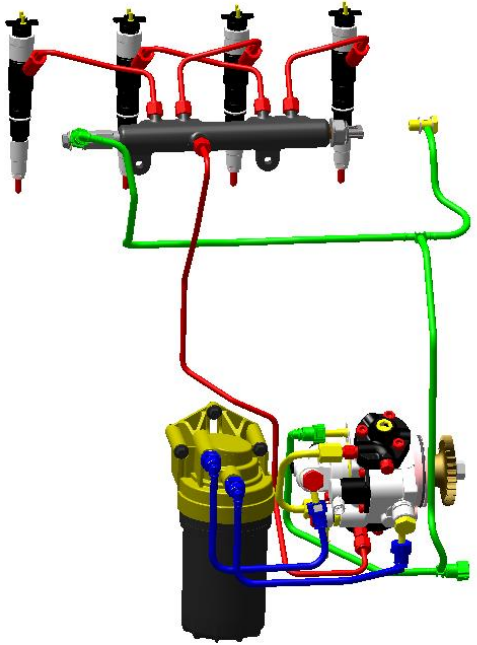
Before servicing any fuel system components, (such as fuel lines, fuel pump, injectors, etc.) which would expose the fuel system or internal engine component to potential contaminants prior to disassembly, clean the fittings, mounting hardware, and the area around the component to be removed.

Dirt or contaminants can be introduced into the fuel system and engine if the surrounding areas are not cleaned, resulting in damage to the fuel system and engine.

Steam is the best method of cleaning a dirty engine or a piece of equipment.

Electrical contact cleaner can be used if steam cleaning tools are not available.

CUMMINS QSF3.8 – Fuel System – Overview and Operation



The fuel system is a High-Pressure Common Rail electronically controlled fuel system.

Provided by the Nippon Denso.

The maximum normal operating pressure is 2000bar [29000 PSI].

Pressure Control:

According to driver's command and engine running condition, ECM determines a "Commanded Pressure". This is a desired pressure that engine should have.

Through the fuel pressure sensor, ECM gets a "Measured Pressure". This is actual pressure in the rail.

ECM compare Measured and Commanded Pressure, then adjust Fuel Pump Actuator, change the fuel flow of pump, make Measure Pressure match with Commanded Pressure.

Injection Timing (& Injection Duration)

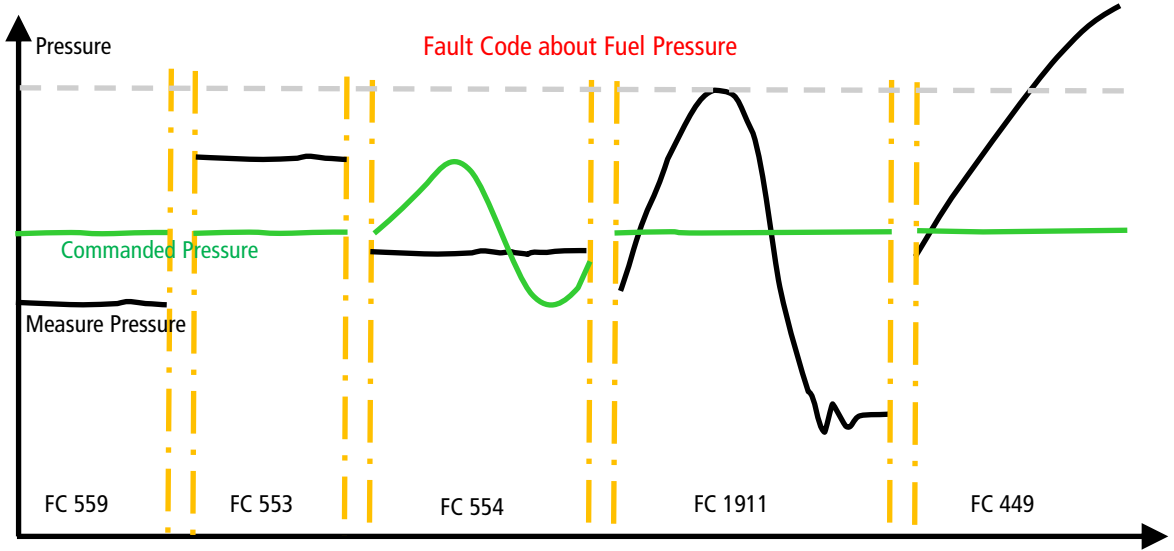
ECM controls the timing of the engine by actuating the injector solenoids.

Injection fuel amount

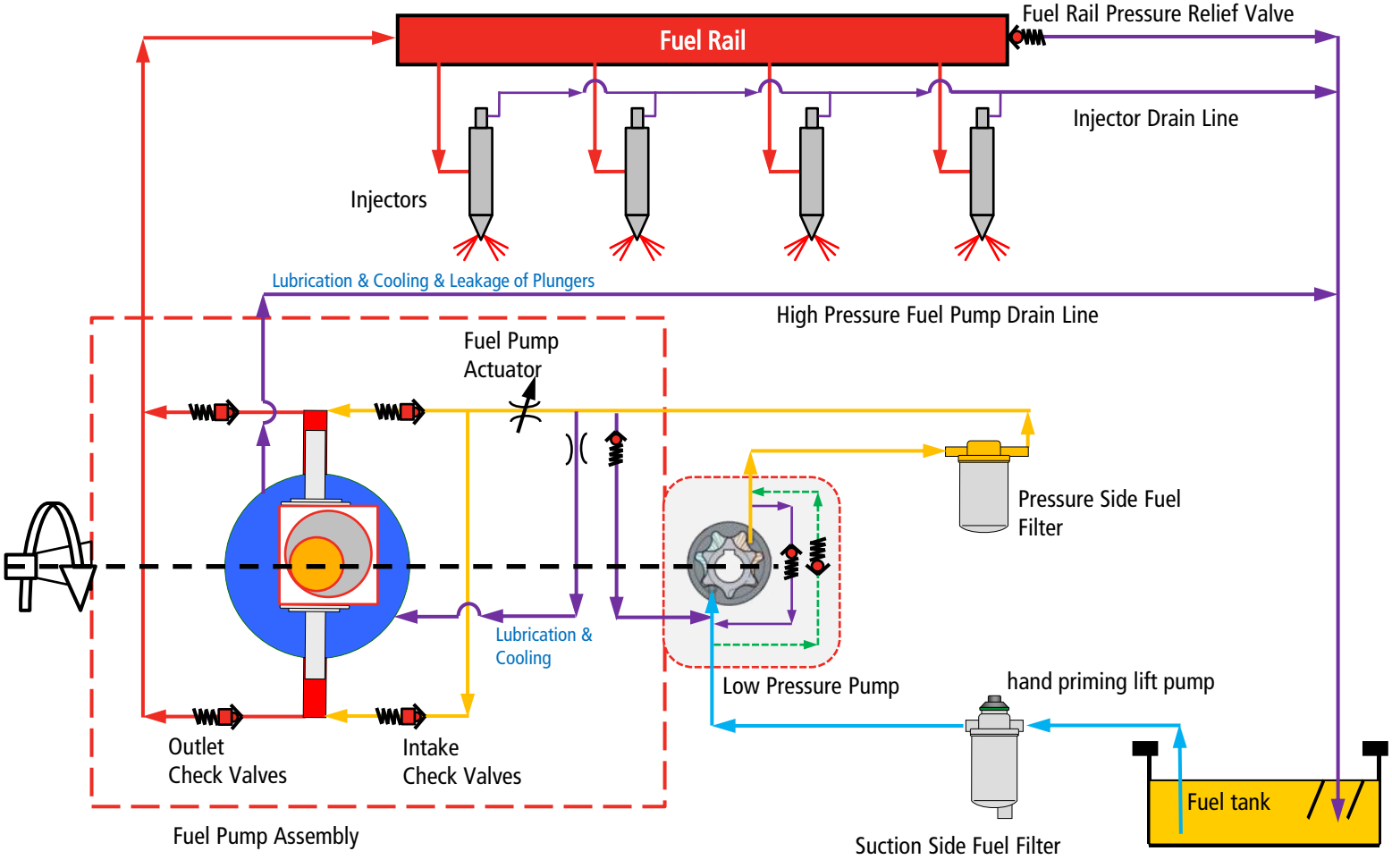
Pressure & Injection duration.

The Rate of Injection

Multiple injection events can be achieved by electronically controlling the injectors.

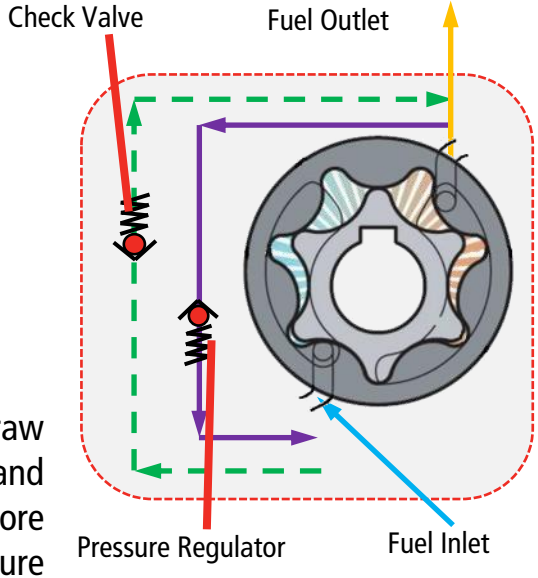


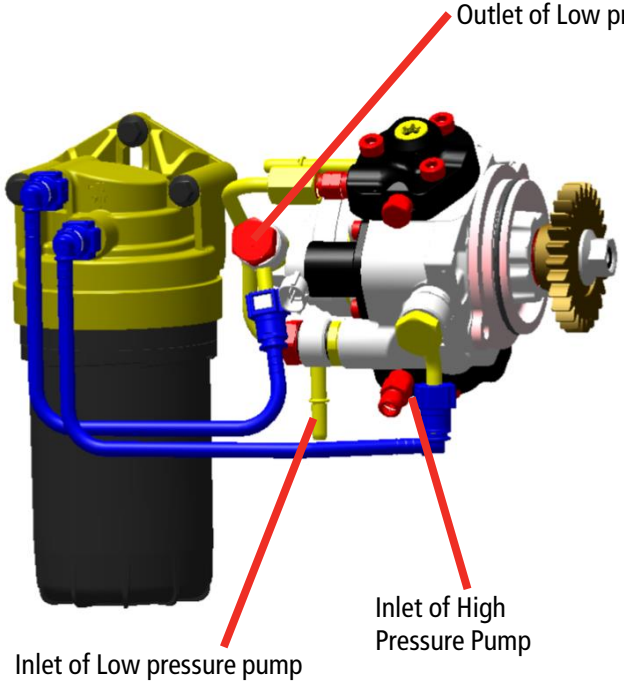
CUMMINS QSF3.8 – Fuel System – Diagram



CUMMINS QSF3.8 – Fuel System – Low Pressure Pump

Fuel is drawn from the OEM fuel supply tank through a suction side fuel filter, which is remotely mounted on the vehicle chassis, by the high-pressure fuel pump mounted low pressure pump.
Fuel exiting the low pressure pump is routed to the pressure side fuel filter, which is mounted on-engine.
From the pressure side fuel filter, fuel flows to the high-pressure fuel pump.





The low pressure pump is used to draw fuel from the OEM supply tank , and increase supply fuel pressure before delivering the fuel to the high-pressure section of the fuel pump.

It is a gerotor type pump. And It use same driveshaft with high pressure pump driveshaft.

A pressure regulator and a check valve are built into the low pressure pump.

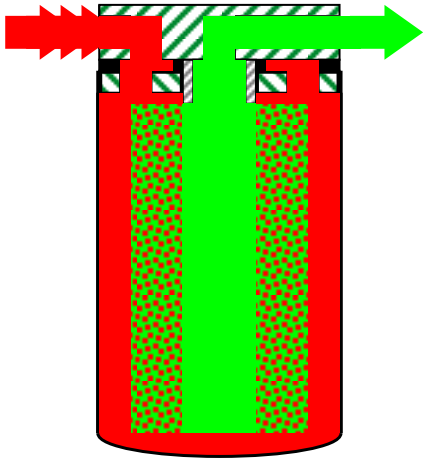
- Pressure regulator limits the pressure in the low pressure pump during normal operation.
- Check valve allow fuel through low pressure pump during priming operation. (Using hand priming pump)

Low pressure pump is not a serviceable component.

CUMMINS QSF3.8 – Fuel System – Filters

Pressure Side Fuel Filter

Engine mounted
Mesh: ≥ 95% @ 5µm
Final point of filtration before high pressure components.
Should not be pre-filled.
Dirty side
Clean side



Suction Side Fuel Filter

OEM install
Mesh: >95% or more @ 8 micron
Water separator efficiency: 99% or more
An hand priming pump is used to prime the fuel system
Water In Fuel (WIF) sensor
Can be pre-filled

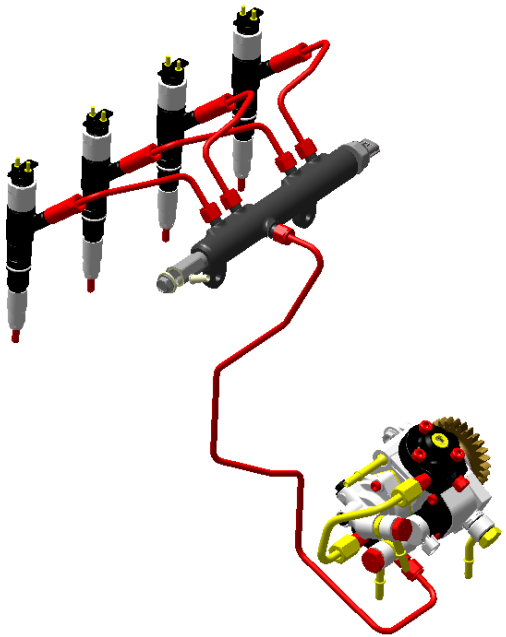
CUMMINS QSF3.8 – Fuel System – HP Fuel Flow

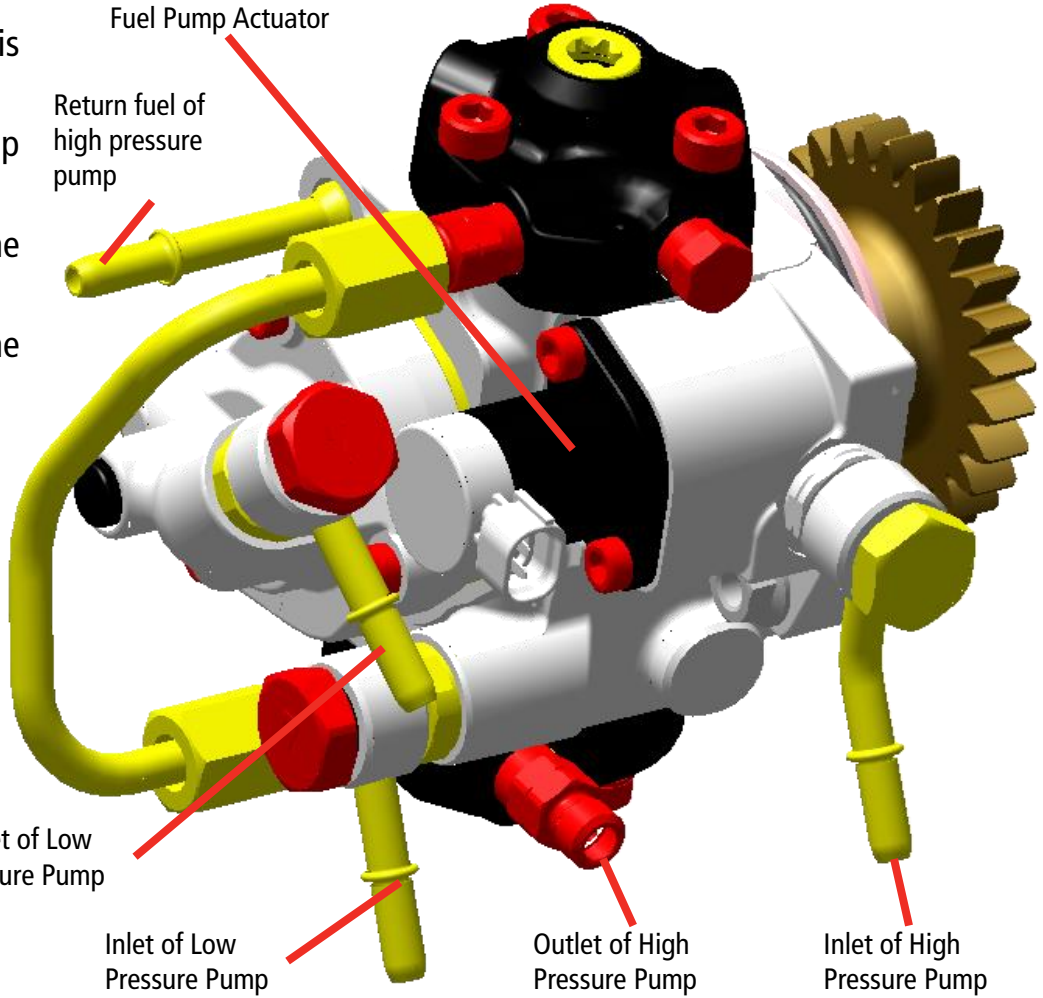
The fuel that enters the high pressure fuel pump is pressurized by two radial pumping chambers.

High pressure fuel leaves the high pressure fuel pump through a fuel rail supply tube to the fuel rail.

From the fuel rail, high-pressure fuel is directed to the injectors through injector supply lines.

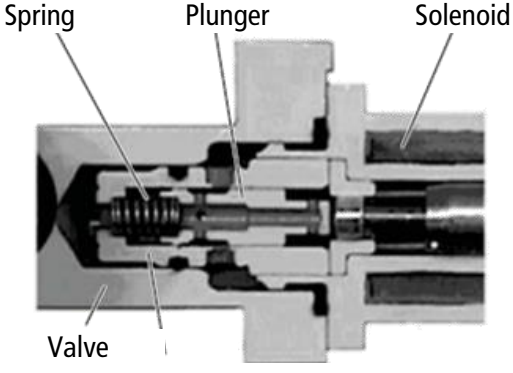
Under the control of ECM, the injector spray the fuel into the cylinder.





CUMMINS QSF3.8 – Fuel System – Fuel Pump Actuator

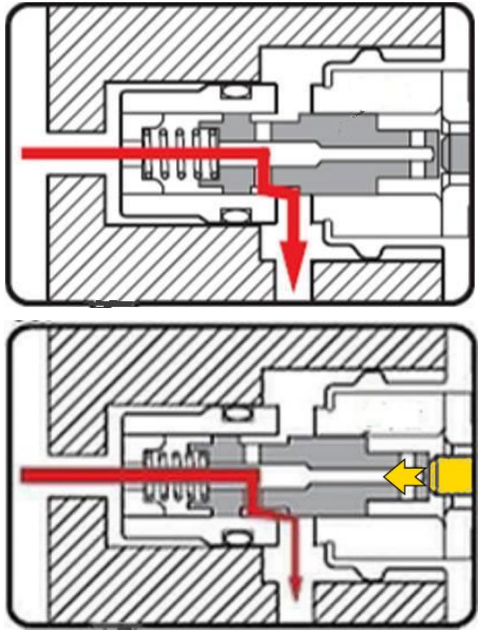
The fuel pump actuator is controlled by the Pulse Width Modulation (PWM) signal from the ECM to maintain the pressure in the fuel rail at a desired level.

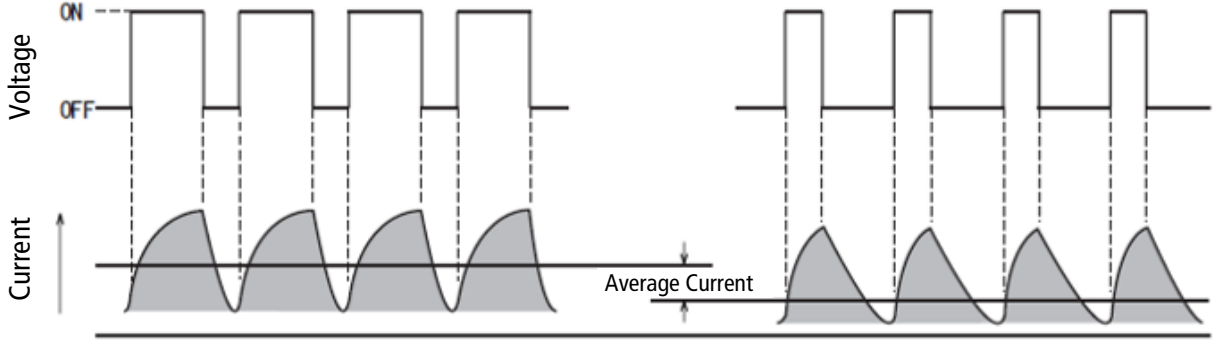


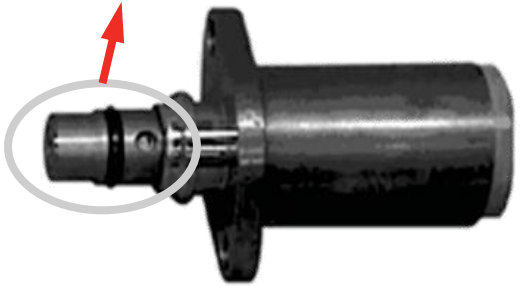
A fuel pump actuator mounted on the high-pressure fuel pump regulates the volume of fuel that is allowed to enter the two pumping chambers.

The inlet metering valve is a normally open valve.

- **The valve is held open by a spring when there is no current flowing to the actuator.**
- **When the current is turned on, a magnetic force generated in the actuator overcomes the spring force and the valve closes, blocking flow into the high pressure pump.**







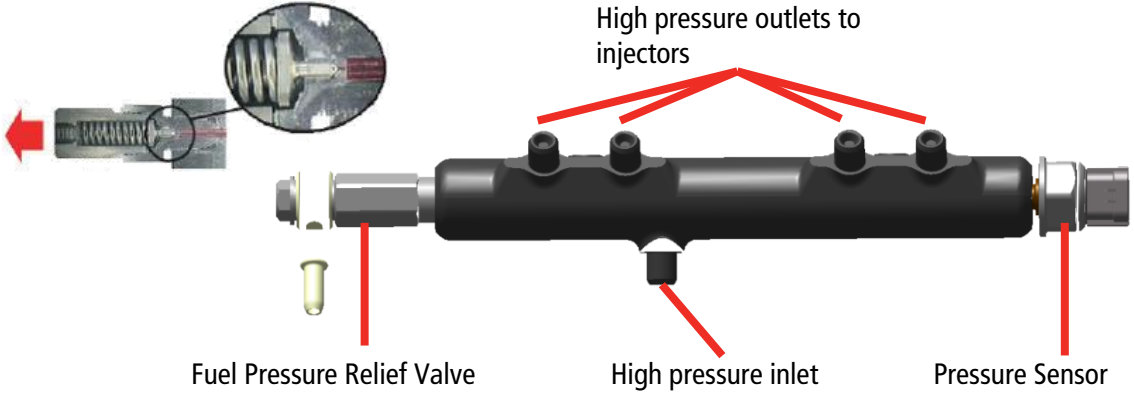
CUMMINS QSF3.8 – Fuel System – Fuel Rail and drain

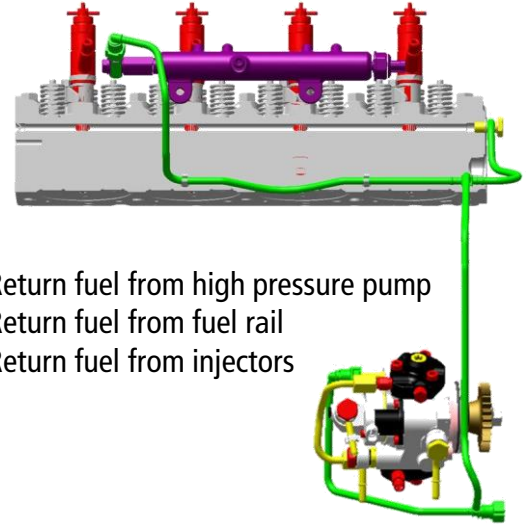
The fuel rail acts as a fuel manifold accumulating and distributing fuel to each of the injector supply lines.

The fuel rail contains a fuel rail pressure sensor that monitors the pressure provided to the fuel rail from the high-pressure fuel pump.

The pressure relief valve protects the system from excessive pressure.

- It opens when rail pressure rises above 2210 bar [32053 PSI].
- Once the pressure relief valve opens it regulates the pressure to ~550 bar [7977 PSI]
- It reseats when the pressure drops below 400 bar [5801 PSI]

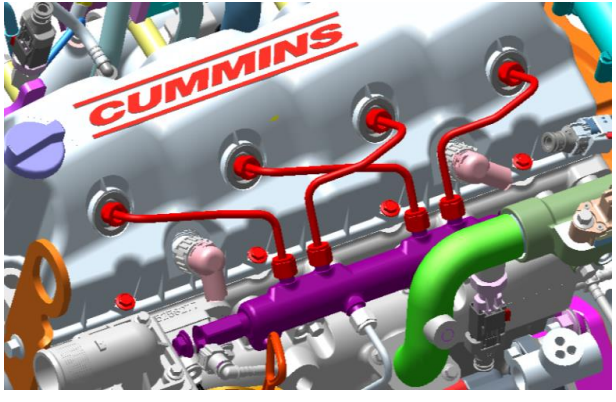




- Return fuel from high pressure pump
- Return fuel from fuel rail
- Return fuel from injectors

The high pressure fuel lines are made of thick-walled tubing with formed ends. High pressure nuts are installed on the lines before the tube ends are formed.

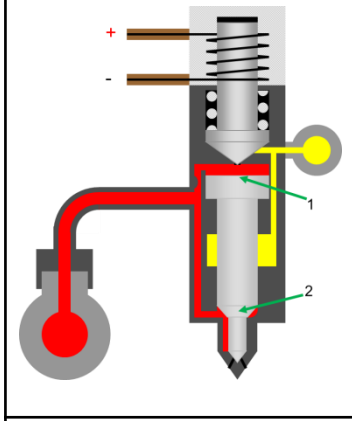
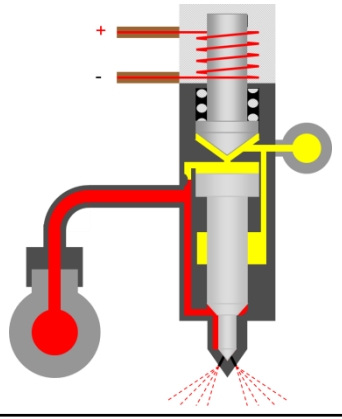
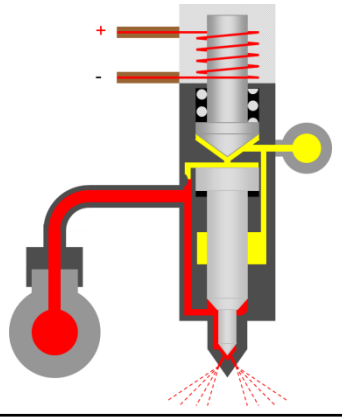
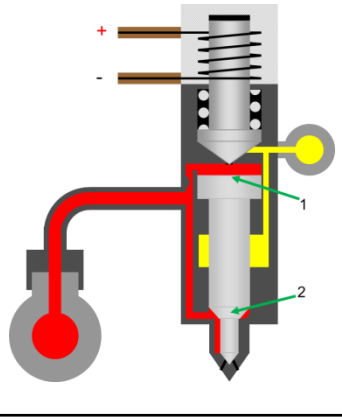
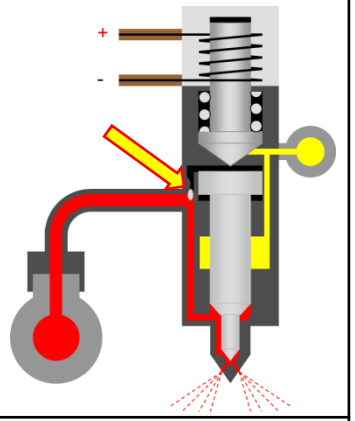
Every effort must be made to maintain the mechanical integrity of high pressure fuel tube clamps and support brackets to prevent high pressure fuel from leaking.



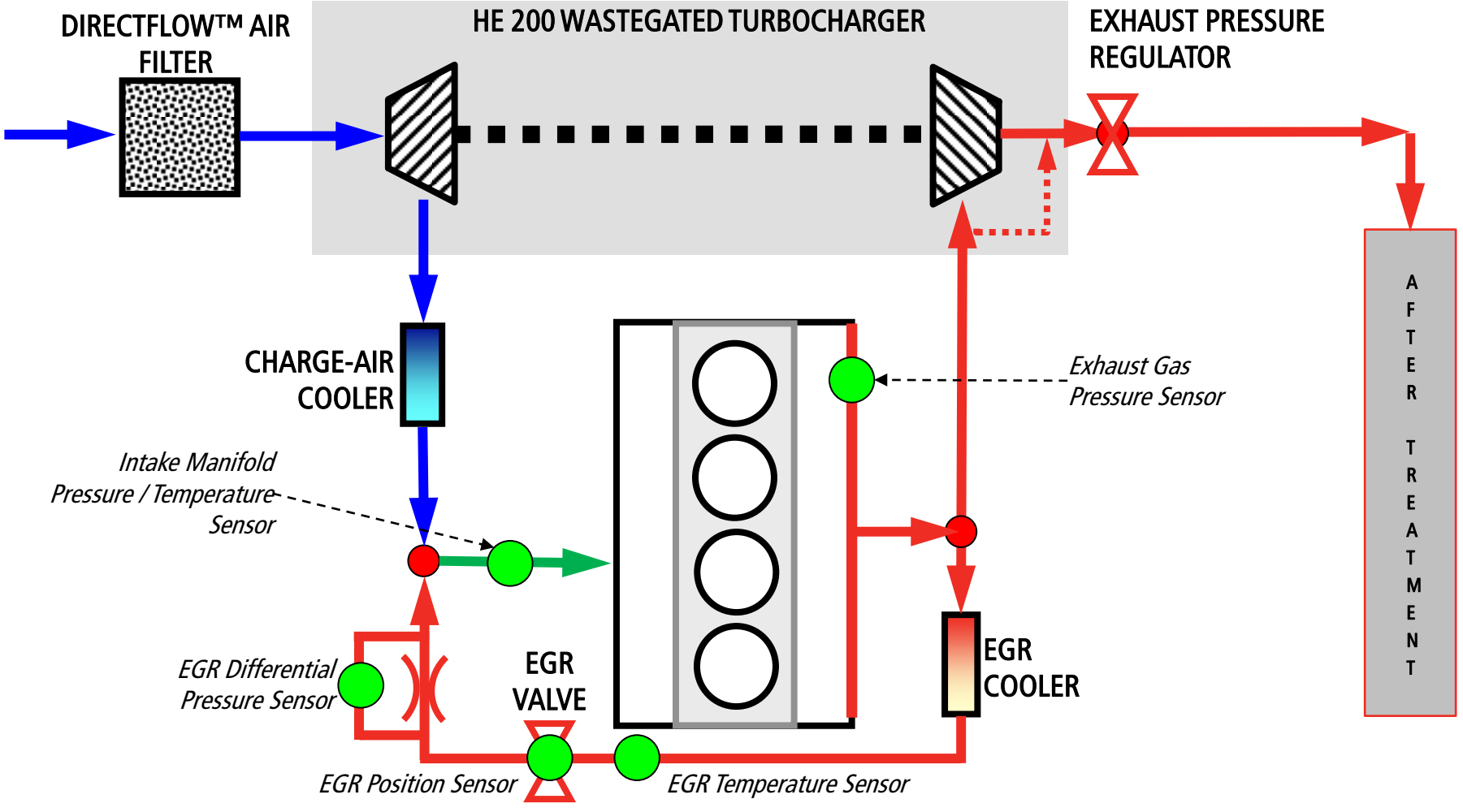
CUMMINS QSF3.8 – Fuel System – Injectors

ECM controls the fueling and timing of the engine by actuating the injector solenoids

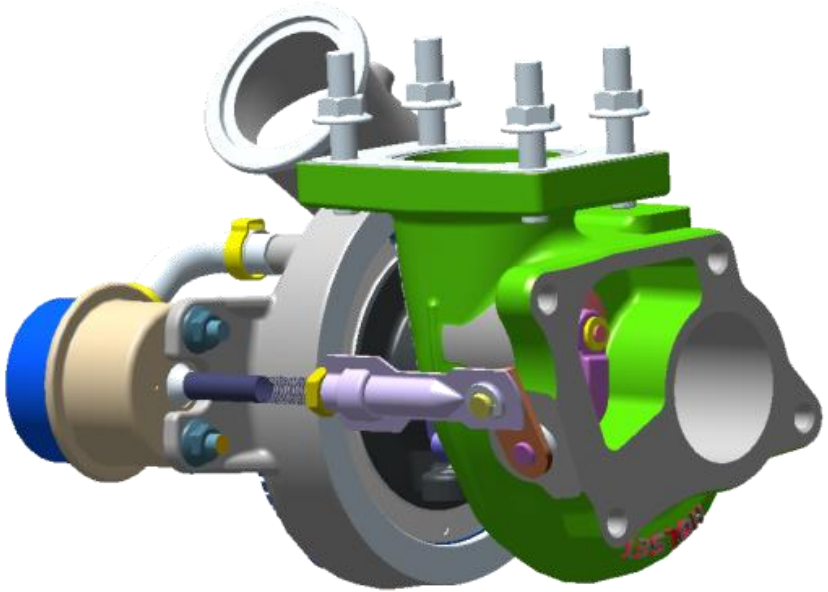
Multiple injection events can be achieved by electronically controlling the injectors

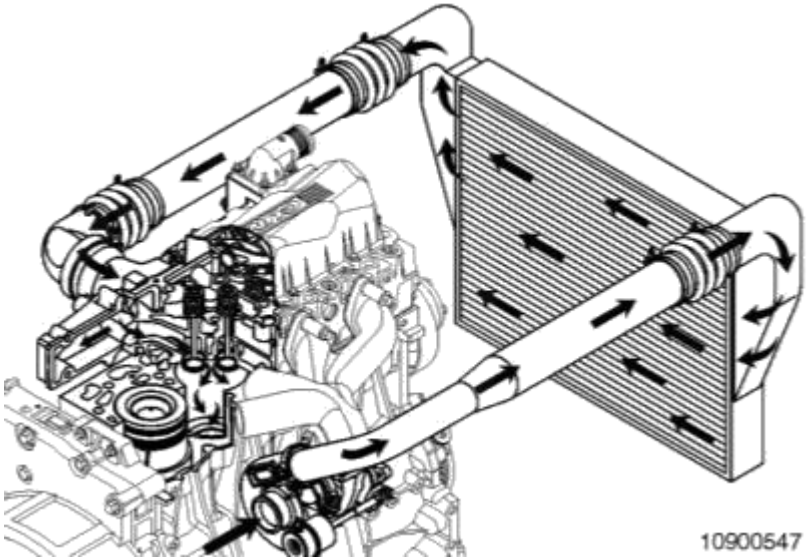
				
Injector Solenoid is not energized. The solenoid spring forces the solenoid in the closed position. Equal fuel pressure is exerted on both the plunger (1) and shoulder area (2) of the needle. The greater surface area of the plunger (2) results in more hydraulic advantage keeping the injector in the closed position	When the ECM requires fuel for a cylinder a voltage is driven to the injector solenoid. This creates an electromagnetic force that is greater than the force of the spring. This forces the solenoids metal core to move upward. As the solenoid lifts a leak path is opened in the fuel injector.	The leak results in the shoulder of the injector needle now seeing a greater hydraulic force than the plunger (due to the leak path). This allows the needle to lift from the closed position. Fuel is then injected into the cylinder through the nozzles.	When fuel is no longer needed the injector solenoid is de-energized by the ECM. The electromagnetic force is removed allowing the spring to force the solenoid to the closed position. When the solenoid is in the closed position the leak path is removed. With the leak path removed the greater surface area of the plunger causes the plunger/needle to reseat and end fuel injection.	Fuel System cleanliness is very important for High Pressure Common Rail Systems Contaminants can lodge in the small passages in the injector preventing critical flows If the contaminant particle lodges in the passage to the plunger area, the result is the injector will remain in the open position With the injector stuck in the open position, engine damage can occur due to uncontrolled fueling of the cylinder

CUMMINS QSF3.8 – Air/Exhaust System – Flow



CUMMINS QSF3.8 – Air/Exhaust System – Components





Turbocharger

HE200WG.

Made by CTT.

Wastegated design allows maximum boost to be developed quickly (low RPM) while making sure that the turbocharger does not overspeed at higher engine rpm's.

Charge Air Cooling

Turbocharging air increases its temperature due to friction.

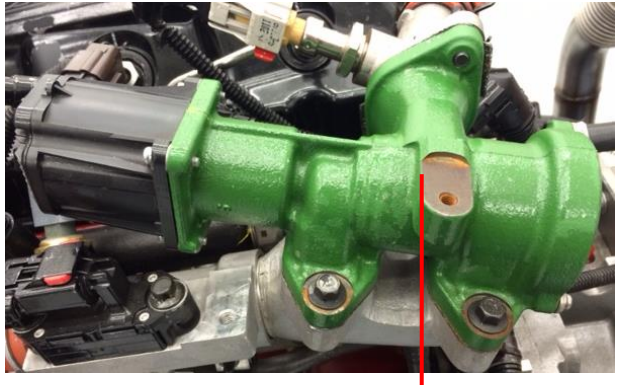
Air-to-air heat exchanging reduces the temperature of the air before it enters the intake manifold, it improve engine performance and reduce emissions.

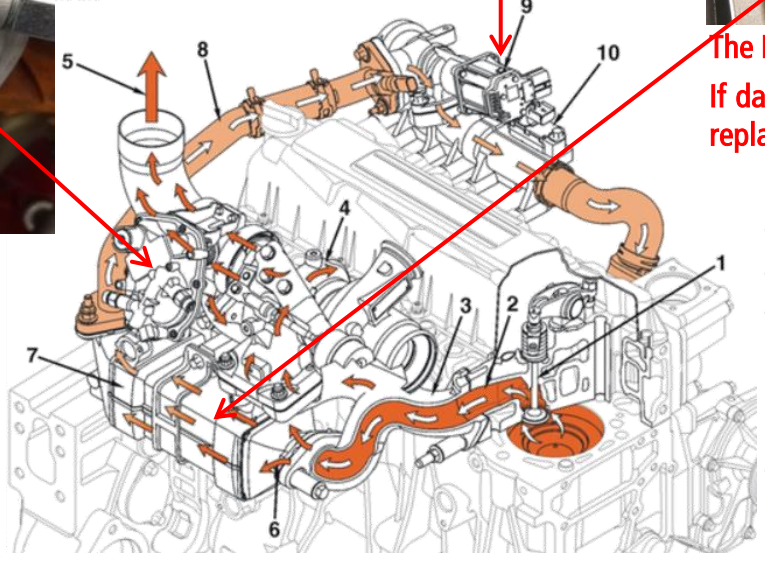
OEM Supplied, OEM responsibility.

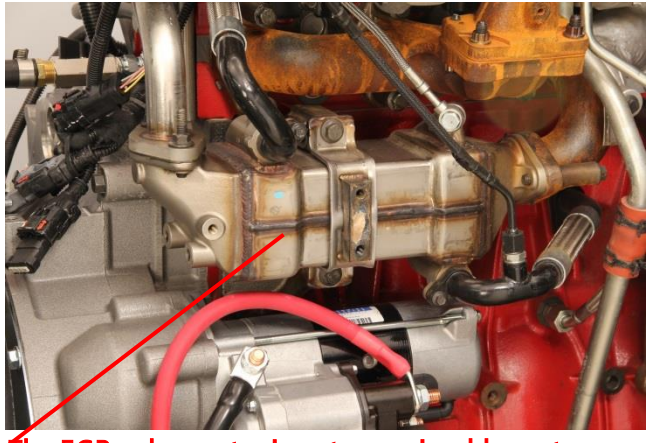
CUMMINS QSF3.8 – Air/Exhaust System – Components

EXHAUST PRESSURE REGULATOR

Necessary for increasing exhaust gas temperature for SCR cleaning process.







The EGR valve motor is not a serviceable part.

If damaged, the entire EGR valve assembly must be replaced.

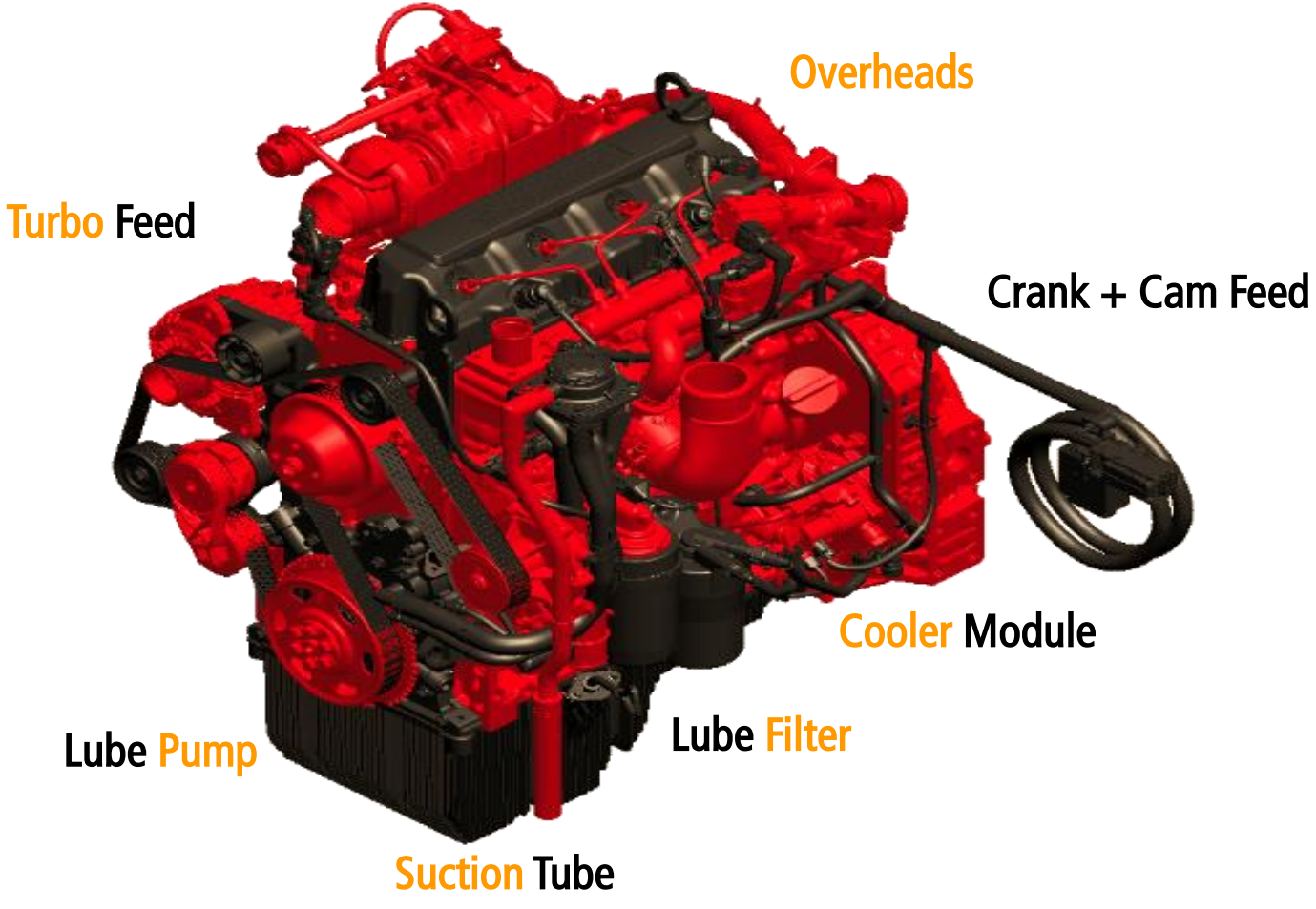
EGR Differential Pressure Sensor

The EGR differential pressure sensor is used by the ECM, in conjunction with the EGR temperature sensor, to calculate the volume of re-circulated exhaust gases that enter the intake manifold from the EGR valve.

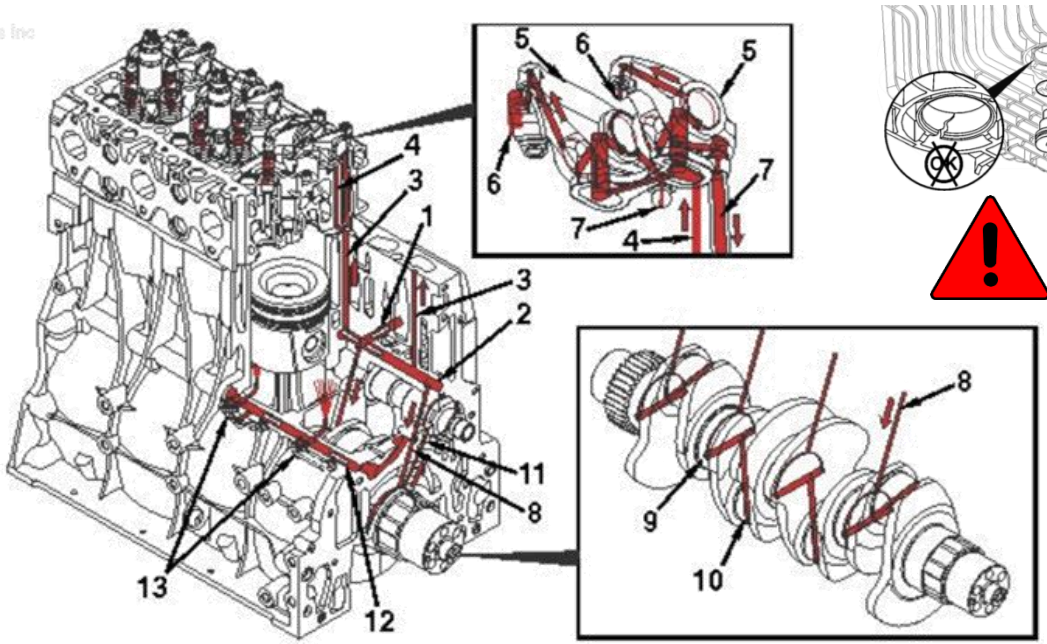
EGR Temperature Sensor

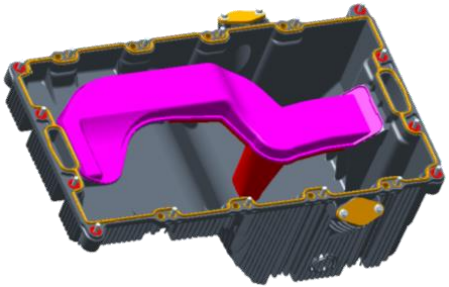
This engine uses the EGR Orifice Pressure Sensor input with the intake manifold pressure sensor to improve EGR flow reading accuracy.

CUMMINS QSF3.8 – Lubrication System – Overview

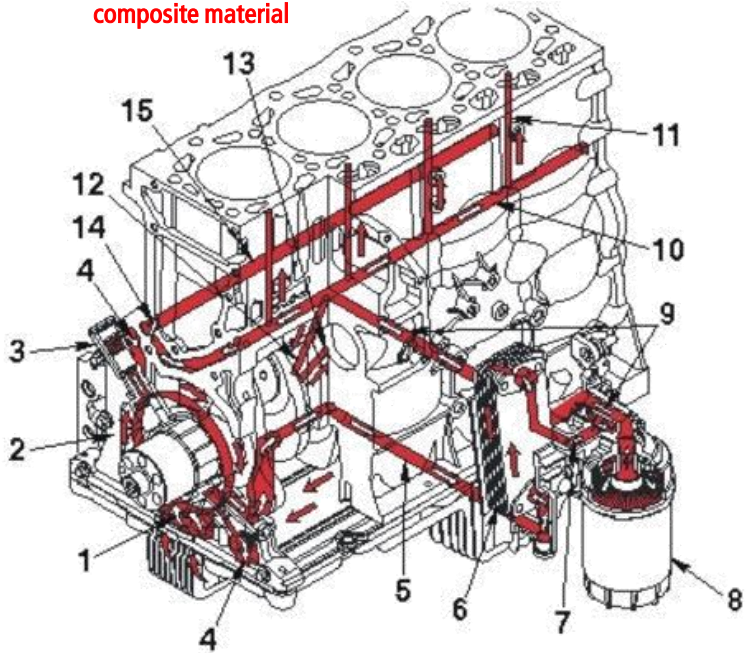


CUMMINS QSF3.8 – Lubrication System – Flow



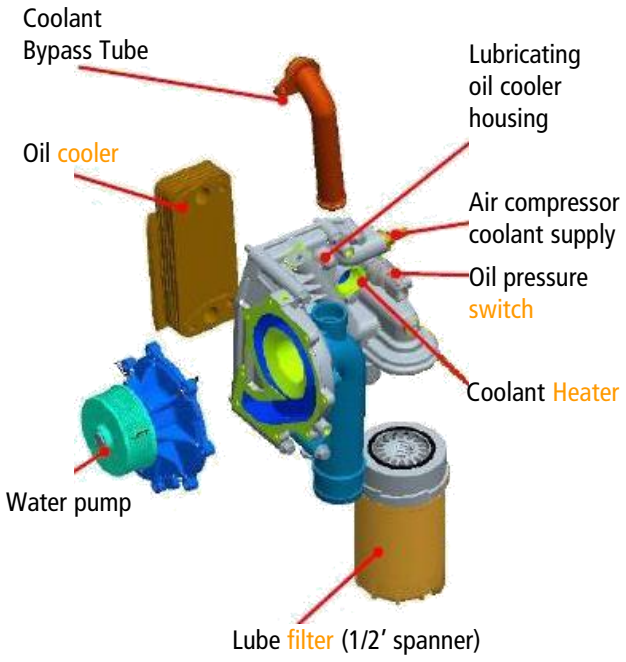


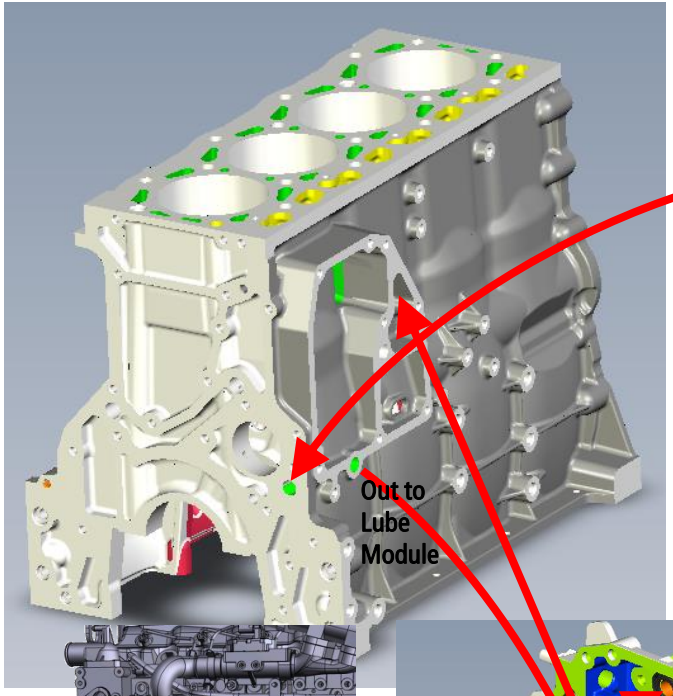
Reliability
Integrated Suction Tube
Integrated Dipstick mounting
Integrated Oil Heater mounting
Reusable molded Gasket
Durability
Integrated Fins
Fiberglass-Enhanced Composite
Low Noise
Integrated Ribs
Drain plug torque is critical due to composite material

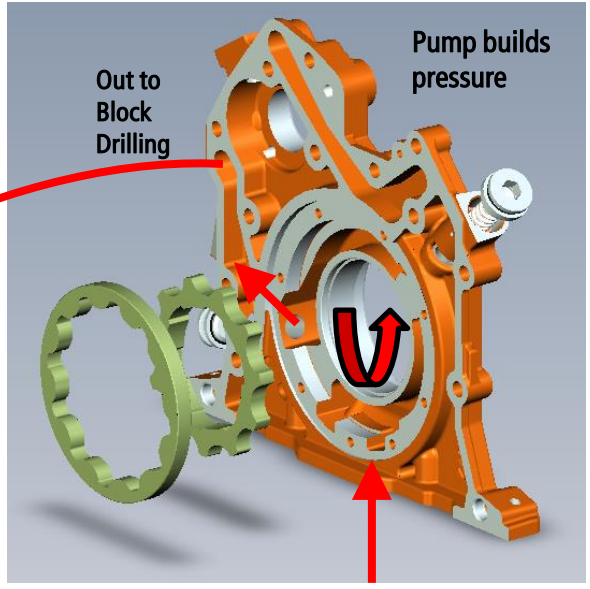


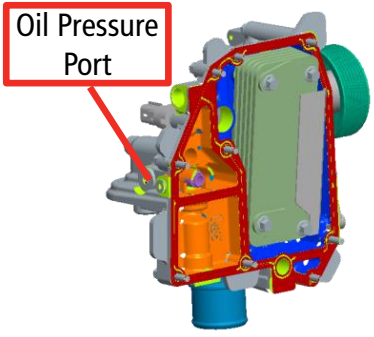
Rotary pump design
Driven directly by the crankshaft
Pump body is the front cover (Cast Aluminum)
Lubricating Oil Pressure Regulator
System is a dump to sump for excess oil pressure

CUMMINS QSF3.8 – Lubrication System – Components

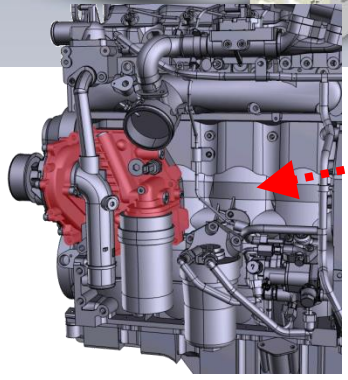


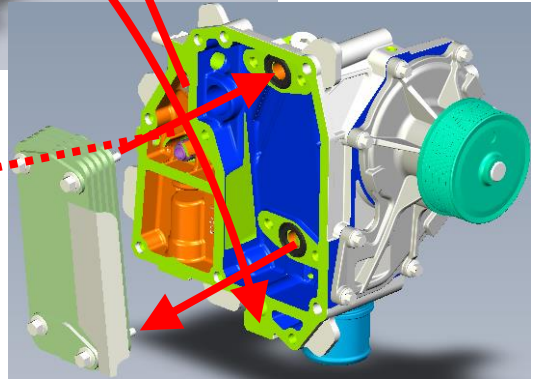






Lubricating oil filter
bypass valve
Bypass valve allows oil to by-pass the filter and cooler during start up in extreme cold conditions





Lubricating Oil Cooler

Plate type heat exchanger

5 plates

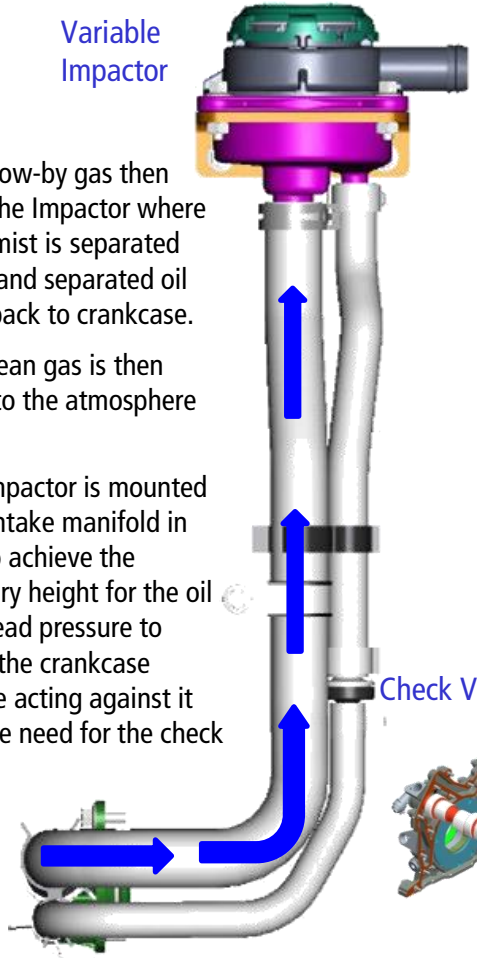
Oil inside the cooler, coolant on the outside

CUMMINS QSF3.8 – Lubrication System – Components

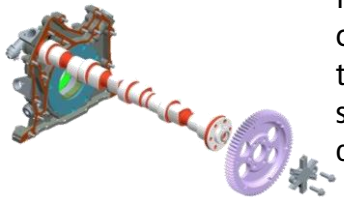
Variable Impactor

Clean Gas to Atmosphere (OCV)

- The blow-by gas then enters the Impactor where the oil mist is separated further and separated oil drains back to crankcase.
- The clean gas is then routed to the atmosphere (OCV)
- The Impactor is mounted to the intake manifold in order to achieve the necessary height for the oil drain head pressure to exceed the crankcase pressure acting against it (thus the need for the check valve).



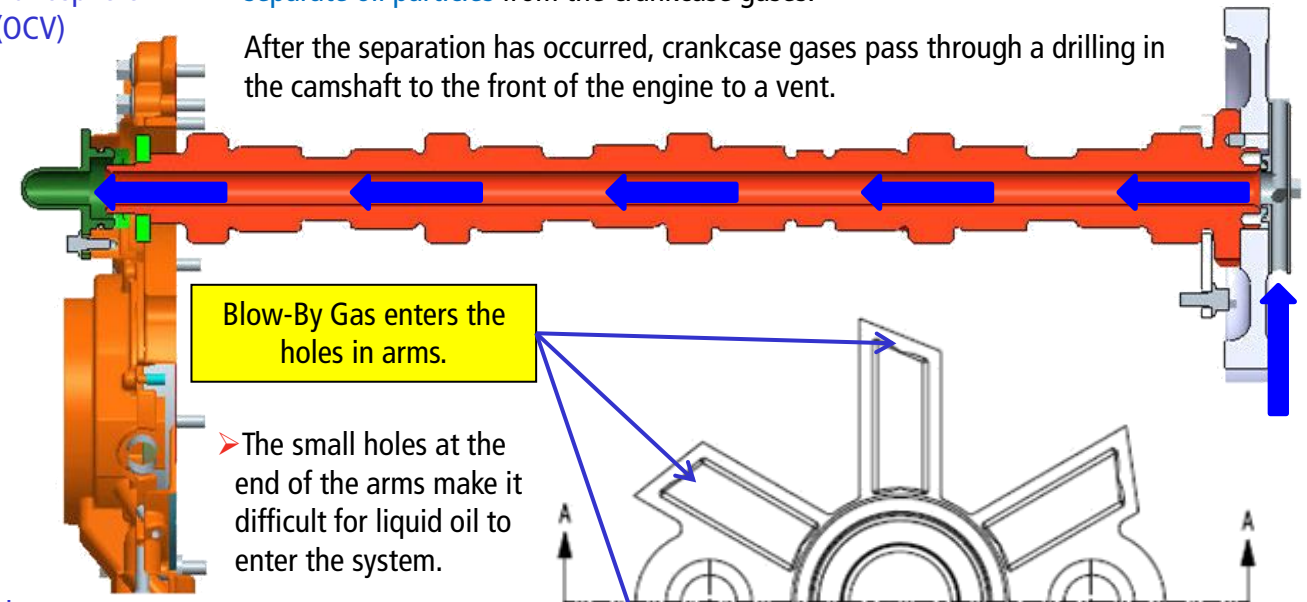
Check Valve



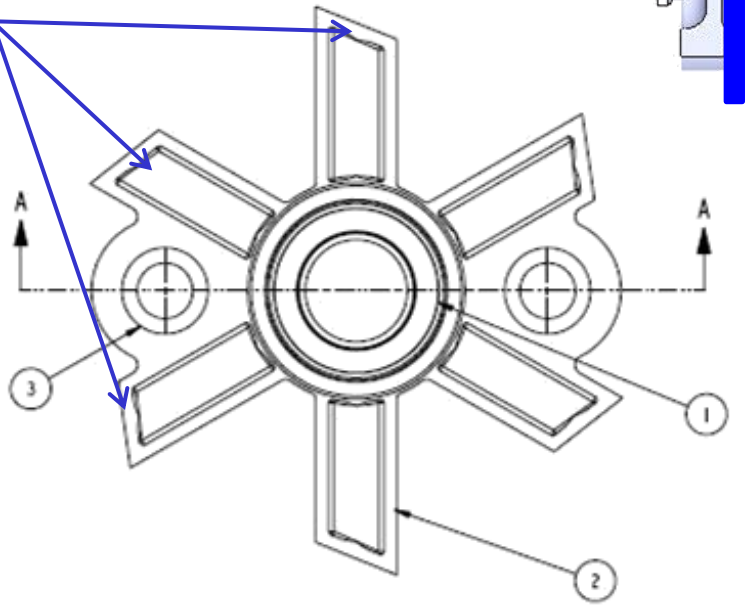
Oil Drain back to Crankcase

This engine uses a crankcase breather disc mounted to the camshaft gear to separate oil particles from the crankcase gases.

After the separation has occurred, crankcase gases pass through a drilling in the camshaft to the front of the engine to a vent.

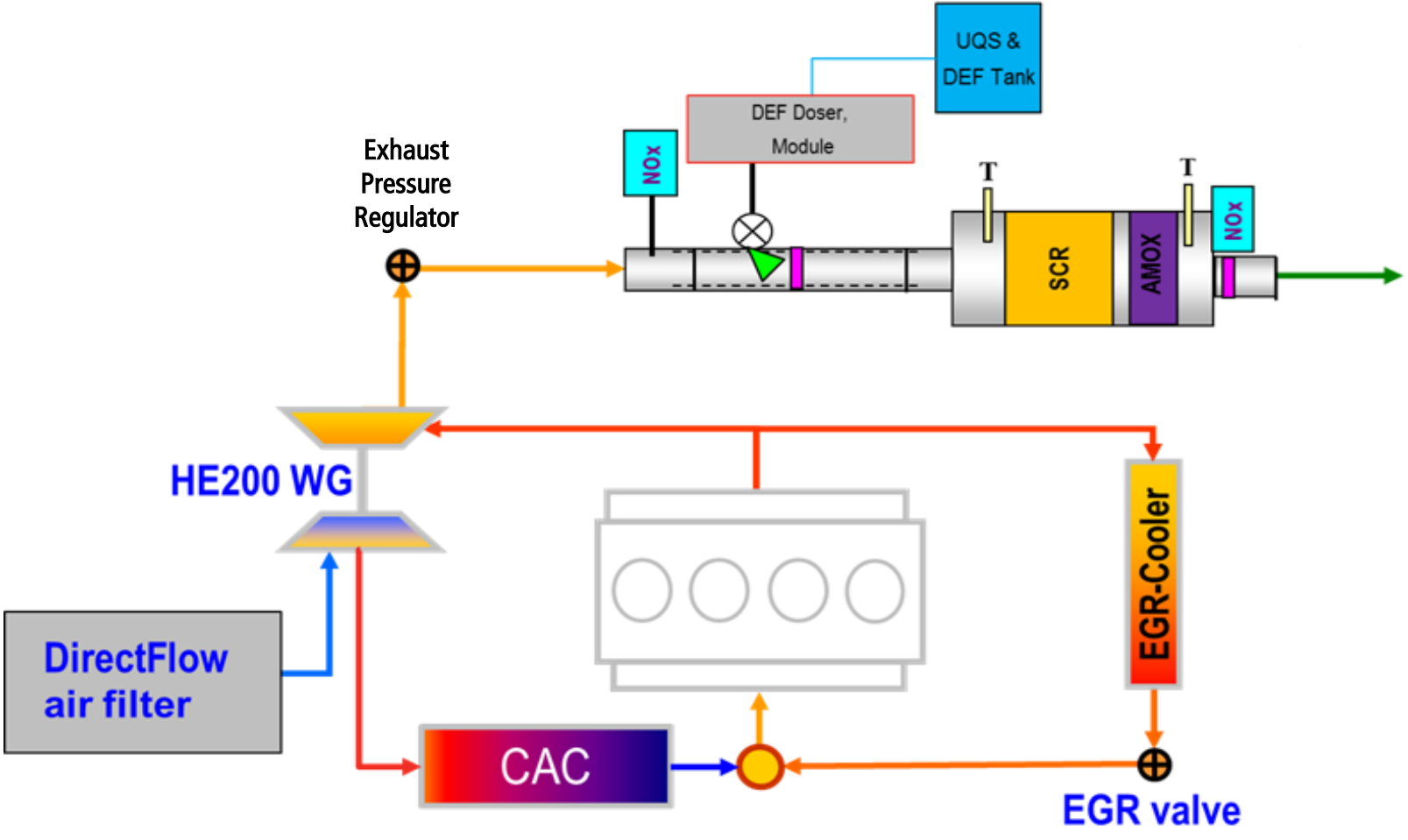


Blow-By Gas enters the holes in arms.

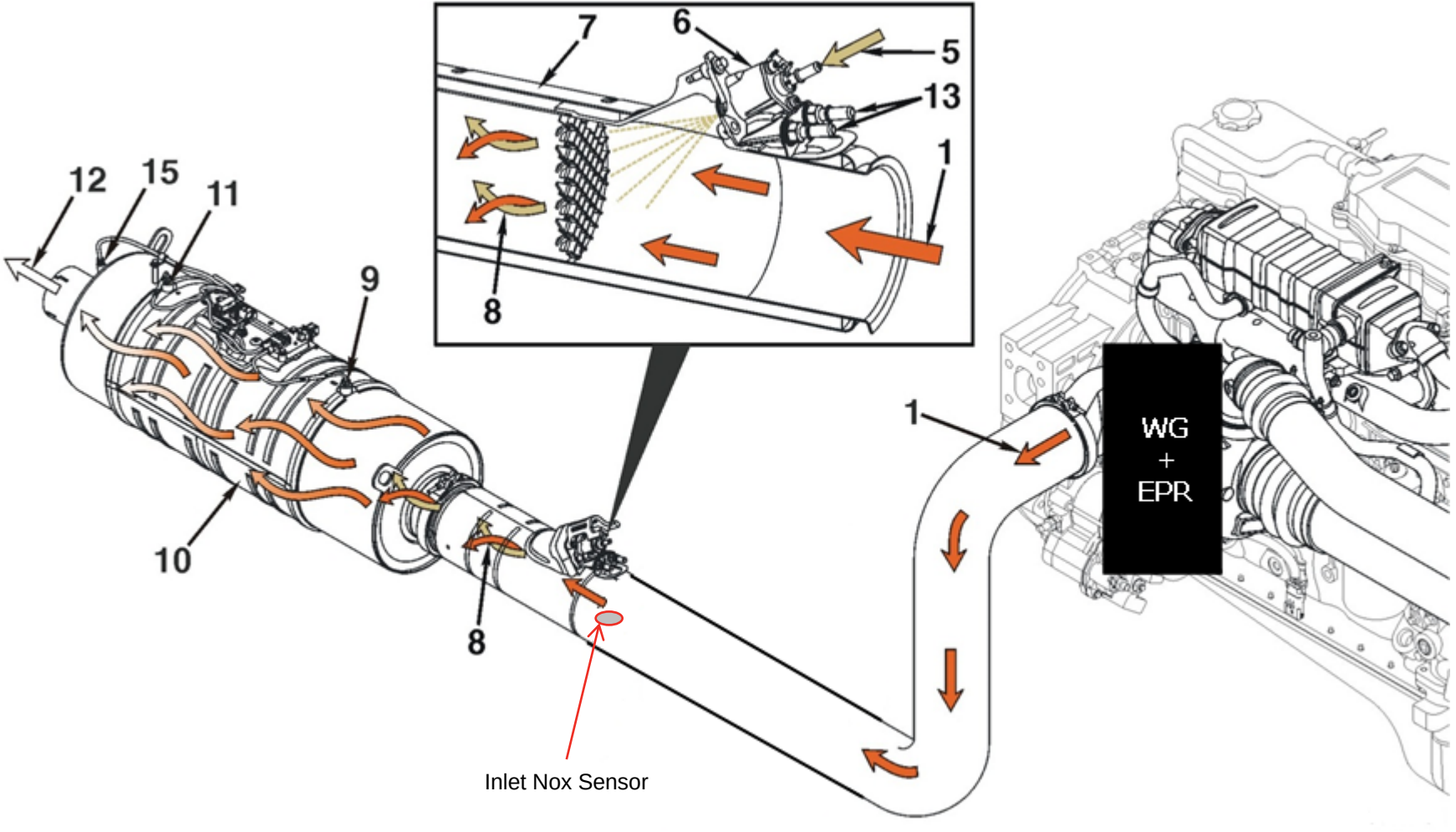


- The small holes at the end of the arms make it difficult for liquid oil to enter the system.
- The blow by gas then flows thru the hollow camshaft to the front of the engine, also separating some of the oil droplets.

CUMMINS QSF3.8 – After Treatment Device – Architecture



CUMMINS QSF3.8 – After Treatment Device – Architecture

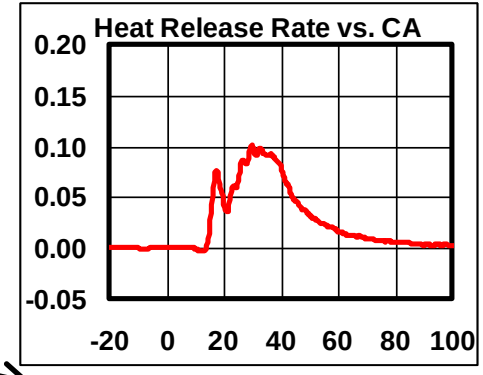


CUMMINS QSF3.8 – After Treatment Device – WHY?

What happens during the combustion process?

Fuel Air Exhaust

Combustion Process (Heat Release Rate)



Heat Products

Work

Heat Transfer
(Coolant & Lube oil)

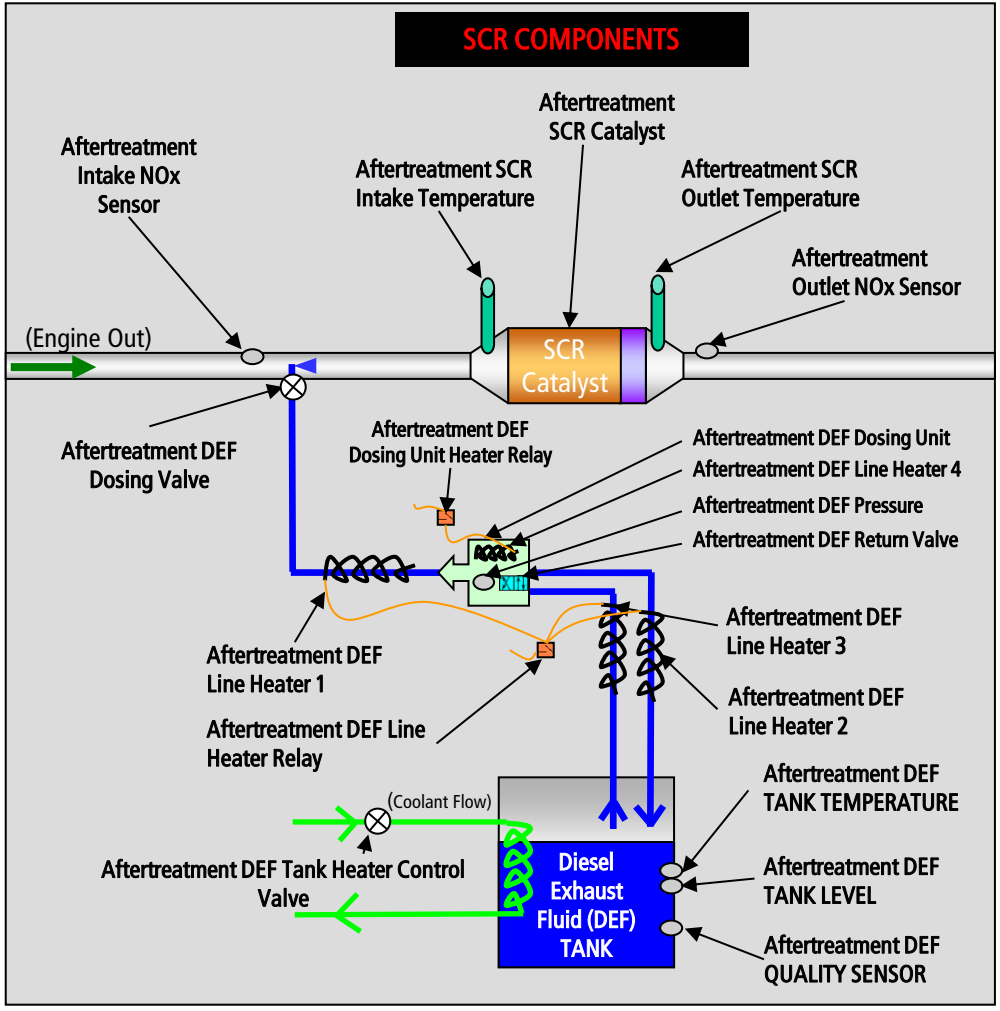
Exhaust

Legislated
(NOx, PM, HC, CO)

Other
(CO2, H2O)

CUMMINS QSF3.8 – After Treatment Device – HOW?

- We increase in-cylinder combustion temperature to produce virtually no PM
- We use EGR to partially reduce NOx when determined possible, beneficial and necessary
- We use SCR to reduce NOx caused by high combustion temperatures.
- Thermal Management is obtained/provided by the Exhaust Gas Pressure Regulator



CUMMINS QSF3.8 – Selective Catalyst Reducer

What is SCR?

- Selective catalytic reduction is a NOx control technique for diesel engine exhaust.
- The process involves the injection of Urea (a nitrogenous compound which readily decomposes into ammonia) into the exhaust over a catalyst.
- The ammonia reacts with NOx and produces harmless nitrogen (N_2) and water (H_2O).

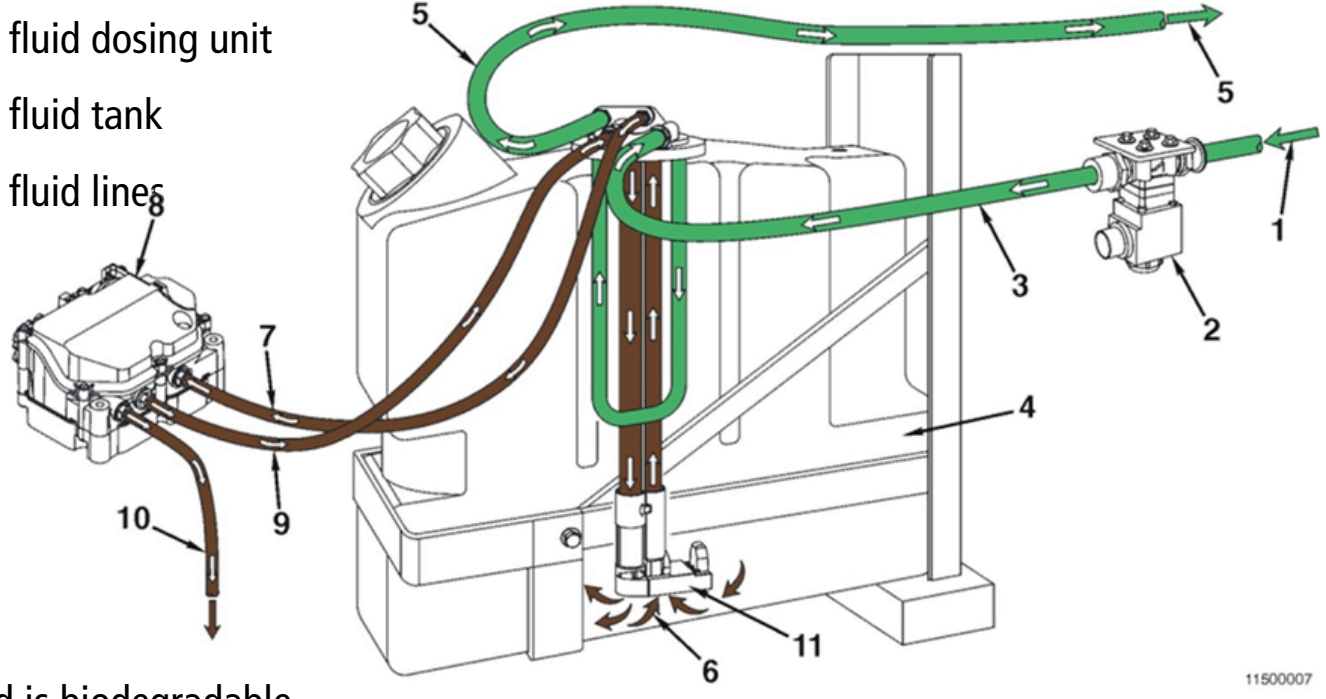
This exhaust system includes the:

- After treatment decomposition tube
- After treatment SCR catalyst
- Any ancillary tubing (elbows, etc.) involved.

CUMMINS QSF3.8 – After treatment device – dosing

The after treatment SCR dosing system monitors and injects diesel exhaust fluid (DEF) into the exhaust stream. **The SCR dosing system is comprised of:**

- Aftertreatment diesel exhaust fluid dosing valve
- Aftertreatment diesel exhaust fluid dosing unit
- Aftertreatment diesel exhaust fluid tank
- Aftertreatment diesel exhaust fluid lines



Diesel Exhaust Fluid (DEF):

- Nontoxic and nonpolluting
- Nonflammable
- Stable and colorless
- Composed of urea and water.
- Urea is naturally occurring and is biodegradable.

CUMMINS QSF3.8 – After treatment device – Fluid

CAUTION

Never attempt to create diesel exhaust fluid by mixing agricultural grade urea with water. Agricultural grade urea does not meet the necessary specifications required and the aftertreatment system may be damaged.

Diesel Exhaust Fluid Specifications

The urea content of the solution must be **32.5 percent ± 0.7**

Adding water to the diesel exhaust fluid tank:

- will change the diesel exhaust fluid concentration levels, which may affect SCR efficiency.
- may add contaminates and/or affect the chemical properties of the diesel exhaust fluid, which may damage the aftertreatment system.
- will alter the freeze point and characteristics of the diesel exhaust fluid solution, potentially leading to damaged diesel exhaust fluid dosing system components during cold weather operation.

CUMMINS QSF3.8 – After treatment device – Fluid

Handling, Storage, and Shelf Life of Diesel Exhaust Fluid

Handling: Diesel exhaust fluid is not harmful to handle, but can be **REACTIVE AND/OR CORROSIVE** to certain materials over time:

- Carbon steels, zinc coated carbon steels, and mild iron
- Nonferrous metals and alloys: copper, copper alloys, zinc, and lead
- Solders containing lead, silver, zinc, or copper
- Aluminum and aluminum alloys
- Magnesium and magnesium alloys
- Plastics or metals coated with nickel.

If diesel exhaust fluid comes in contact with any of the materials referenced, clean immediately.

CUMMINS QSF3.8 – After treatment device – Fluid

Handling, Storage, and Shelf Life of Diesel Exhaust Fluid

Shelf life: The following conditions are ideal for maintaining diesel exhaust fluid quality and shelf life during prolonged transportation and storage:

- Storage temperature between -5° C to 25° C [23° F to 77° F]
- Store in sealed containers to reduce the possibility of contamination
- Avoid direct sunlight.

In these conditions, diesel exhaust fluid has a minimum expected shelf life of 18 months. However, each 5°C [9°F] increment above recommended temperatures reduces shelf life by 6 months (for example 30°C [86°F] = 12 month shelf life, 35°C [95°F] = 6 month shelf life, etc.).

STORAGE: Long term storage in a vehicle (in excess of 6 months) is not recommended.

CUMMINS QSF3.8 – After treatment device – Fluid

First Aid

In case of contact with eyes, immediately flush eyes with large amounts of water for a minimum of 15 minutes. Do not swallow internally. In the event that diesel exhaust fluid is ingested, contact a physician immediately.

Alternate Names/References for Diesel Exhaust Fluid

The following are other names used for diesel exhaust fluid (DEF):

- Urea
- AUS 32 (Aqueous Urea Solution 32)
- AdBlue™
- NOx Reduction Agent
- Catalyst Solution
- Stableguard 32.

Regardless of what the diesel exhaust fluid is called, it must meet the requirements as outlined in the specifications section of this service bulletin.

CUMMINS QSF3.8 – After treatment device – Fluid

Diesel exhaust fluid freezes at approximately -11° C [12° F]. The diesel exhaust fluid system on the vehicle is designed to accommodate this and does not require any intervention by the vehicle operator.

Once the DEF has melted, it can be used without problem. The first melted drop has the same consistency as defined in the Diesel Exhaust Fluid specification.

The SCR system is designed to provide heating for the DEF tank and supply lines which will reduce the melting time for frozen DEF.

If DEF freezes, start up and normal operation of the vehicle is not inhibited so the operator is not impacted.

For further information, reference the diesel exhaust fluid manufacturer's Material Safety Data Sheet.

CAUTION

Do not add any chemicals/additives to the diesel exhaust fluid in an effort to prevent freezing. If chemicals/additives are added to the diesel exhaust fluid, the aftertreatment system may be damaged.

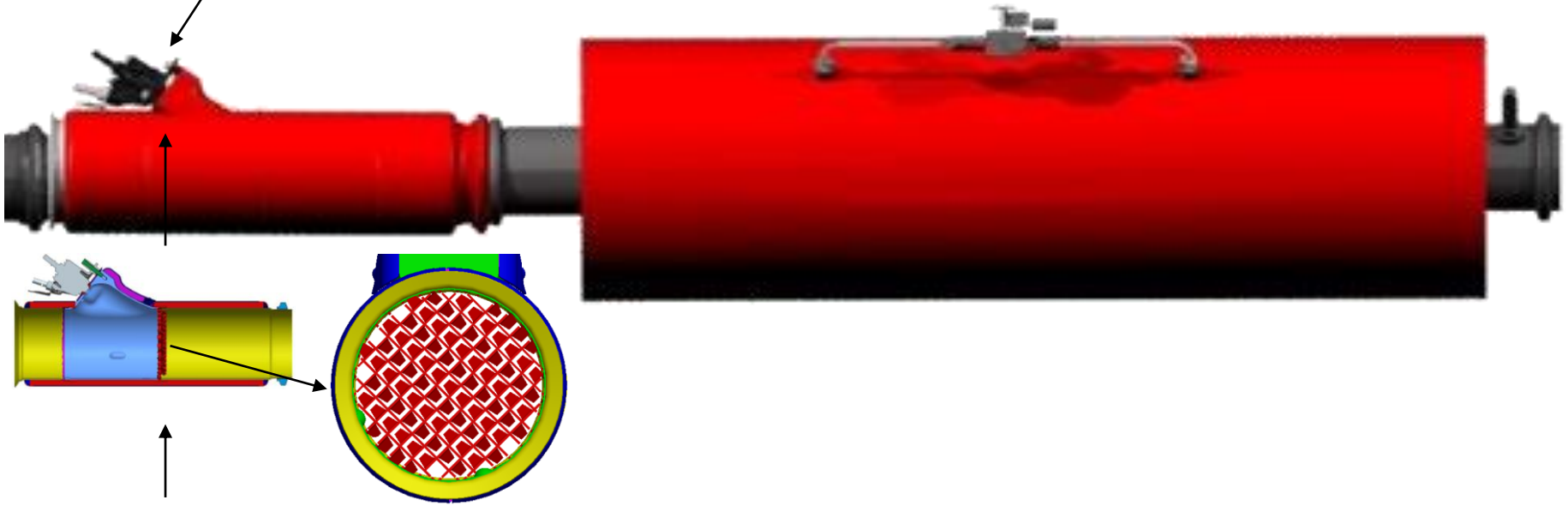
To test the concentration of the diesel exhaust fluid, use the Cummins® diesel exhaust fluid refractometer, Part Number 4919554. Follow the instructions provided with this service tool.

For detailed instructions on testing diesel exhaust fluid, reference ISO 22241-2.

Perform DEF concentration testing with refractometer on the DEF samples with different concentration

CUMMINS QSF3.8 – After treatment device – SCR

DEF Dosing Valve sprays a fine mist of DEF into hot exhaust stream



Decomposition occurs in 3 steps within the Decomposition Tube

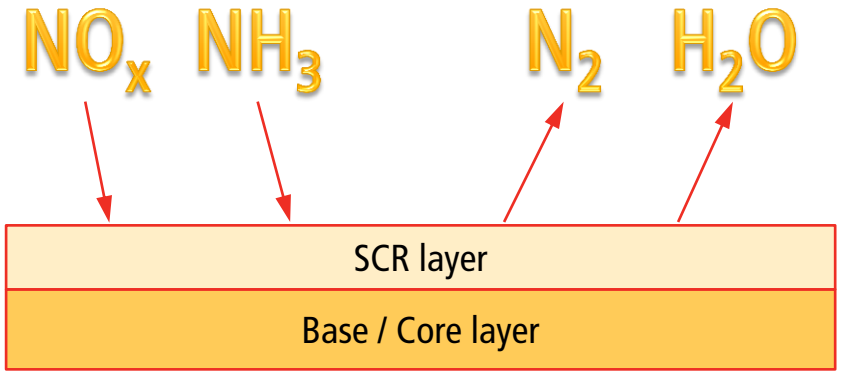
Step 1: Evaporation

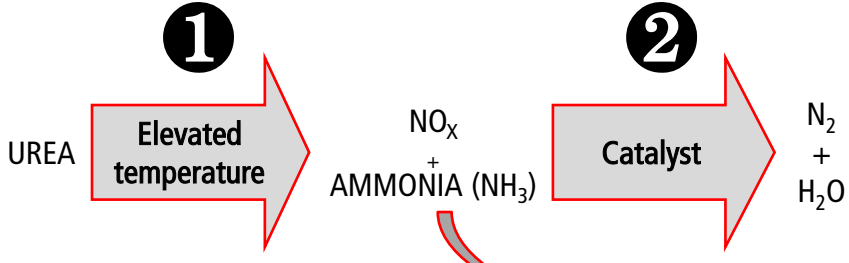
Step 2: Thermolysis

Step 3: Hydrolysis

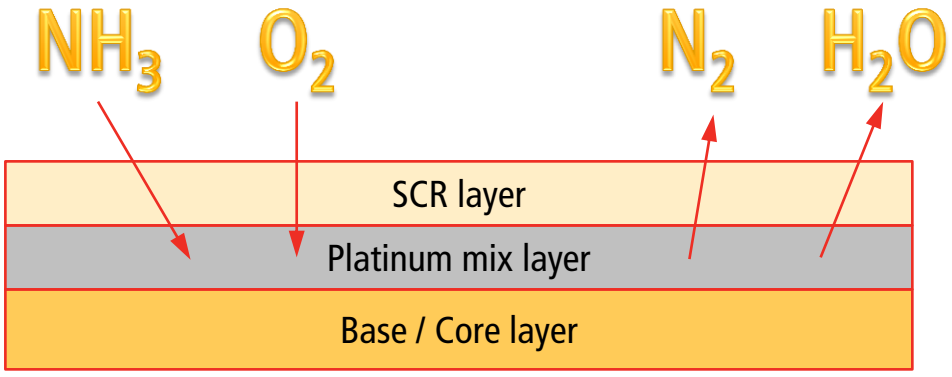
CUMMINS QSF3.8 – After treatment device – SCR

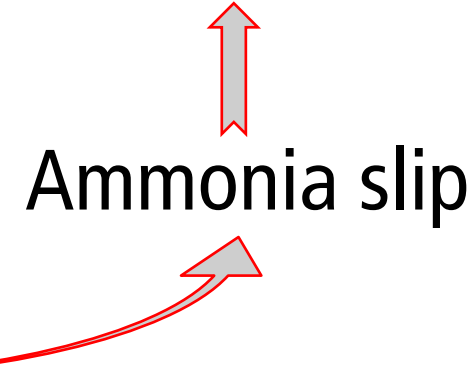
Base Reaction in **SCR** brick





Base Reaction in **AMOX** brick



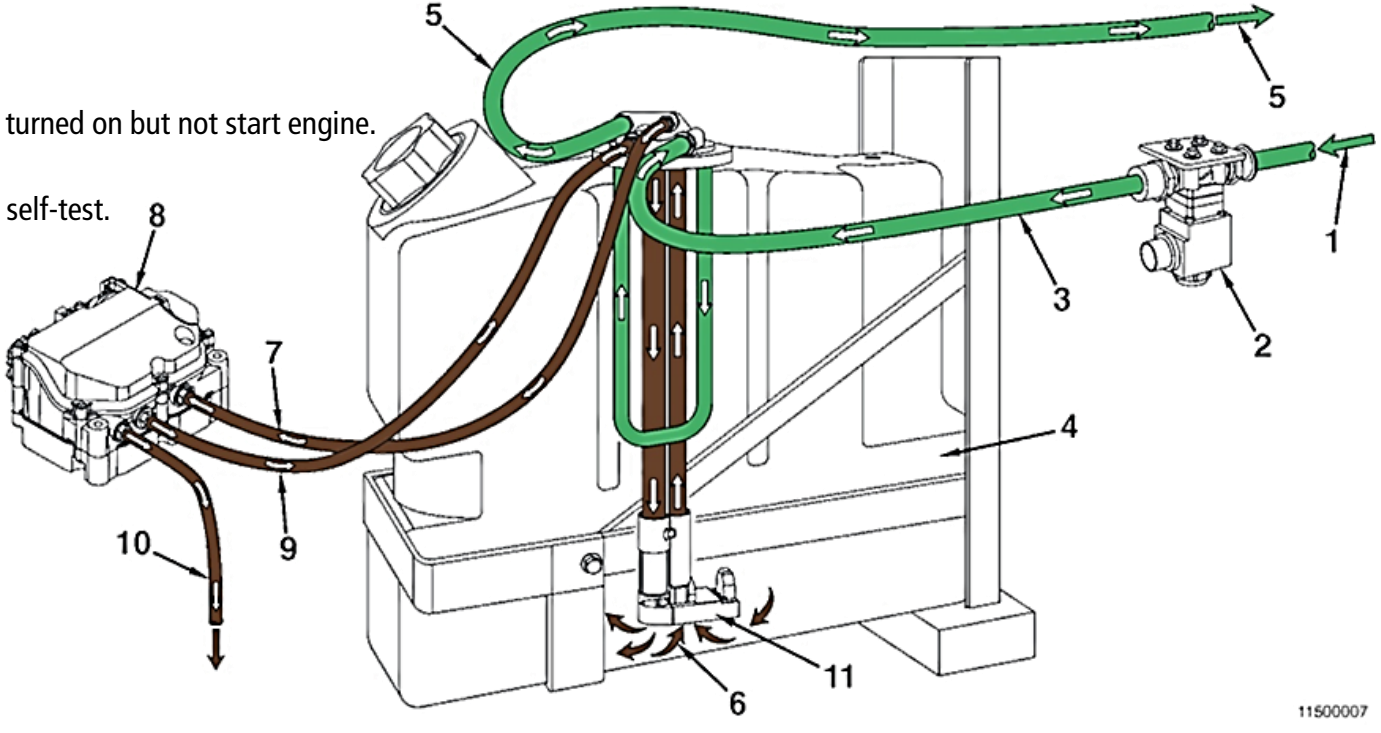


CUMMINS QSF3.8 – After treatment device – OPERATION

The SCR system is comprised of many components but requires a minimal amount of servicing or driver intervention.

The SCR system is comprised of FIVE main states:

1. Initializing
   - **Beginning:**
     - Engine ignition switch is turned on but not start engine.
   - **Action:**
     - System initialization and self-test.
   - **Ending:**
     - Priming stage is begin.
2. Priming
3. Dosing
4. Purging
5. Heating



CUMMINS QSF3.8 – After treatment device – OPERATION

The SCR system is comprised of many components but requires a minimal amount of servicing or driver intervention.

The SCR system is comprised of FIVE main states:

~~1. Initializing~~

2. Priming

Beginning:

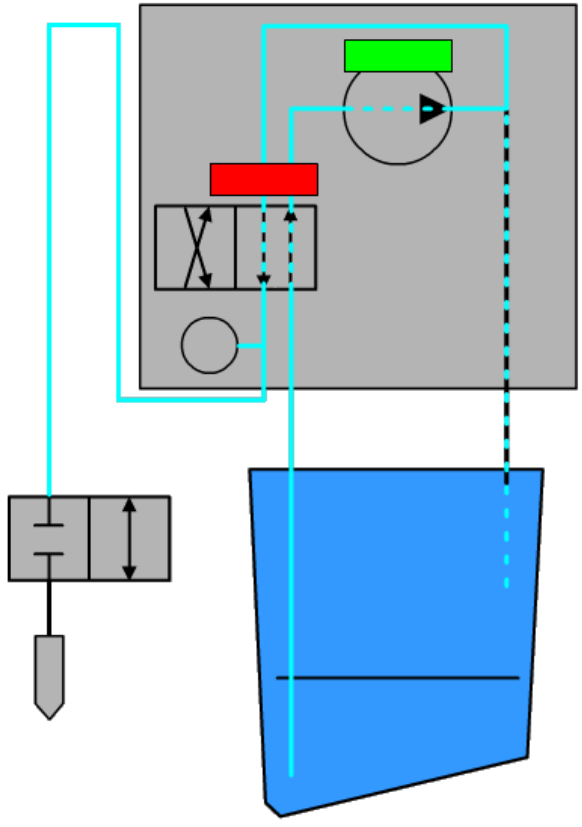
- Engine start successfully.
- And exhaust temperature is higher than preset value.

Action:

- Pump running to build up constant DEF pressure.
  - ✓ Can be monitored by Insite.
- Dosing Valve Test.(Dosing valve will open 2 seconds)
  - ✓ DEF pressure should decrease and should recover quickly.

Ending:

- DEF pressure is OK and dosing valve is OK.



CUMMINS QSF3.8 – After treatment device – OPERATION

The SCR system is comprised of many components but requires a minimal amount of servicing or driver intervention.

The SCR system is comprised of FIVE main states:

~~1. Initializing~~

~~2. Priming~~

3. Dosing

Beginning:

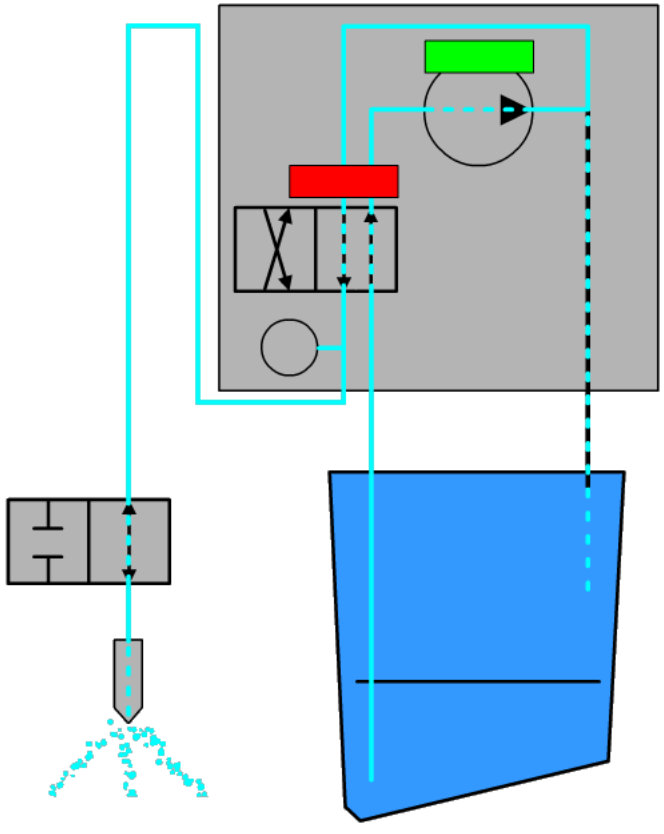
- When system successfully primed, it is ready to dose.

At Dosing State:

- Pump runs continuously to maintain system pressure around 900 kPa (130 Psi).
- Dosing valve is closed. No DEF spray into exhaust.
- When ECM determines need to dose it will energies solenoid with PWM signal
- DEF will be delivered into exhaust by impulse injection
- DEF pressure is kept in DEF that is supplied by pump is returned to the DEF tank through backflow valve.

Required Conditions for Dosing

- Above 200 degrees C @ both Catalyst Inlet and Outlet
- No ACTIVE SCR System Related Fault codes
- DEF Tank Level above 6% (trimable)
- Above - 3 degrees C (DEF temp)
- Cummins NOx Calibration



CUMMINS QSF3.8 – After treatment device – OPERATION

The SCR system is comprised of many components but requires a minimal amount of servicing or driver intervention.

The SCR system is comprised of FIVE main states:

~~1. Initializing~~

~~2. Priming~~

~~3. Dosing~~

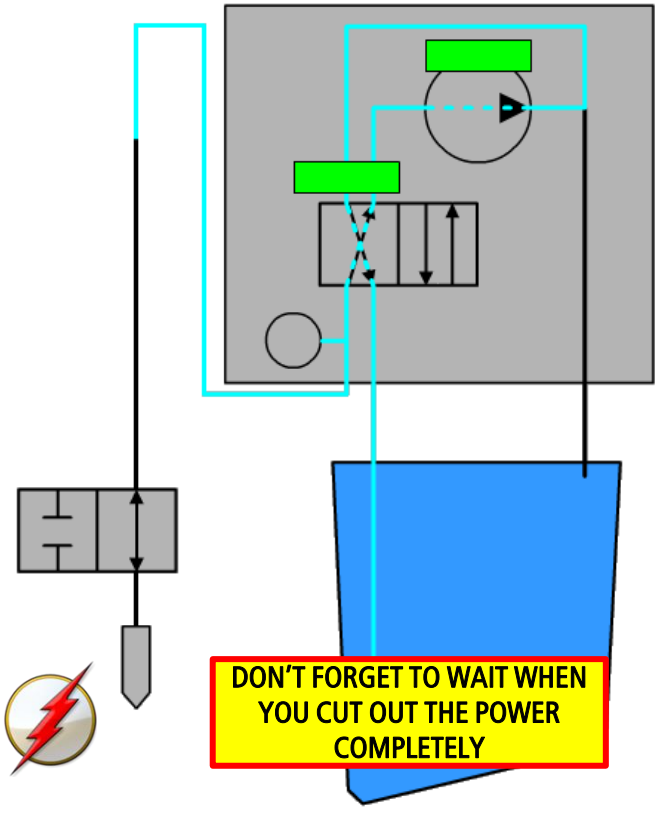
4. Purging

When the driver turns the key OFF, the dosing system will shut down with a purge cycle to prevent DEF from being left in the system and in cold climates, potentially freezing.
After a complete purge, the majority of the system will be free of any remaining DEF.

- The DEF dosing unit slides its internal return valve and causes a change in the flow direction of the DEF control.
- The DEF dosing unit pulls all of the DEF out of dosing valve and the lines then return the unused DEF to the DEF tank.
- In this process, the dosing valve will open, eliminating the vacuum created in the lines for a more complete purge process.

If the main power to DEF controller was removed (via battery cut off or other means) before the purging state was competed, an internal fault will be logged in the ECM.

- The incomplete purge counter can be viewed in INSITE™.

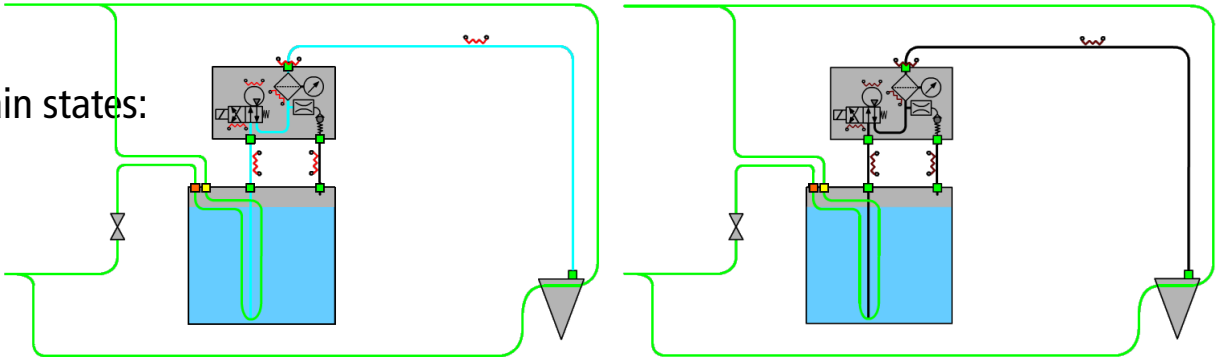


CUMMINS QSF3.8 – After treatment device – OPERATION

The SCR system is comprised of many components but requires a minimal amount of servicing or driver intervention.

The SCR system is comprised of FIVE main states:

1. ~~Initializing~~
2. ~~Priming~~
3. ~~Dosing~~
4. ~~Purging~~
5. **Heating**



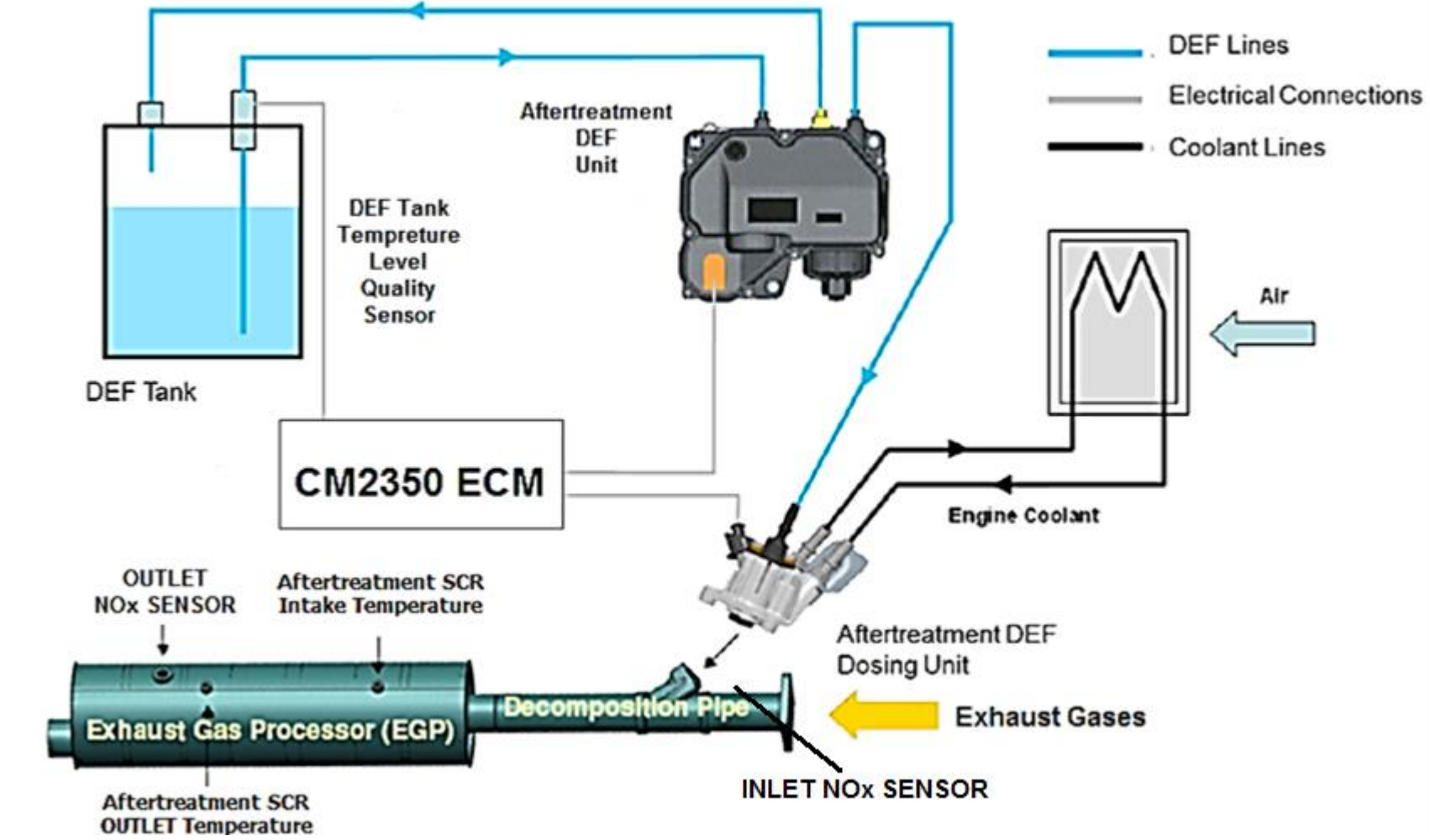
If the ambient air temperature is below -4° C [25° F], the DEF controller will command the dosing system to go into the defrost state.

- The dosing unit will turn on its internal heater to defrost any remaining DEF inside it.
- If the application has the DEF line heating option, the heated DEF lines will also be commanded on.
- If the DEF tank temperature drops below -5° C [23° F], the DEF tank coolant valve will be commanded open by the DEF controller, engine coolant will flow through the tank to defrost the frozen DEF.
- The system will not prime until every component is defrosted.

If ambient conditions continue to be cold after the system has primed, the DEF controller will command a maintenance heating feature to prevent the system from freezing again.

- This feature will cycle the heating ON and OFF to the DEF lines, DEF tank and DEF dosing unit

CUMMINS QSF3.8 – After treatment device – FLOW



CUMMINS QSF3.8 – After treatment device – HARDWARE

Ultrasonic level meter
- Assuming the fluid density is constant, time for signal to travel from sender (located in the bottom) to the top reflector and back to receiver (located in the bottom) will vary depending on the fluid level

Smart component (datalink)
Shown as integrated sensor with temperature and level
All sensors in this setup are communicating via datalink
Codes will vary due to setup configuration

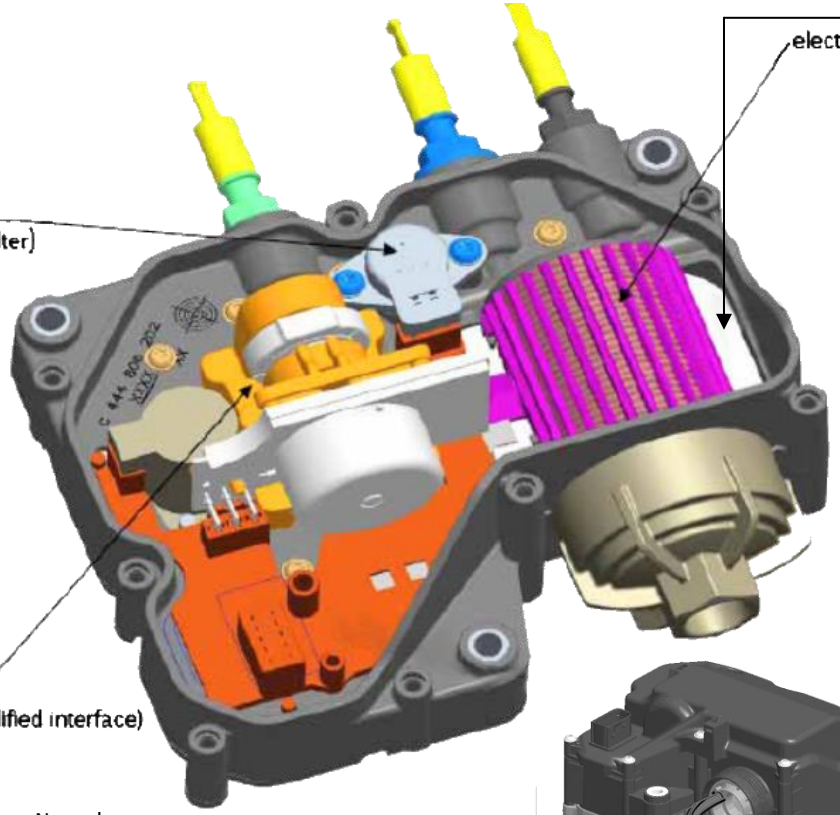
Ultrasonic density meter
- Assuming the distance between receiver and sender is constant
- Receiver sends the signal to reflect and receives it back,
- Time to travel this distance will vary depending on the fluid density,
- Though DEF concentration will be verified

Smart component (datalink)
Shown as integrated sensor with temperature and level
All sensors in this setup are communicating via datalink
Codes will vary due to setup configuration

Temperature sensor
Integrated into the bottom of the combination sensor
Required to properly start / stop heating/defrosting of the tank
Smart component (datalink) in this application, could be hardwired
Shown as integrated sensor with temperature and level

CUMMINS QSF3.8 – After treatment device – HARDWARE

Pressure sensor
(New position- clean side of filter)



electrical heater

Diaphragm pump + Reverting valve
(New orientation in the housing, modified interface)

Description	Current	New
2. Filter Equalizing Element		
3. Filter Element		

PUMP

Uni-directional diaphragm pump

Pump delivery: 20 L/h @ 9 bar (gauge)

Pump motor driven by PWM signal from ECM

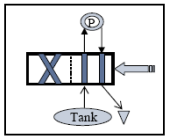
Pump can only operate after DEF Unit defrosted to avoid damage

Max current draw: 4A @ 14 V

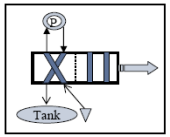
REVERTING V/V

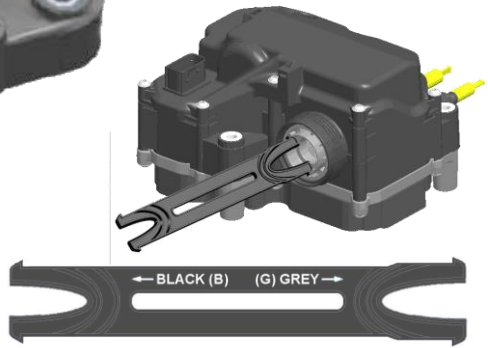
Enable purging with uni-directional pump
Current draw: 3A @ 16 V, -15 degC

Normal Operation



Purging





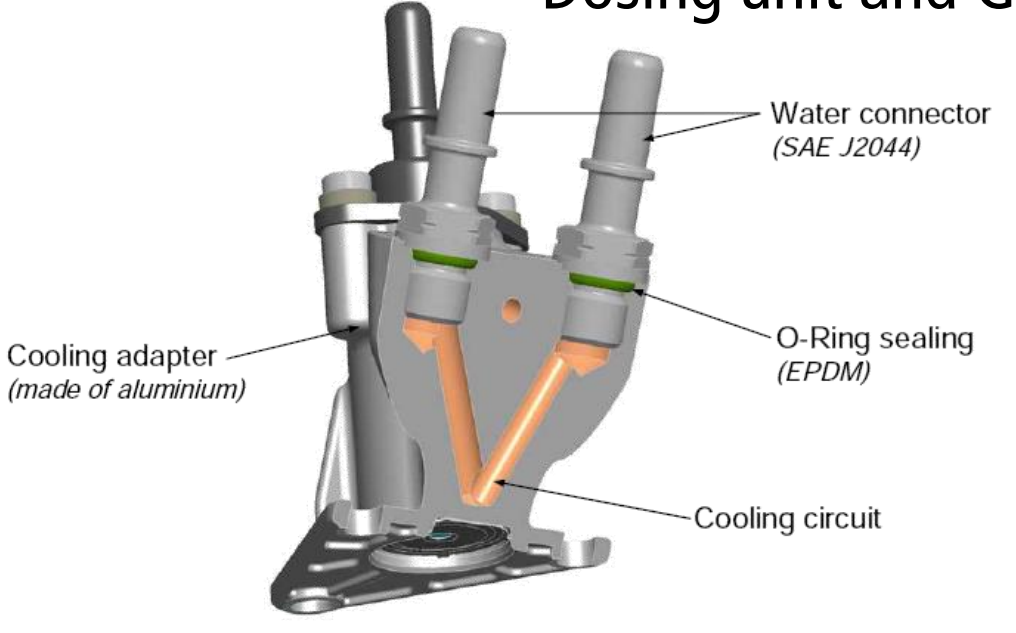
Service Kit for High Capacity Filter will include

- Filter element
- Compensation device/equalizing element
- Tool for filter removal

CUMMINS QSF3.8 – After treatment device – HARDWARE

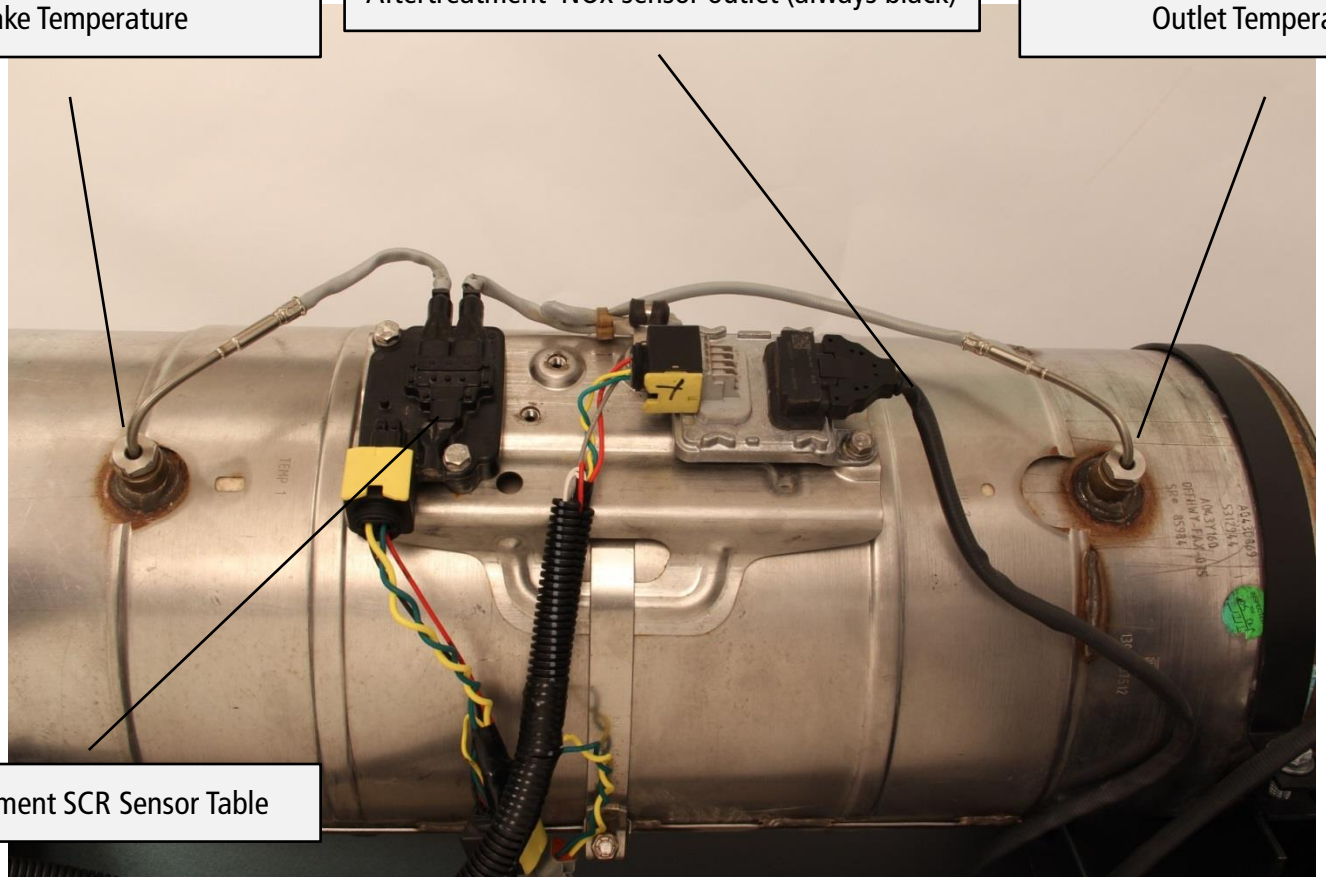
- Solenoid injector that delivers pressurized urea into exhaust
- Mounted on exhaust pipe with flange
- Water cooled

Dosing unit and Gasket

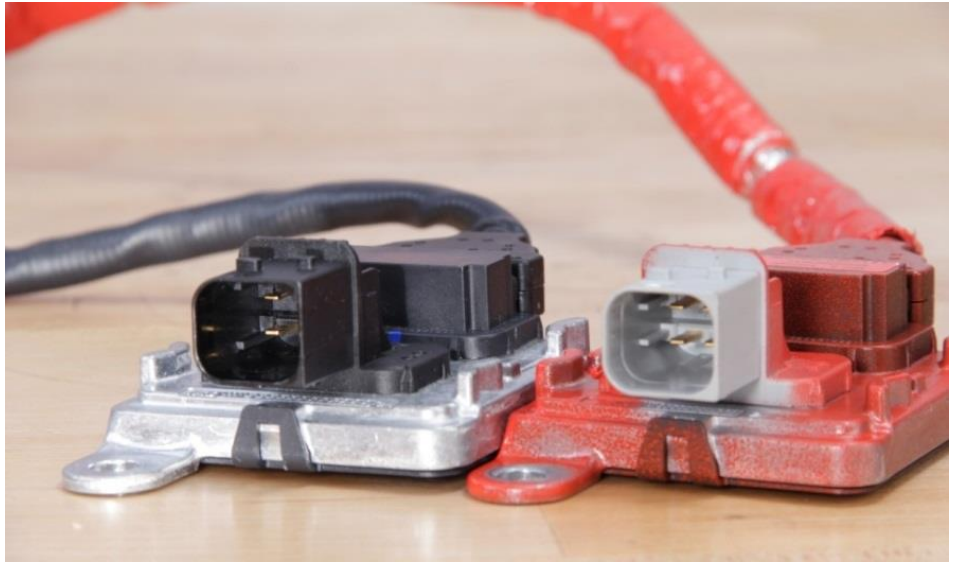


- Insulated Gasket
- Includes an insulation layer
- Utilizes current sealing surface
- Retains thermal isolator
- Addition of metal spacers under DM mounting feet

CUMMINS QSF3.8 – After treatment device – HARDWARE



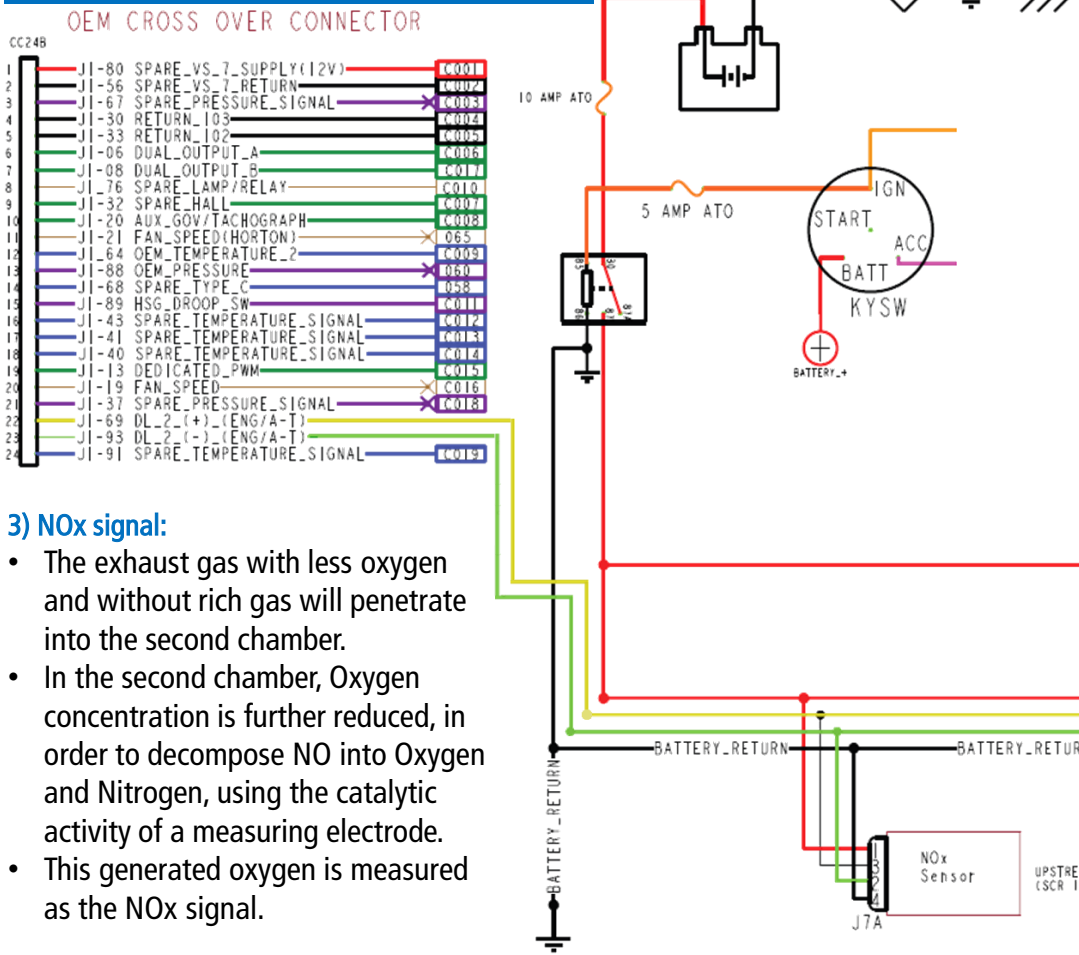
CUMMINS QSF3.8 – After treatment device – EMISSION CTRL



- Reads tailpipe NOx emissions
- Processor mounting is critical
- Not serviceable
- Never pressure wash
- Not Re-programmable
- Self Diagnosing intelligent device
- Accuracy improvement to ± 10 ppm/%,
- Probe cover to improve water splash resistance
- Faster response time
- Extend the temperature range
- 4 pin connector change
- 24 volts and 12 volts sensors with specific part #'s
- Inlet and Outlet sensors use different connector key
- Different internal software for Inlet and Outlet sensors (Preprogrammed)
- NOx heating will begin when the intake NOx sensor reaches 150 C and the outlet NOx sensor reaches 200 C

CUMMINS QSF3.8 – After treatment device – EMISSION CTRL

Bidirectional Digital Data Transmission



The NOx sensor provides three signals in parallel:

1) Binary λ-signal:

- Obtained by measuring voltage between reference and main pump electrode (=Nernstian voltage)

2) Wide range λ-signal:

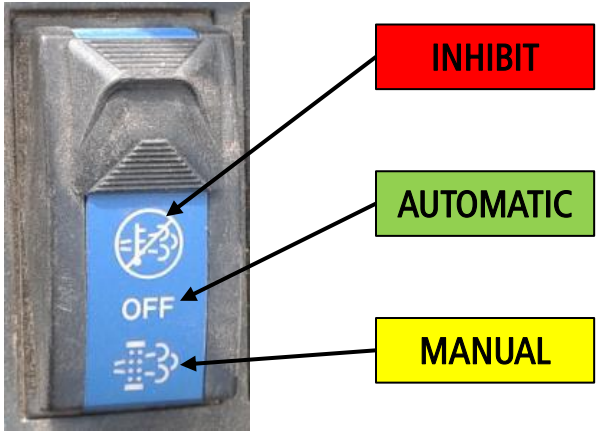
- The exhaust gas penetrates into the first cavity and the main pumping cell controls O2 concentration at low-digit ppm levels.
- In this condition, NO will not be decomposed but all rich gases, like HCs, CO and H2 will be oxidized.
- The resulting pumping current is proportional to the wide range λ-signal.

3) NOx signal:

- The exhaust gas with less oxygen and without rich gas will penetrate into the second chamber.
- In the second chamber, Oxygen concentration is further reduced, in order to decompose NO into Oxygen and Nitrogen, using the catalytic activity of a measuring electrode.
- This generated oxygen is measured as the NOx signal.

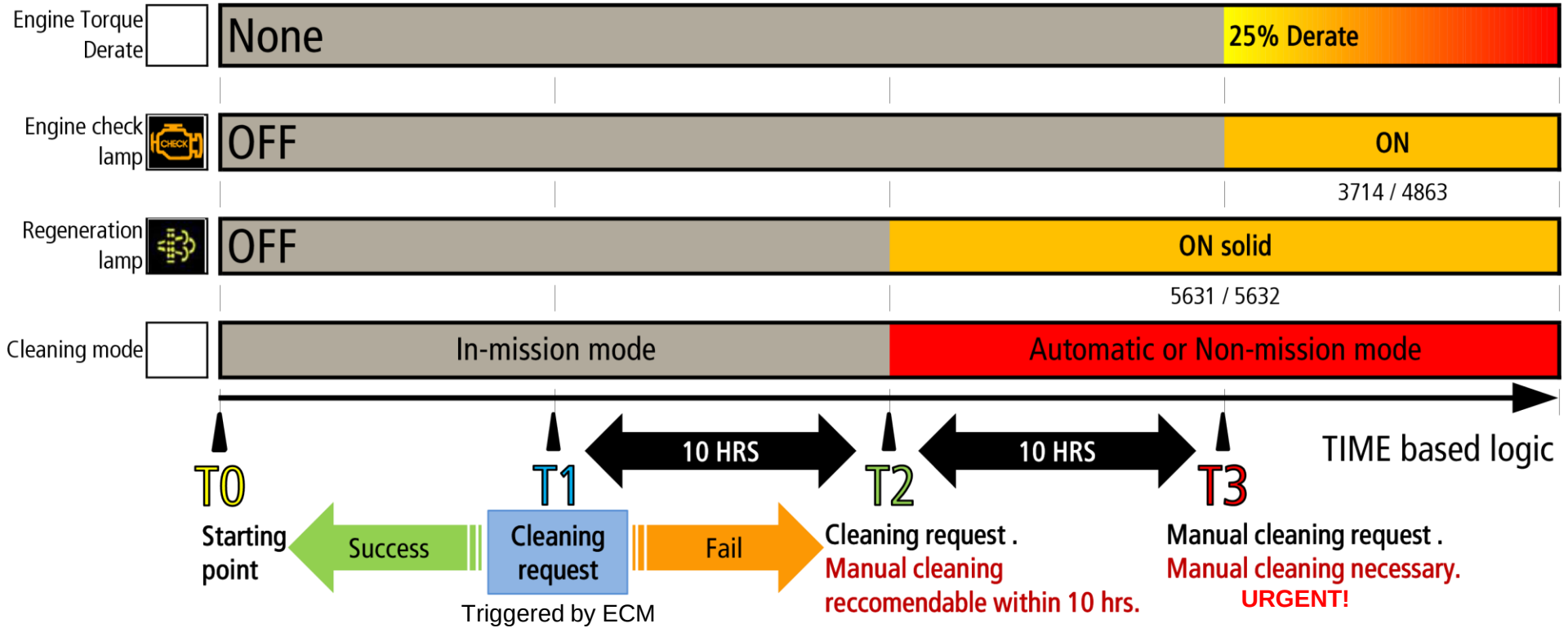
CUMMINS QSF3.8 – After treatment device – CLEANING

To avoid urea deposits at the injection point in the DRT, exhaust **cleaning** is needed.

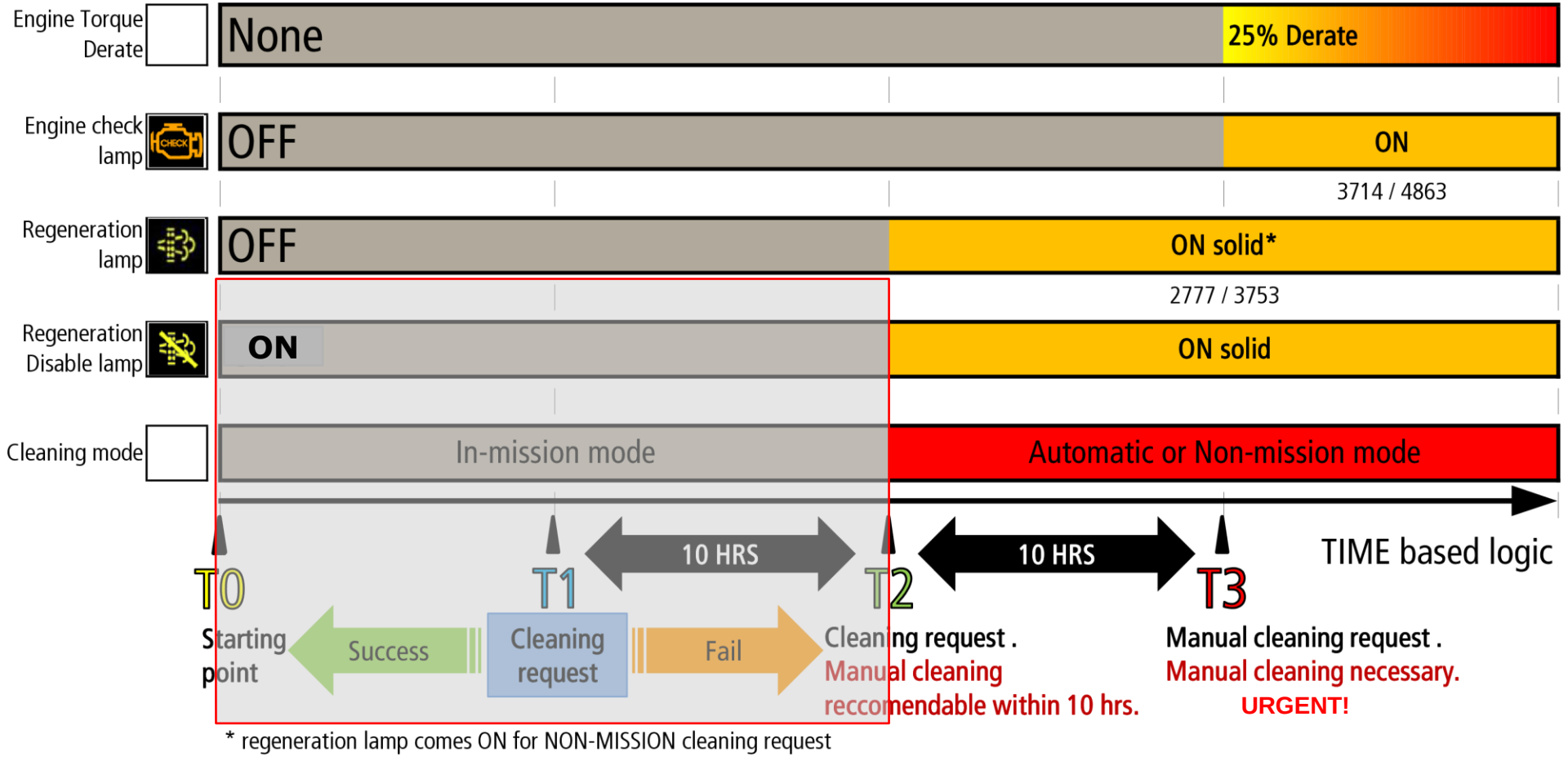


Cleaning is basically, melting down the urea deposits by high temperatures.
The way to rise exhaust gas temperature is control exhaust throttle.

CUMMINS QSF3.8 – After treatment device – CLEANING



CUMMINS QSF3.8 – After treatment device – CLEANING



* regeneration lamp comes ON for NON-MISSION cleaning request

CUMMINS QSF3.8 – After treatment device – CLEANING

Condition	Warning lamp				Remark
	SCR cleaning lamp	DEF Low Lamp	Engine Check Lamp	Engine Stop Lamp	
SCR needs to be cleaned	On	-	-	-	1. Change to a more challenging duty cycle. 2. Perform manual SCR cleaning.
SCR needs to be cleaned immediately	On	-	On	-	Manual SCR cleaning is required.
Stationary SCR cleaning status	Flash	-	-	-	-
DEF level initial warning	-	On	-	-	DEF level 10% Engine error code 3497
DEF level critical warning	-	Flash	-	-	DEF level 5% Engine error code 3498
DEF level initial warning	-	Flash	On	-	DEF level 2.5% Engine error code 1673, 25% derate
DEF level secondary derate warning	-	Flash	On	-	DEF level 0% Engine error code 3547,3714 50% derate, 30 min.
DEF level final derate warning	-	Flash	On	On	Engine error code 3712 Contact Hyundai service center or dealer.

Manual SCR cleaning applies if the machine is in a fireproof area and there is no plan to turn off the machine during the SCR cleaning.

- ***Stop and park the machine.***
- ***Pull the safety button and push the switch to position to initiate the manual SCR cleaning.***
  - The engine speed may increase during SCR cleaning and it will take approximately 20~60 minutes depending on condition.
  - The SCR cleaning lamp flash and HEST warning lamp will light on during the manual SCR cleaning function is operating.
  - The SCR cleaning and/or HEST warning lamp will light OFF when the SCR cleaning function is completed.

Engine Diagnostic Tool

INSITE 8.0.0.pdf

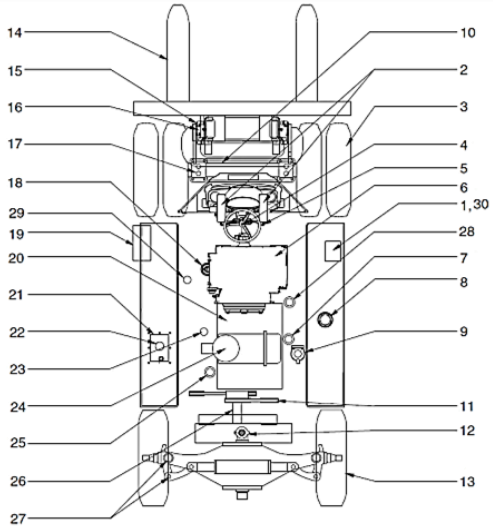
Maintenance Recommendations

MAINTENANCE

Service interval	Item No.	Description	Service Action	Oil symbol	Capacity (l)	Service point No.
10 Hours or daily	1	Diesel exhaust fluid level	Check, Add	DEF	18.9	-
	2	Pedal linkage	Check, Adjust	-	-	1
	3	Drive rim & Tire air pressure	Check, Add	-	-	2
	4	Horn operation	Check, Replace	-	-	2
	5	Lamp operation	Check, Replace	-	-	10
	8	Fuel level	Check, Add	DF	171.5	1
	9	Prefilter (water separator)	Check, Drain	-	-	1
	11	Fan belt tension	Check, Replace	-	-	1
	12	Radiator coolant	Check, Add	C	20.4	1
	13	Steer rim & Tire air pressure	Check, Add	-	-	2
	15	Lift chain and fastener	Check, Adjust	-	-	2
	16	Tilt pin & Mast roller	Check, Lubricate	G	-	2
	20	Engine oil level	Check, Add	EO	12	1
	21	Hydraulic oil level	Check, Add	HO	80	1
Initial 50 Hours	29	Pilot line filter element	Replace	-	-	1
50 Hours or weekly	6	Transmission oil level	Check, Add	EO	18	1
	26	Fan pulley drive	Check, Lubricate	-	-	1
	27	Steering axle linkage	Check, Lubricate	G	-	2
Initial 100 Hours	10	Differential gear oil	Change	GO	12.5	1
	6	Transmission oil	Change	EO	18	1
	18	Transmission oil filter	Replace	-	-	1

OM.pdf

SM.pdf



250 Hours or monthly	10	Differential gear oil	Check, Refill	GO	12.5	1
	11	Fan belt tension	Check, Adjust	-	-	1
	14	Forks	Check	-	-	2
	15	Lift chain	Check, Lubricate	EO	-	2
	16	Tilt pin & Mast roller	Check, Lubricate	G	-	2
	23	Hydraulic oil air breather element	Check, Replace	-	-	1
	28	Brake line filter (strainer)	Check, Clean	-	-	1
500 Hours or 3 monthly	7	Fuel filter	Replace	-	-	1
	9	Prefilter (water separator)	Clean	-	-	1
	17	Mast & Drive axle mounting bolt	Check, Tight	-	-	4
	19	Battery	Clean	-	-	2
	20	Engine oil	Change	EO	12	1
	22	Hydraulic oil return filter	Replace	-	-	1
	25	Engine oil filter	Replace	-	-	1
	24	Air cleaner element	Check, Clean	-	-	1
	25	Engine oil and filter	Replace	-	-	1
1000 Hours or 6 monthly	10	Differential gear oil	Change	GO	12.5	1
	6	Transmission oil	Change	EO	18	1
	11	Fan belt tension & Damage	Check, Replace	-	-	1
	18	Transmission oil filter	Replace	-	-	1
	29	Pilot line filter element	Replace	-	-	1
2000 Hours	12	Radiator coolant	Replace	C	6.3	1
	21	Hydraulic strainer	Check, Clean	-	-	1
	21	Hydraulic oil *1	Change	HO	80	1
4000 Hours	30	Aftertreatment diesel exhaust fluid dosing unit filter	Change	-	-	1
5000 Hours	21	Hydraulic oil *2	Change	HO	80	1

A/F HHI (A/F HHI.pdf)

Cummins Air Filter mainetnance.pdf

MAINTENANCE

Service point	Kind of fluid	Capacity ℓ (U.S. gal)	Ambient temperature ˚C (˚F)
			-50 (-58) / -30 (-22) / -20 (-4) / -10 (14) / 0 (32) / 10 (50) / 20 (68) / 30 (86) / 40 (104)
Engine oil pan	Engine oil	12 (3.2)	★SAE 5W-40 SAE 30 SAE 10W SAE 10W-30 SAE 15W-40
Torque converter transmission	Transmission oil	18 (4.8)	SHELL DONAX TD
Axle	Gear oil	12.5 (3.3)	SHELL DONAX TD
Hydraulic tank	Hydraulic oil	115 (30)	★ISO VG 15 ISO VG 46
Cabin tilt hand pump	Hydraulic oil	0.7 (0.2)	ISO VG 68
Fuel tank	Diesel fuel★1	160 (42.3)	★ASTM D975 NO.1 ASTM D975 NO.2
Fitting (Grease nipple)	Grease	-	★NLGI NO.1 NLGI NO.2
Radiator	Antifreeze : Soft water	20.4 (5.4)	Ethylene glycol base permanent type (50:50) ★Ethylene glycol base permanent type (60 : 40)
DEF/AdBlue® tank	Mixture of urea and deionized water	18.9 (5)	ISO 22241 (High-purity urea + deionized water (32.5:67.5))

NOTES :

① SAE numbers given to engine oil should be selected according to ambient temperature.

② For engine oil used in engine oil pan, use SAE 10W oil when the temperature at the time of engine start up is below 0˚C, even if the ambient temperature in daytime is expected to rise to 10˚C or more.

③ Use engine oil of API service class CJ-4.

★1 : Ultra low sulfur diesel
- sulfur content 15 ppm

★ : Cold region
Russia, CIS, Mongolia

MAINTENANCE – Cummins recommendations

Maintenance Procedures at Daily Interval
Crankcase Breather Tube - Check
Fuel-Water Separator - Check
Lubricating Oil Level - Check
Coolant Level - Check
Fan, Cooling - Check
Drive Belts - Check
Air Cleaner Restriction - Check
Dust Ejection Valve - Check
Air Intake Piping - Check
Diesel Exhaust Fluid Level - Check

Maintenance Procedures at 250 Hour or 3 Months
Charge-Air Cooler - Check
Charge-Air Piping - Check

Maintenance Procedures at 500 Hours or 6 Months
Fuel Filter (Canister Type) - Change
Fuel Filter (Spin-On Type) - Change
Lubricating Oil and Filters - Change[1]
Cooling System Antifreeze - Check[2]
Cooling Fan Belt Tensioner - Check
Batteries - Check
Battery Cables and Connectors - Check

Maintenance Procedures at 1000 Hours or 1 Year
Radiator Pressure Cap - Check
Fan Hub, Belt-Driven - Check

Maintenance Procedures at 2000 Hours or 2 Years
Cooling System - Drain and Flush
Radiator Hoses - Check

Maintenance Procedures at 4000 Hours or 3 Years
Aftertreatment Diesel Exhaust Fluid Dosing Unit Filter - Change

Maintenance Procedures at 5000 Hours or 4 Years
Overhead Set - Adjust

Notes:

1. Use CJ-4 (15W-40) oil that meets CES 20081 specifications.

2. Coolant testing for additive and glycol levels must be performed at least twice a year. The coolant must be tested for replacement limits every 4000 hours or once a year, whichever occurs first.

Use the following procedure for fuel recommendations and specifications.

Table 1: Cummins Inc. Required Diesel Fuel Specifications[1]	
Viscosity	1.3 to 4.1 centistokes at 40°C [104°]
Cetane Number	42 minimum above 0°C [32°F]; 45 minimum below 0°C [32°F][2]
Sulfur Content	Maximum sulfur content of 15 ppm in the United States and Canada and 10 ppm in the EU
Active Sulfur	Copper strip corrosion **not** to exceed number 3 rating after 3 hours at 50°C [122°F].
Water Sediment	**Not** to exceed 0.05 volume-percent
Carbon Residue	**Not** to exceed 0.35 mass-percent on 10 volume-percent residuum
Density	0.816 to 0.876 grams per cubic centimeter (g/cc) at 15°C [59°F]
Cloud Point	6°C or 11°F below lowest ambient temperature at which the fuel is expected to operate
Ash	Not to exceed 0.02 mass-percent. For vehicles equipped with exhaust aftertreatment, there shall be no detectable ash in the fuel
Distillation	10 volume-percent at 282°C [540°F] maximum, 90 volume-percent at 360°C [680°F] maximum, 100 volume-percent at 385°C [725°F]maximum. The distillation curve **must** be smooth and continuous
Lubricity (HFRR)or (SLBOCLE)	High Frequency Reciprocating Rig (HFRR): Maximum of 0.52 mm[0.020 in] Wear Scar Diameter (WSD) at 60°C [140°F].Scuffing Load Ball-on-Cylinder Lubricity Evaluator (SLBOCLE):Minimum of 3100 grams

Q&A